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Fondata da Mario Arcelli

Le sfide per il Sistema Sanitario Nazionale

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Le sfide per il Sistema Sanitario Nazionale

RECENSIONI

Le sfide per il Sistema Sanitario Nazionale. Guida alla lettura

Vincenzo Atella *

Negli ultimi quattro decenni, i sistemi sanitari nazionali sono stati investiti da trasformazioni di portata storica che ne hanno profondamente modificato il ruolo, le funzioni e le modalità operative. L'invecchiamento della popolazione, l'epidemia globale di obesità e di patologie croniche associate agli stili di vita malsani, l'intensificarsi dell'inquinamento ambientale, il riscaldamento climatico e lo sfruttamento intensivo delle risorse naturali rappresentano oggi fattori strutturali di vulnerabilità, che rendono sempre più complesso garantire, al contempo, la salute della popolazione e la sostenibilità economico-organizzativa dei sistemi sanitari.

Tali fenomeni non agiscono in modo isolato, ma si rafforzano reciprocamente, generando effetti sistemici che mettono in crisi i modelli assistenziali tradizionali, storicamente centrati sulla cura episodica delle patologie acute. Se da un lato l'aspettativa di vita ha continuato ad aumentare — circa un

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anno ogni quattro — grazie al progresso medico e tecnologico, dall'altro è emersa una vera e propria "epidemia di cronicità", che ha reso più diffusa la fragilità, la disabilità e la comorbidità, imponendo sfide nuove e più complesse ai sistemi sanitari pubblici. A questa dimensione clinico-epidemiologica si affianca quella sociale: l'impatto delle crisi economiche, in particolare quella del 2008, ha contribuito ad acuire le disuguaglianze, soprattutto nei territori economicamente più fragili, minando l'equità nell'accesso ai servizi e nella qualità delle cure.

La compresenza di questi fattori clinico-epidemiologici, ambientali ed economico-sociali impone oggi una riflessione sistemica su come ripensare l'intero impianto dei servizi sanitari. La capacità dei sistemi sanitari di restare resilienti di fronte a crisi plurime — sanitarie, ambientali, economiche — dipende in misura crescente dalla loro flessibilità istituzionale, dalla capacità di agire sui determinanti strutturali della salute e dall'adozione di modelli organizzativi orientati alla prevenzione primaria e alla promozione attiva della salute lungo tutto l'arco della vita.

In particolare, appare evidente come l'attuale predominanza di un modello sanitario incentrato sulla cura piuttosto che sulla prevenzione sia ormai insostenibile. Le principali patologie croniche — malattie cardiovascolari, diabete, disturbi respiratori — richiedono interventi prolungati, costosi e spesso evitabili. Secondo l'Organizzazione Mondiale della Sanità, l'investimento in strategie preventive, quali screening, campagne educative, promozione di stili di vita sani e medicina di iniziativa, può generare benefici sanitari e risparmi economici rilevanti, fino a 16 dollari per ogni dollaro investito. Tuttavia, nei paesi OCSE solo il 3% della spesa sanitaria è oggi destinata alla prevenzione, e in Italia questa quota è persino inferiore all'1%. Il mancato investimento in prevenzione genera effetti a catena su tutto il sistema: si aggravano i bisogni

sanitari insoddisfatti, si ritardano le diagnosi precoci, si riduce l'efficacia terapeutica e si amplificano i costi di gestione delle malattie avanzate. A ciò si aggiunge una grave carenza di competenze professionali specifiche in ambito preventivo e una frammentazione delle iniziative sui territori, che ostacola la costruzione di una rete di salute pubblica integrata e proattiva.

Di fronte a queste evidenze, la sostenibilità del Servizio Sanitario Nazionale (SSN) richiede una profonda revisione strategica e operativa, orientata a rafforzare la prevenzione, promuovere l'alfabetizzazione sanitaria, investire nella salute di comunità e costruire alleanze sistemiche tra sanità, ambiente, scuola, lavoro e urbanistica. Solo attraverso un approccio integrato, capace di superare le logiche settoriali e i silos istituzionali, sarà possibile generare esternalità positive in grado di migliorare la salute della popolazione, contenere la spesa sanitaria e rafforzare la resilienza del SSN. I nodi concettuali e le criticità operative qui delineati costituiscono il filo conduttore di questo numero speciale, che si articola in sei capitoli, ciascuno dedicato a un ambito strategico per comprendere e riprogettare il SSN in un'ottica di equità, innovazione e sostenibilità. I temi sollevati in questa introduzione verranno approfonditi nei contributi che seguono, con approcci diversi ma complementari.

Perché è necessaria una riforma del SSN. Il primo contributo, dal titolo *"The Urgent Need for an NHS Reform: Adapting to Overlooked Years of Transformation in Healthcare"* (Atella), propone un'analisi ampia e articolata sulle ragioni strutturali che rendono oggi imprescindibile una riforma del Servizio Sanitario Nazionale (SSN). A partire dall'assunto che i progressi medici e scientifici hanno ampiamente superato la capacità delle istituzioni sanitarie di adattarsi, l'articolo mette in luce il crescente divario tra ciò che è tecnicamente possibile in medicina e ciò che è istituzionalmente realizzabile nel sistema sanitario italiano. Il contributo traccia un'accurata ricostruzione sto-

rica delle principali tappe evolutive del SSN, evidenziando come le riforme susseguitesi dal 1978 a oggi – dalla centralizzazione iniziale alla progressiva regionalizzazione – abbiano spesso risposto a esigenze di contenimento della spesa piuttosto che a una visione sistemica capace di anticipare i profondi mutamenti epidemiologici, demografici e tecnologici. L'articolo evidenzia come la pandemia di COVID-19 abbia amplificato le criticità preesistenti, accelerando la necessità di un ripensamento complessivo dell'architettura del SSN. Uno degli aspetti centrali del saggio è l'analisi dei cambiamenti di paradigma in medicina: l'affermarsi della medicina preventiva e personalizzata, il modello di "*life-course health*", l'emergere della medicina basata sullo stile di vita e l'uso crescente dell'intelligenza artificiale e dei big data. Tutti questi sviluppi impongono un nuovo assetto istituzionale e organizzativo, che l'attuale configurazione del SSN fatica a recepire. Infine, si mette in evidenza come il nostro SSN sia sempre più da considerare come un sistema ormai immerso in una rete complessa e adattiva, in cui la salute è influenzata da fattori sociali, ambientali, economici e tecnologici. Per questo, la riforma non può essere solo tecnica o amministrativa, ma deve essere anche culturale e sistemica. Viene quindi proposta una strategia articolata su tre orizzonti temporali (breve, medio e lungo periodo) e cinque priorità: rafforzamento del personale, espansione dei servizi preventivi, trasformazione digitale, maggiore trasparenza e partecipazione dei cittadini, revisione dei modelli di finanziamento. Il messaggio conclusivo è chiaro: senza una riforma radicale, il SSN rischia di non essere più in grado di garantire i suoi principi fondanti di universalismo, equità e solidarietà. Tuttavia, con un'azione riformatrice lungimirante, il sistema sanitario italiano può non solo preservare i suoi punti di forza, ma diventare un modello di riferimento internazionale.

L'innovazione tecnologica. L'innovazione tecnologica è unanimemente considerata la causa principale dell'allungamento dell'aspettativa di vita della popolazione nei paesi più avanzati negli ultimi 50 anni. Le scoperte fatte negli ultimi anni hanno offerto opportunità straordinarie per avanzare nella cura dei pazienti e nell›efficienza operativa all›interno del sistema sanitario. Tuttavia, il rapido ritmo di questi avanzamenti richiede investimenti significativi in nuove tecnologie, formazione per i professionisti sanitari e sviluppo infrastrutturale per realizzare appieno i loro potenziali benefici. Un sistema sanitario sostenibile deve incorporare un approccio strategico all›adozione tecnologica, assicurando che questa migliori le prospettive di vita in buona salute per tutti i cittadini senza esacerbare, le disparità sanitarie esistenti. Il secondo lavoro, dal titolo *"Digital Disruption in Healthcare: What It Means for the NHS"* (Atella e Chiari), dedicato alle tecnologie digitali analizza il ruolo sempre più centrale della trasformazione tecnologica nel Servizio Sanitario Nazionale (SSN), evidenziandone sia le potenzialità sia le criticità. Gli autori riflettono sulle condizioni che renderebbero la digitalizzazione un'opportunità concreta per migliorare equità, qualità ed efficienza dell'assistenza sanitaria, a fronte però di un panorama nazionale ancora segnato da frammentazione, ritardi implementativi e disparità territoriali. Il testo si sofferma su tre grandi direttrici della transizione digitale: la raccolta e gestione dei dati sanitari, lo sviluppo di algoritmi predittivi e strumenti di intelligenza artificiale, e l'uso della telemedicina e dei servizi da remoto. Per ciascuna di queste aree vengono descritti benefici potenziali — ad esempio, un migliore coordinamento dei percorsi di cura, l'identificazione precoce dei bisogni, il monitoraggio continuo dei pazienti — ma anche rischi significativi, legati alla governance, alla sicurezza dei dati, alla qualità degli algoritmi e al rischio di rafforzare le disuguaglianze esistenti. Particolare attenzione viene data al tema dell'interopera-

bilità, considerata una precondizione per l'effettiva integrazione dei sistemi digitali, oggi ostacolata da infrastrutture disomogenee e da una governance multilivello che non ha ancora trovato un equilibrio efficace. Il capitolo evidenzia inoltre come l'accelerazione indotta dalla pandemia abbia fatto emergere tutte le contraddizioni di un sistema ancora non pronto, in cui l'adozione di nuove tecnologie non è stata sempre accompagnata da adeguate strategie formative, valutative e regolatorie. Il messaggio di fondo è che la tecnologia da sola non è sufficiente a produrre trasformazioni significative: occorrono visione politica, capacità istituzionale e investimenti coerenti. Solo in presenza di una regia forte e orientata all'equità sarà possibile evitare che l'innovazione si traduca in nuovi divari di accesso e qualità. In questo senso, il capitolo rappresenta un invito a concepire la digitalizzazione non come una scorciatoia tecnica, ma come una leva per ripensare strutturalmente il SSN, integrando obiettivi di modernizzazione con quelli di giustizia sociale.

Il finanziamento della sanità pubblica. I problemi generati dall'invecchiamento della popolazione e dall'avanzamento delle nuove tecnologie sono aggravati dalla natura cronica della mancanza di risorse pubbliche, che limitano la capacità del sistema di espandere i servizi, mantenere le infrastrutture e investire nelle innovazioni necessarie. Affrontare questo problema richiede non solo un aumento dei finanziamenti, ma anche una più intelligente allocazione delle risorse e l'esplorazione di nuovi modelli di finanziamento per garantire la sostenibilità a lungo termine del sistema sanitario. La spesa sanitaria rimane una questione centrale per i decisori politici, specialmente in un periodo di incertezza economica. Secondo l'OCSE (2023), la spesa sanitaria in rapporto al PIL è aumentata significativamente durante la pandemia, passando da una media dell'8,8% nel 2019 al 9,7% nel 2021, per poi ridursi leggermente al 9,2% nel 2022. Questa fluttuazione riflette l'eccezionale spesa

necessaria per gestire la crisi del COVID-19, seguita da una riduzione dei costi legati alla pandemia. Tuttavia, l'inflazione e le priorità di bilancio concorrenti stanno limitando la capacità dei governi di mantenere investimenti adeguati nella sanità. L'aumento dei costi è aggravato da inefficienze come le spese amministrative eccessive, la frammentazione nell'erogazione delle cure e i ricoveri ospedalieri evitabili (OCSE, 2023). Il terzo contributo, dal titolo "*Il Finanziamento e la Spesa Sanitaria in Italia"* (Atella, Cincotti, d'Angela, Polistena e Spandonaro), affronta in modo sistematico l'evoluzione del finanziamento e della spesa del Servizio Sanitario Nazionale (SSN) italiano, mettendo in luce le criticità strutturali e i rischi per la sostenibilità futura del sistema. Il lavoro parte dall'analisi del quadro multilivello di finanziamento—centrale, regionale e locale—e documenta le persistenti disuguaglianze territoriali e le inefficienze nell'allocazione delle risorse. Il confronto con i Paesi europei mostra come l'Italia si collochi sotto la media per spesa pubblica sanitaria, con una crescente incidenza della componente privata a carico delle famiglie, che ha ormai raggiunto quasi un quarto della spesa complessiva. I vincoli di finanza pubblica hanno prodotto un sottofinanziamento cronico che ha inciso sulla capacità del SSN di mantenere le promesse di equità e universalismo, non risolvendo le disuguaglianze tra Nord e Sud. Il contributo si conclude con una riflessione su possibili scenari di riforma, basati su un rafforzamento della governance, una riallocazione più equa delle risorse, una regolazione più efficace del ruolo del privato e l'urgenza di rivedere i criteri di riparto del fabbisogno sanitario nazionale. Il lavoro fornisce una base per orientare il dibattito sulle politiche di finanziamento del sistema sanitario, anche alla luce del crescente peso della spesa privata e della necessità di integrare le forme emergenti di protezione sanitaria in un quadro di sussidiarietà e regolazione.

Le disuguaglianze sanitarie. A livello OCSE, nonostante l'esistenza di una copertura sanitaria universale nella maggior parte dei paesi membri, le disuguaglianze sanitarie rimangono significative e le barriere all'accesso persistono significative. Le malattie croniche colpiscono in modo sproporzionato le popolazioni a basso reddito (OCSE, 2023). Se oltre un terzo delle persone di età pari o superiore a 16 anni riporta di soffrire di una malattia cronica, tra il quintile di reddito più basso, questa percentuale sale al 43%, rispetto al 27% nel quintile più ricco. Queste disparità sono determinate da differenze nell'accesso alla prevenzione, nella sostenibilità economica delle cure e negli stili di vita (OCSE, 2023). Una delle principali preoccupazioni è il peso finanziario sulle famiglie, poiché in media i pagamenti diretti rappresentano quasi il 20% della spesa sanitaria totale (OCSE, 2023). Gli individui a basso reddito hanno tre volte più probabilità rispetto ai gruppi a reddito più alto di ritardare o rinunciare alle cure mediche a causa di vincoli finanziari. Il quarto capitolo, dal titolo *"L'evoluzione delle disuguaglianze di salute in Italia (1984-2023)"* (Atella, De Luca, d'Angela, Maresch, Polistena e Spandonaro), dedicato alle diseguaglianze sanitarie in Italia approfondisce, su base empirica e storica, l'evoluzione delle disparità nell'accesso, nella spesa e negli esiti di salute in Italia nel lungo periodo, con particolare riferimento alle disuguaglianze per condizione socioeconomica, livello di istruzione e area geografica. Utilizzando microdati armonizzati provenienti dalle indagini ISTAT su *Aspetti della vita quotidiana* e *Bilanci delle Famiglie*, il contributo documenta la tenuta complessiva del SSN ma, al contempo, la sua incapacità di ridurre strutturalmente le diseguaglianze. Tra i principali risultati, si evidenzia che i divari più ampi e persistenti si osservano per livello di istruzione, che agisce da principale discriminante nell'accesso e nella qualità percepita dei servizi sanitari. Le diseguaglianze di genere, spesso misurate nei dati aggregati, tendono a ridursi o annullarsi una volta che

si controlla per il titolo di studio. Parallelamente, i dati mostrano una crescente polarizzazione territoriale, con il Mezzogiorno colpito più duramente sia in termini di rinuncia alle cure che di insoddisfazione per l'offerta sanitaria. Infine, una sezione del capitolo è dedicata all'analisi delle spese sanitarie private out-of-pocket (OOP): qui le disuguaglianze risultano crescenti, con una quota sempre maggiore di famiglie a basso reddito che sostiene costi sanitari diretti. In molti casi, la riduzione della spesa OOP nei segmenti più vulnerabili riflette non un miglioramento dell'accesso, ma un fenomeno di rinuncia. Questa tendenza, aggravata dagli effetti della crisi economica e dalla pandemia, solleva interrogativi sulla capacità redistributiva effettiva del sistema. Infine, il capitolo sottolinea come le fonti utilizzate, pur garantendo ampia copertura temporale e rappresentatività nazionale, non sempre colgano le sfaccettature più sottili delle disuguaglianze (es. disabilità, status migratorio, determinanti ambientali), per cui si auspica l'integrazione con dati amministrativi e clinici. Nel complesso, il contributo offre una base empirica rigorosa per riconsiderare le politiche di equità del SSN e sollecita un ripensamento delle strategie di contrasto alle diseguaglianze sanitarie in chiave intersettoriale e preventiva.

L'utilizzo dei dati sanitari e le regole della privacy per migliorare i risultati di salute della popolazione. Nell'era digitale, i sistemi sanitari generano enormi quantità di dati ogni giorno—dalle cartelle cliniche elettroniche (EHR) alle informazioni genetiche, agli studi clinici e ai database di salute pubblica. Sfruttati in modo efficace, i dati sanitari rappresentano un'opportunità straordinaria per rivoluzionare l'erogazione dell'assistenza sanitaria e migliorare i risultati di salute della popolazione. Inoltre, l'ascesa dell'intelligenza artificiale (AI) e del machine learning nella ricerca sanitaria sta sbloccando ancora più possibilità per l'uso dei dati sanitari. Il lavoro, dal titolo *"Optimizing Population Health Through Strategic Use of Health Data"* (Atella,

Ganna, Lombardi), fornisce un contributo in questa direzione esplorando il ruolo strategico dei dati sanitari nella promozione della salute pubblica, sottolineandone il potenziale trasformativo in ambiti come prevenzione, medicina personalizzata, gestione delle crisi sanitarie e riduzione delle disuguaglianze. Gli autori evidenziano come la digitalizzazione e l'analisi dei dati possano migliorare la qualità delle cure e l'efficienza del sistema sanitario, a patto di superare le barriere normative che oggi limitano l'uso secondario dei dati, specialmente in Italia. Il contributo si articola in più sezioni: dopo aver illustrato le potenzialità dei dati sanitari per la diagnosi precoce, la medicina di precisione, l'equità nella salute e la governance delle crisi (es. COVID-19), il testo si sofferma sulle sfide etiche e regolatorie. In particolare, viene discusso l'impatto del GDPR e delle normative italiane sulla difficoltà di riutilizzo dei dati per scopi di ricerca, in un contesto dove il principio di tutela della privacy finisce spesso per ostacolare la produzione di conoscenza. Le normative sulla privacy svolgono un ruolo cruciale nella protezione dei diritti individuali e nel mantenimento della fiducia pubblica nel sistema sanitario. Tuttavia, queste normative possono anche limitare la capacità dei ricercatori di accedere ai dati sanitari e utilizzarli, ritardando potenzialmente scoperte importanti che potrebbero migliorare i risultati di salute della popolazione. La sfida principale per il futuro sarà trovare modi per bilanciare la protezione della privacy con la promozione della ricerca basata sui dati, che può migliorare la salute pubblica. Gli autori propongono una serie di soluzioni pragmatiche per superare il "data gap" che ostacola la valutazione delle politiche sanitarie: ambienti sicuri per l'elaborazione dei dati, dati sintetici, semplificazione normativa e maggiore coordinamento tra enti. I modelli di governance di paesi come Finlandia e Danimarca vengono presentati come esempi virtuosi, capaci di bilanciare accesso ai dati e protezione della privacy.

Rafforzare la resilienza del sistema sanitario – Approccio One Health. La pandemia di COVID-19 ha dimostrato la vulnerabilità dei sistemi sanitari globali di fronte a crisi sanitarie inaspettate e su larga scala. Ha evidenziato l'importanza di costruire sistemi resilienti in grado di resistere agli shock continuando a fornire servizi essenziali. La prevenzione gioca un ruolo chiave in questa resilienza riducendo il carico complessivo delle malattie, consentendo ai sistemi sanitari di allocare le risorse in modo più efficace in tempi di crisi. Investendo nella prevenzione, i sistemi sanitari possono gestire meglio le risorse durante le emergenze. Ad esempio, durante una pandemia, se un numero minore di persone soffre di condizioni croniche, i fornitori di assistenza sanitaria possono concentrarsi maggiormente sulla gestione della crisi immediata. Inoltre, l'assistenza sanitaria preventiva, come le vaccinazioni di massa e le iniziative di salute pubblica, può aiutare a contenere le epidemie e a ridurre la gravità delle future pandemie, rafforzando così la resilienza complessiva dei sistemi sanitari. Il capitolo, dal titolo "*The One Health (OH) Approach and the Sustainability of Healthcare Systems" (*Atella e Scandizzo), introduce e approfondisce l'approccio One Health (OH), proponendolo come una nuova epistemologia della salute capace di affrontare in modo integrato le sfide contemporanee alla sostenibilità economica e operativa dei sistemi sanitari. L'OH interpreta la salute come una proprietà emergente dalle interdipendenze tra esseri umani, animali e ambiente, superando visioni settoriali e riduzioniste. Gli autori ricostruiscono le radici teoriche dell'approccio (da Virchow alla nozione di "exposome") e mostrano come esso rappresenti non solo una strategia politica, ma anche una cornice concettuale capace di ridefinire il significato stesso di benessere. La salute viene così riletta come bene pubblico non-rivale e sistemico, i cui benefici aumentano con la partecipazione collettiva. L'analisi si estende poi alla dimensione economica e istituzionale, mettendo in

evidenza come le politiche basate su OH possano contribuire a ridurre i costi sanitari attraverso azioni preventive (es. sorveglianza zoonotica, contenimento dell'antimicrobico-resistenza), aumentare la resilienza dei sistemi e favorire un uso più efficiente delle risorse. Tuttavia, il capitolo sottolinea anche i limiti dell'attuale implementazione del paradigma OH: mancano ancora modelli economici robusti, strumenti decisionali integrati e indicatori condivisi per misurarne l'efficacia nel lungo termine. Attraverso l'analisi di casi europei (Svizzera, Inghilterra, Malta, Serbia), l'articolo propone raccomandazioni operative e di *policy* per integrare OH nelle strategie sanitarie dell'Unione Europea, in sinergia con il Green Deal, la Farm to Fork Strategy e i piani di contrasto all'AMR. In sintesi, il contributo invita a riconoscere l'approccio One Health non solo come un'aggiunta utile alla sanità pubblica, ma come una visione trasformativa necessaria per garantire l'equità, la resilienza e la sostenibilità della salute nel XXI secolo.

In conclusione, la congiunzione di queste sfide - invecchiamento della popolazione, innovazione tecnologica, carenza di risorse, cambiamenti di paradigmi clinici ed organizzativi e disuguaglianze socioeconomiche - richiede una riforma radicale e completa del sistema sanitario italiano. Tale riforma dovrebbe mirare a potenziare la resilienza del sistema, promuovere la sostenibilità e l'efficienza, migliorare l'equità e l'accesso, e assicurare che il sistema sanitario possa adattarsi ai cambiamenti delle esigenze e delle aspettative della società. Solo attraverso cambiamenti audaci e visionari, il sistema sanitario italiano può continuare a fornire assistenza sanitaria di alta qualità ed equa a tutti i suoi cittadini negli anni a venire.

Riferimenti bibliografici

[1] OCSE. (2023). *Health at a Glance 2023*. OCSE Publishing.

The Urgent Need for an NHS Reform: Adapting to Overlooked Years of Transformation in Healthcare

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Abstract

The Italian National Health Service (NHS) stands at a critical juncture, grappling with the pressing need to reform in response to years of overlooked transformation in the healthcare landscape. Despite significant medical advancements and shifting demographic and epidemiological trends, the NHS has struggled to adapt its institutional structures to meet contemporary demands. Decades of medical innovation have rapidly changed the landscape, yet the NHS's organizational framework has lagged, resulting in inefficiencies and disparities in care. To ensure high-quality, equitable, and sustainable healthcare for future generations, we argue that the NHS must undergo comprehensive reforms. These changes should align healthcare financing, service delivery, and workforce planning with modern medical capabilities and population health needs. A forward-thinking approach is essential, acknowledging the coevolution of healthcare policy and medical science and ensuring that institutional adaptation aligns with the realities of contemporary medicine. By addressing these challenges, the NHS can transform its service delivery

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mechanisms and maintain its commitment to providing equitable healthcare for all. Overall, to preserve its strengths the Italian healthcare system needs forward-looking reforms that align with the evolving needs of society and medicine.

Sintesi - L'urgente necessità di una riforma del SSN: adattarsi ad anni di trasformazioni trascurate nella sanità

Il Servizio Sanitario Nazionale (SSN) italiano si trova in una fase critica, alle prese con l'impellente necessità di riformarsi in risposta ad anni di trascurata trasformazione del panorama sanitario. Nonostante i significativi progressi della medicina e le mutate tendenze demografiche ed epidemiologiche, il SSN ha stentato ad adattare le proprie strutture istituzionali per rispondere alle esigenze contemporanee. Decenni di innovazione medica hanno cambiato rapidamente il panorama, ma il quadro organizzativo del SSN è rimasto indietro, con conseguenti inefficienze e disparità nell'assistenza. Per garantire un'assistenza sanitaria di alta qualità, equa e sostenibile per le generazioni future, sosteniamo che il SSN debba essere sottoposto a riforme complete. Questi cambiamenti dovrebbero allineare il finanziamento dell'assistenza sanitaria, l'erogazione dei servizi e la pianificazione del personale alle moderne capacità mediche e alle esigenze di salute della popolazione. È essenziale un approccio lungimirante, che riconosca l'evoluzione congiunta della politica sanitaria e della scienza medica e garantisca che l'adattamento istituzionale sia in linea con le realtà della medicina contemporanea. Affrontando queste sfide, il Servizio sanitario nazionale può trasformare i suoi meccanismi di erogazione dei servizi e mantenere il suo impegno a fornire un'assistenza sanitaria equa per tutti. Nel complesso, per preservare i suoi punti di forza il sistema sanitario italiano ha bisogno di riforme lungimiranti che si allineino alle esigenze in evoluzione della società e della medicina.

JEL Classification: I1.

Parole chiave: *Riforma del sistema sanitario; Sostenibilità del sistema sanitario; Governance strategica in sanità; Complessità del sistema sanitario; Italia,.*

Keywords: Healthcare system reform; Health system sustainability; Strategic governance in healthcare; Health System Complexity; Italy; NHS.

1. Introduction [1]

National healthcare systems' ability to deliver services and improve health outcomes relies on the interplay of two main forces. First, policy frameworks set by governments and regulatory bodies shape how these systems are financed, organized, and managed. Second, scientific and technological advances in medicine bring new treatment protocols, pharmaceuticals, medical technologies, and care processes. This interaction creates complex and dynamic balances, which often follows an asymmetric pattern, where medicine advances rapidly, while healthcare institutions and policies change more slowly (Weisbrod, 1991). This disparity creates vulnerabilities, as healthcare systems risk becoming obsolete when they fail to align with modern medical advancements. Several key challenges emerge from this mismatch. For example, new medical technologies require updated reimbursement models, regulatory frameworks, and infrastructure investments. When bureaucratic and political barriers slow these adaptations, we may have delays in policy and infrastructure adaptation and healthcare systems may become inefficient. Furthermore, many cutting-edge treatments are highly effective but come at a premium price. Without cost-containment measures and value-based care models, we can incur in unsustainable escalating healthcare costs (Cutler & McClellan, 2001). Finally, if insurance systems, hospital networks, and physician training programs do not keep pace with medical progress, access to innovative treatments remains unequal (Marmot & Wilkinson, 2006).

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While policymakers strive to create stable, efficient, and equitable systems, often the medical field continues to evolve with new discoveries and technological advancements. Historically, medical advancements have outpaced healthcare systems' ability to adapt. This gap creates a divide between scientific possibilities and institutional capabilities, leading to inefficiencies, escalating costs, and disparities in access to care. Adding to the complexity are external factors like demographic, epidemiological, and economic changes have evolved so significantly that existing structures are now outdated.

Many healthcare systems, built in a different era, are now struggling to keep pace with the modern realities of medical science and population health needs. Without substantial reform efforts, these systems risk becoming increasingly inefficient, costly, and inequitable. The future of healthcare depends on bridging the gap between scientific progress and institutional adaptation, ensuring that every individual has access to the most advanced, efficient, and equitable care possible. The need for a comprehensive reform of the healthcare systems is now widely recognized. However, any reform effort must be preceded by a clear understanding of what needs to be reformed and why.

In this article, we will focus on the current Italian National Health Service (NHS), which is significantly more complex than the one addressed by the foundational reform of 1978 and even than that considered during the major revision of Title V of the Constitution in 2001. Over recent decades, substantial innovations have transformed the ways in which patients are managed, leading to an intricate interconnection between healthcare and broader social systems.

Since the 1990s, at least three major paradigm shifts have profoundly altered the healthcare landscape. First, the adoption of the life-cycle approach to health by the World Health Organization introduced a holistic perspective

that considers health outcomes across an individual's entire lifespan. Second, increasing evidence has highlighted the decisive role of lifestyle factors in the onset of chronic diseases, thus elevating the importance of preventive medicine within healthcare strategies. Third, the genomic and exposomic revolutions have driven the emergence of personalized medicine, making it possible to tailor therapies based on individual biological profiles.

These innovations have significantly expanded the boundaries of the healthcare system, making it increasingly dependent on actions and interventions originating from other sectors. As a result, the SSN cannot be considered a closed system; rather, it must interact dynamically with broader societal, environmental, and technological contexts. Consequently, any future reform must incorporate mechanisms of "self-correction"—adaptive features capable of responding to internal and external pressures more dynamically than traditional policymaking cycles allow.

Furthermore, emerging evidence highlights how healthcare needs have evolved significantly over recent decades. The demographic profile of the population has shifted, leading to a growing prevalence of multimorbidity and chronic conditions. Data from official statistics show increasing healthcare utilization patterns: higher numbers of medical visits, diagnostic procedures, prescriptions, and overall healthcare expenditures. Furthermore, the range of therapeutic and diagnostic options available today for managing major chronic diseases—including diabetes, hypertension, neurodegenerative disorders, and cancer—has expanded dramatically compared to the early 1980s.

Despite the many challenges it faces, the SSN continues to perform relatively well when compared to healthcare systems in other advanced economies, particularly those within the OECD. Indicators such as life expectancy and access to essential healthcare services remain strong, underscoring the

system's resilience. Nevertheless, critical warning signs are evident. Socioeconomic inequalities in healthcare access and outcomes are widening, financial and human resource sustainability is under increasing strain, and the changing patterns of healthcare demand and supply—fueled by demographic shifts and technological advancements—risk overwhelming existing structures.

These trends, if not adequately addressed through a systemic and forward-looking reform, risk undermining the SSN's founding principles of universality, equity, and solidarity. Thus, the current juncture demands not merely incremental adjustments but a fundamental rethinking of the Italian healthcare model to ensure its sustainability and responsiveness to contemporary and future health challenges.

We will discuss how reforms implemented since the NHS's inception in 1978 have either overlooked medical progress or been introduced too late, hindering their effectiveness in delivering high-quality, efficient services. These persistent disparities have created significant challenges for Italy's healthcare system, including financial sustainability issues, regional disparities in care quality, inefficiencies in service organization, and difficulties in integrating new medical technologies into daily practice. The misalignment between policy reforms and medical advancements has resulted in critical gaps in healthcare accessibility and efficiency, exacerbating existing structural weaknesses.

Given these challenges, the Italian NHS stands at a critical juncture, facing the urgent necessity of reform in response to years of neglected transformation in the healthcare environment. It's increasingly clear that comprehensive reform is essential to ensure its long-term viability. Without structural changes that align healthcare financing, service delivery, and workforce planning with modern medical capabilities and population health needs, the NHS risks becoming inefficient, financially unsustainable, and unable to provide equi-

table healthcare for future generations. Addressing this challenge requires a forward-thinking approach that acknowledges the coevolution of healthcare policy and medical science. It is crucial to ensure that institutional adaptation keeps pace with the realities of contemporary medicine and healthcare demands. By implementing these reforms, the NHS can enhance its service delivery mechanisms and maintain its commitment to providing equitable healthcare for all.

In what follows, Section 2 describes the major legislative and structural changes in the Italian NHS since its inception through the key phases based on the centralized model (1978–1992), decentralization and market-oriented reforms (1992–2001),cost-containment efforts (2001–2010), austerity measures following the 2008 financial crisis, and the impact of COVID-19 on healthcare resilience. It also assesses Italy's current healthcare performance by comparing key indicators with those of other OECD countries. Section 3 discusses the major shifts in medical paradigm occurred over the years, introducing the life-cycle perspective in healthcare, that emphasize the role of early-life conditions and lifestyle factors in shaping long-term health outcomes. It also discusses how preventive and patient-centered care models have emerged as critical components of modern healthcare. In Section 4 focuses on the Italian context, describing how healthcare needs have dramatically changed due to population aging and the rising prevalence of chronic diseases, and how these trends are expected to create increasing pressure on the SSN. Section 5 introduces the conceptualization of the healthcare system as a complex adaptive system, discussing the implications of this paradigm shift for governance, coordination among stakeholders, and policy design. Finally, Section 6 argues for the necessity of structural reform, outlining five strategic priorities: workforce strengthening, expansion of preventive services, acceleration of digital

health transformation, enhancement of transparency and citizen engagement, and revision of financing models to promote sustainability. It then proposes a phased set of policy recommendations organized into short-, medium-, and long-term actions, with the goal of modernizing the SSN and ensuring its resilience and equity for future generations. Section 7 concludes.

2. The Historical Evolution of the Italian National Health System

Since the 1950s, the modern European welfare state has evolved around the concept of solidarity, although declined differently across the countries. This means individuals contribute based on their ability and receive benefits based on need, with a system designed to protect them "from cradle to grave." It involves wealth transfers from rich to poor, from working-age individuals to children and seniors, and from the healthy to the ill.

The design and structure of a healthcare system play a critical role in determining how medical services are delivered and how effectively health outcomes are achieved. Healthcare systems around the world vary widely in their financing models, organizational frameworks, and delivery mechanisms. In some countries, such as the United Kingdom, publicly funded National Health Service (NHS) models dominate, while in others, such as Germany and France, social health insurance-based models are prevalent (Reinhardt, 2006). The United States follows a predominantly private insurance model, supplemented by large public programs like Medicare and Medicaid. Despite these structural differences, all healthcare systems share three fundamental components that define their functionality:

1. Financing Mechanisms – Healthcare services require funding, which may come from tax revenues, insurance premiums, or out-of-pocket payments by patients.
2. Service Organization and Management – The efficiency of a healthcare system depends on how primary care networks, hospital services, and specialist care are structured.
3. Delivery Efficiency – The ability to mobilize healthcare professionals, infrastructure, and technology to meet population health needs determines how well a system functions (Cutler, 2004).

Concerning Italy, the Italian National Health Service (SSN) was established in 1978, inspired by the principles of universality, equity, and solidarity (France et Al., 2005; Ferré et Al., 2014). Designed to provide comprehensive and accessible healthcare to all citizens, the SSN replaced a fragmented system that had left large portions of the population without adequate coverage (Donatini et Al., 2001). However, when national healthcare systems like the SSN were initially designed, they were structured as simpler models with clear cause-and-effect relationships, reflecting the medical knowledge, demographic structure, and economic conditions of their time (Saltman et Al., 2004). For years, many of these systems followed models conceived before the 1970s, when acute infections and communicable diseases were the primary health threats, life expectancy was lower, populations were younger, and chronic diseases were less prevalent (OECD, 2019). Since then, the world has changed significantly. Populations are aging, chronic diseases have become the leading causes of morbidity and mortality, healthcare costs have risen dramatically, and medical technology has advanced at an unprecedented pace (Weisbrod, 1991; World Health Organization, 2020).

To tackle these challenges, the SSN has undergone several structural trans-

formations, spurred by economic pressures, regional disparities, and the quest for greater efficiency (Mapelli, 2020). In this section, we explore the historical evolution of SSN reforms, from its inception to the present day. Despite major legislative changes with significant economic implications for healthcare delivery and population health (Tediosi et Al., 2009), the SSN still struggles to evolve at the same pace, leaving gaps in efficiency, sustainability, and alignment with modern healthcare challenges (Cylus et Al., 2015).

2.1. The evolution of the SSN from 1978 to 2025: a brief overview

The Law No. 833 of December 23, 1978, marked a pivotal moment in Italy's healthcare history. It abolished the previous social security-based system, which had provided coverage primarily through occupation-linked funds, and replaced it with a nationalized public health service. The SSN was designed to ensure that all residents had access to essential healthcare services, funded through general taxation and contributions from both employers and employees (Guzzanti, 1981).

Initially, the system was highly centralized, with the Ministry of Health overseeing national health planning, while Local Health Units (Unità Sanitarie Locali, USLs) were responsible for service delivery at the municipal level. The objective was to eliminate disparities in healthcare access, particularly between the affluent northern regions and the economically weaker southern regions. Despite its ambitious goals, the centralized model soon faced operational inefficiencies, excessive bureaucracy, and growing financial constraints. Rising healthcare expenditures led to concerns about the system's long-term sustainability, prompting policymakers to consider reforms aimed at improv-

ing financial efficiency while maintaining universal coverage (Donatini et Al., 2001).

A major shift occurred with Legislative Decree No. 502 of December 30, 1992, later amended by Legislative Decree No. 517 of 1993, which decentralized healthcare governance by transferring greater authority to regional governments. This reform transformed the USLs into Local Health Authorities (Aziende Sanitarie Locali, ASLs), granting them greater financial and managerial autonomy. The rationale behind this move was to increase efficiency, foster competition among providers, and reduce the bureaucratic rigidity that had characterized the earlier model (Fattore, 1999).

The decentralization reforms also introduced quasi-market mechanisms by encouraging greater private sector participation in service provision. Regions were given the flexibility to contract out services to private healthcare providers, provided that these services remained within the publicly funded system. This shift marked a departure from the purely state-run model and laid the foundation for a mixed public-private healthcare landscape.

Despite the intended benefits, decentralization exacerbated regional disparities, as wealthier regions in the north were better equipped to manage healthcare resources efficiently, while the south struggled with underfunding, mismanagement, and higher patient migration to northern hospitals. Moreover, fiscal constraints led to growing reliance on co-payments (ticket sanitari) for certain services, introducing new financial barriers for lower-income populations (France et Al., 2005).

By the early 2000s, rising healthcare expenditures prompted fiscal consolidation measures to curb budget deficits while preserving universal coverage. The 2001 Constitutional Reform (Legge Costituzionale No. 3/2001) further strengthened regional autonomy by granting regions full responsibility for

healthcare planning and service delivery. However, this reform also created tensions between national budgetary constraints and regional healthcare spending autonomy, leading to financial imbalances and the emergence of bailout mechanisms for financially distressed regions (Ferré et Al., 2014).

In response to these challenges, the Pact for Health Agreements (Patto per la Salute) between the central government and regional authorities were introduced to improve financial accountability and set spending caps. Additionally, the widespread introduction of Diagnosis-Related Groups (DRGs) in hospital reimbursement mechanisms sought to enhance cost-effectiveness by linking hospital funding to the complexity of cases treated rather than lump-sum allocations (Cappellaro et Al., 2009).

During this period, the expansion of private healthcare providers continued, particularly in specialized care services such as diagnostics, rehabilitation, and elective surgeries. Although this trend improved service availability and reduced waiting times, it also raised concerns about inequalities in healthcare access, as wealthier individuals were increasingly able to bypass long waitlists by paying out-of-pocket for private care (Mapelli, 2012).

The 2008 global financial crisis had profound effects on the SSN, prompting severe austerity measures aimed at reducing public spending. Budget cuts led to hospital closures, staff reductions, and stricter spending limits, particularly in regions already struggling with financial deficits. The Health Stability Pacts (Patti di Stabilità in Sanità) imposed stringent expenditure ceilings, forcing regions to adopt cost-cutting measures that often resulted in reduced service availability and longer waiting times (De Belvis et Al., 2012).

Despite financial constraints, this period also saw advancements in healthcare digitization, with the introduction of electronic health records (EHRs) and some telemedicine initiatives aimed at improving efficiency. However,

concerns about healthcare workforce shortages grew, as budgetary constraints led to frozen hiring policies, particularly affecting hospitals in southern regions (Agenas, 2023).

Finally, the COVID-19 pandemic in 2020 exposed longstanding weaknesses in Italy's healthcare system, particularly in terms of hospital capacity, regional disparities, and workforce shortages. The crisis underscored the need for stronger public health infrastructure, greater investment in preventive care, and improved emergency preparedness. In response, the government allocated €20 billion in additional healthcare funding as part of the National Recovery and Resilience Plan (PNRR), with a focus on expanding primary care networks, digital health initiatives, and hospital infrastructure (Ministero della Salute, 2021a,b). Reforms also aimed to strengthen community-based healthcare, reducing dependence on hospitals and improving access to outpatient and home-care services.

The evolution of the SSN from its centralized inception in 1978 to its current regionally managed, mixed public-private system reflects a continuous balancing act between equity, efficiency, and fiscal sustainability. While decentralization has improved regional autonomy, it has also exacerbated healthcare inequalities, with southern regions facing greater financial and service delivery challenges.

The COVID-19 pandemic has highlighted both strengths and weaknesses of the system, reinforcing the need for increased investment in public health infrastructure and workforce expansion. As Italy navigates post-pandemic recovery, maintaining universal coverage while ensuring economic sustainability remains a key challenge for policymakers.

2.2. Did the reforming process help improving the Italian SSN?

Based on this evidence it is easy to conclude that the reforms implemented in the Italian National Health Service (SSN) over the past decades have predominantly focused on organizational restructuring and financial sustainability, often overlooking the transformative forces reshaping global healthcare. While efforts have been made to decentralize healthcare governance, introduce market-oriented mechanisms, and enhance cost-effectiveness, these measures have not sufficiently addressed the rapid advancements in medical science, evolving healthcare paradigms, and shifting disease burdens. This issue is not unique to Italy. Many European health systems, including those in Spain, France, and Germany, have implemented cost-containment policies and administrative reorganizations but have struggled to adapt quickly to new medical technologies, the growing role of digital health, and the increasing burden of chronic diseases (OECD, 2021). In Spain, for example, regionalized healthcare management has led to disparities in the adoption of telemedicine and personalized medicine, limiting the potential benefits of innovation (García-Armesto et Al., 2010). Similarly, France's historically hospital-centric model has delayed the shift toward integrated primary care and community-based health services, leading to inefficiencies in managing aging populations and multimorbidity (Chevreul et Al., 2015).

One of the most significant global changes has been the acceleration of medical innovation, including breakthroughs in precision medicine, biotechnology, and digital health (Topol, 2019). However, Italy's healthcare reforms have largely concentrated on administrative decentralization and cost containment, rather than on effectively integrating these advancements into the healthcare system. Similar trends are visible in Germany, where the focus on

maintaining a multi-payer insurance-based system has created barriers to the widespread adoption of value-based healthcare models (Busse et Al., 2010). In contrast, Nordic countries have proactively adapted to medical advancements by investing heavily in digital health infrastructure, making Denmark and Sweden leaders in electronic health records (EHRs) and telemedicine adoption. The United Kingdom's NHS, despite facing budget constraints, has made efforts to integrate artificial intelligence (AI) and genomics into care pathways, though financial and political instability have slowed full implementation. Similarly, Finland's "Kanta" digital health system has significantly improved access to patient data and personalized care, highlighting the importance of long-term digital health investment (Vuorenkoski, 2008).[2]

2 See Atella et Al. (2025) and Atella and Chiari (2025) in this special issue.

Table 1 **Population health and health system performance - OECD 2021 Core indicators**

Dimensions	Indicators	Italy		OECD	Worst country	Best country
		Level	Change over time			
Health Status	Life expectancy - Years of life at birth	82,7	+	80,3	73,1	84,5
	Avoidable mortality - Preventable and treatable deaths (per 100 000 people age-standardized)	146,0	+	237,0	665,0	133,0
	Chronic conditions - Diabetes prevalence (o/o adults age-standardized)	6,4	-	7,0	16,9	3,0
	Self-rated health - Population in poor health (% population aged 15+)	8,1	+	8,0	14,0	1,0
Risk factor for health	Smoking — Daily smokers (% population aged 15+)	19,1	+	16,0	28,0	7,2
	Alcohol - Liters consumed per capita (population aged 15+) based on sales data	7,7	-	8,6	12,2	1,4
	Obesity - Population with body mass index (BMI) 230 (% population aged 15+)	12,0	-	19,5	33,5	4,3
	Ambient air pollution - Deaths due to ambient particulate matter especially PM2.5 (per 100 000 people)	40,8	+	29,0	73,0	5,0
Access to care	Population coverage eligibility - Population covered for core set of services (% population)	100,0	=	97,9	72,7	100,0
	Population coverage satisfaction - Population satisfied with availability of quality healthcare (% population)	55,0	=	67,0	39,0	94,0
	Financial protection - Expenditure covered by compulsory prepayment schemes (% total expenditure)	75,5	-	76,0	50,0	86,0
	Service coverage - Population reporting unmet needs for medical care (% population)	1,8	+	2,3	8,1	0,1
Quality of care	Safe primary care - Antibiotics prescribed (defined daily dose per 1.000 people)	15,9	+	13,1	21,7	7,2
	Effective primary care - Avoidable hospital admissions (per 100.000 people age- and sex-standardized)	214,0	+	463,0	827,0	195,0
	Effective preventive care - Mammography screening within the past two years (% of women aged 50-69)	55,9	-	55,1	20,2	83,0
	Effective secondary care - 30-day modality following acute myocardial infarction and ischemic stroke (per 100 admissions for people aged 45 and over age- and sex-standardized)	5,3	+	6,8	23,7	1,7
Health system capacity and resources	Health spending - Total health spending (per capita USD using purchasing power parities)	4291,0		5000,0	1200,0	12500,0
	Health spending - Total health spending (% GDP)	9,0	+	9,2	4,3	16,6
	Doctors - Number of practicing physicians (per 1.000 people)	4,1	+	3,7	2,2	6,3
	Nurses - Number of practicing nurses (per 1.000 people)	6,2	+	9,2	1,6	18,9
	Hospital beds - Number of hospital beds (per 1.000 people)	3,1	+	4,3	1	12,8

Note: The symbol "+" indicates an improvement over time, "–" a deterioration over time, "=" no change.
Source: HEALTH AT A GLANCE 2023 © OECD 2023

Better than the OECD average. Close to the OECD average. Worse than the OECD average.

Simultaneously, the life-cycle approach and the increasing acknowledgment of lifestyle factors as key health determinants (Marmot, 2005) have transformed modern medicine, highlighting the importance of preventive and patient-centered care. Despite this, many European health systems, including the SSN, have remained predominantly reactive, focusing on acute and hospital-based care rather than prioritizing prevention, early intervention, and comprehensive health promotion (Kickbusch & Payne, 2003). Countries such as the Netherlands and Sweden have made significant strides by embedding preventive measures into primary care and linking health policies to broader social determinants of health. Conversely, countries like Italy and Greece have been slower to adopt this shift, constrained by rigid institutional structures and budgetary limitations (Saltman et Al., 2007).

As already mentioned in the introduction, even with these challenges, the SSN holds its own compared to healthcare systems in other advanced economies, especially those within the OECD. The OECD 2021 Core Indicators reported in Table 1 provides a comprehensive overview of Italy's population health and health system performance in comparison to the OECD average, highlighting key strengths and critical areas for improvement.

In terms of health status indicators Italy performs favorably in several key areas. Life expectancy at birth stands at 82.7 years, above the OECD average of 80.3 years and closer to the best-performing countries. Avoidable mortality is also notably low at 146 preventable and treatable deaths per 100,000 people, significantly better than the OECD average of 237. However, Italy shows poorer performance in diabetes prevalence (6.4%) compared to the best-performing countries, though still close to the OECD average (7.0%). Self-rated poor health is relatively low at 8.1%, comparable to the OECD mean (8.0%).

In terms of risk factors for health, Italy's performance is more mixed. While

alcohol consumption is below the OECD average (7.7 vs. 8.6 liters per capita), smoking prevalence (19.1%) and obesity (12%) are slightly worse than the OECD average, indicating persisting behavioral risk factors. The most concerning metric in this category is deaths due to ambient particulate matter (PM2.5), with Italy reporting a rate of 40.8 deaths per 100,000—significantly above the OECD average of 29.0, highlighting ongoing environmental health risks.

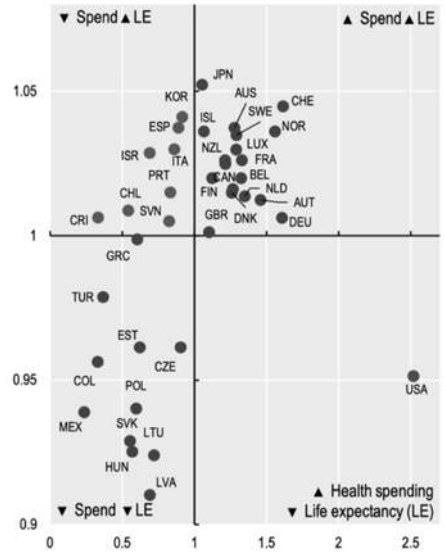
In terms of access to care, Italy demonstrates near-universal population coverage for essential services (100%) and a relatively low rate of unmet medical needs (1.8%), both indicators performing better than OECD averages. However, only 55% of the population reports being satisfied with the availability of quality healthcare—considerably below the OECD average (67%), suggesting possible gaps in perceived service quality.

Quality of care indicators present a nuanced picture. Italy shows strong performance in reducing avoidable hospital admissions (214 per 100,000 people), far below the OECD average of 463, indicating effective primary care. However, mammography screening coverage is just 55.9%, only marginally above the OECD average, and lower than best-performing countries. Antibiotic prescription rates remain higher than the OECD average (15.9 vs. 13.1 defined daily doses per 1,000 people), indicating potential overuse and a target for antimicrobial stewardship policies.

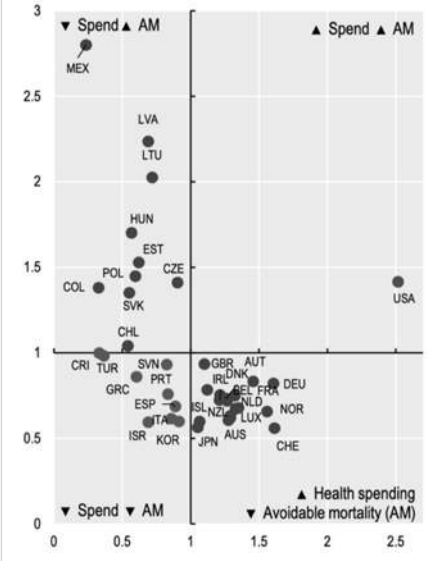
Finally, regarding healthcare system capacity and resources, Italy spends slightly below the OECD average on health in per capita terms ($4,291 vs. $5,000) but maintains a higher-than-average percentage of GDP allocated to health (9.0%). While the number of practicing physicians is above average (4.1 per 1,000), the nurse-to-population ratio is substantially below the OECD average (6.2 vs. 9.2), which may strain care delivery. Hospital bed availability is moderate (3.1 per 1,000), close to the OECD average.

Figure 1 **Health care efficacy comparison: where do we stand now**

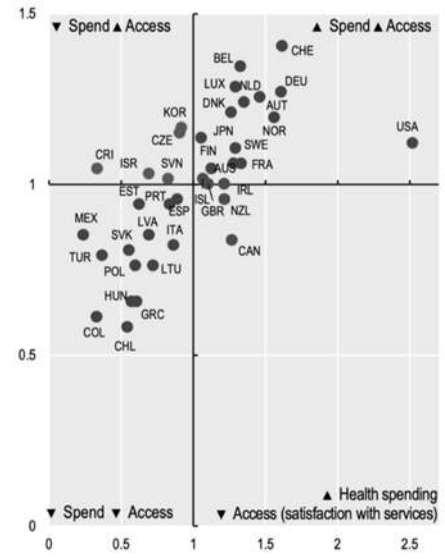
A - Life expectancy and health expenditure



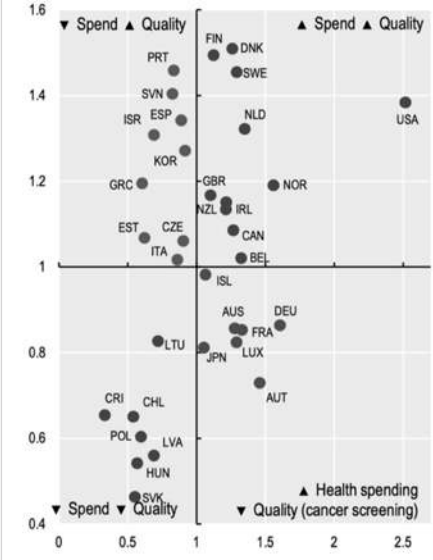
B - Avoidable mortality (preventable and treatable) and health expenditure



C – Satisfaction with availability of quality services and health expenditure



D - Breast cancer screening and health expenditure



Source: Health at a glance 2023 © OECD 2023

Rather than simply presenting raw data as in Table 1, Figure 1 offers a visual comparative analysis of healthcare system performance across OECD countries in relation to their health expenditure levels.[3] The quadrant diagrams compare key indicators—including life expectancy, avoidable mortality, satisfaction with care quality, and breast cancer screening rates—against per capita health spending. By plotting countries based on their deviation from the OECD average, each graph provides an immediate understanding of the relative efficiency and effectiveness of various healthcare systems.

Italy occupies a particularly interesting position in these graphs. In panel A (life expectancy vs. health expenditure), Italy demonstrates a higher life expectancy than would be expected given its relatively moderate health spending. This placement suggests that Italy's healthcare system achieves commendable outcomes in terms of longevity despite spending less than many OECD peers, highlighting a degree of system efficiency.

In panel B (avoidable mortality vs. health expenditure), Italy again outperforms expectations, recording lower preventable and treatable mortality rates compared to other countries with similar or even higher expenditures. This underlines the strength of Italy's primary and acute care sectors, although it must be noted that regional disparities within the country could partially mask underlying inequalities.

Panel C (satisfaction with healthcare services vs. health expenditure) paints a less favorable picture. Here, Italy falls below the OECD average in terms of population satisfaction with the availability of quality services, despite maintaining reasonable expenditure levels. This dissatisfaction may reflect systemic

3 It is important to emphasize that these charts do not imply causal relationships but rather depict simple associations between the level of investment in healthcare and the outcomes achieved in terms of public health. Their primary function is to provide an immediate comparison among OECD member countries, highlighting discrepancies and general trends.

issues related to waiting times, regional access inequities, and perceived gaps in service quality rather than deficiencies in health outcomes themselves.

Finally, panel D (breast cancer screening vs. health expenditure) shows that Italy's performance is slightly above the OECD average, but not among the top performers. This result suggests that while preventive care measures like screening programs are in place, they have room for improvement in terms of coverage and effectiveness.

Overall, Figure 1 confirms that Italy's SSN achieves solid health outcomes at comparatively moderate costs but reveals structural weaknesses in patient satisfaction and preventive care uptake. These findings reinforce the argument that although the SSN remains fundamentally strong, targeted reforms focusing on quality improvement, preventive services expansion, and equity are urgently needed to sustain and enhance Italy's position among advanced healthcare systems.

3. The Role of Medicine Paradigm Shifts in Shaping Healthcare Systems.

Over the past several decades, the field of medicine has undergone substantial paradigm shifts that have fundamentally redefined the objectives, methods, and structures of healthcare systems. While earlier models of care were primarily reactive—focused on the diagnosis and treatment of acute illnesses—the current paradigm increasingly emphasizes prevention, patient engagement, and a holistic understanding of health. Precision medicine is one of the most emblematic developments of this transition, offering treatment

strategies tailored to individual genetic, environmental, and lifestyle factors. This model has contributed to a deeper understanding of disease pathways, more targeted therapies, and the potential to predict disease onset before symptoms manifest. Such advancements signal a departure from the traditional one-size-fits-all approach and demand new frameworks for organizing health services around prevention and individualized care.

This evolving paradigm highlights the necessity of integrating long-term management strategies into standard care, promoting early detection and behavioral health as central pillars of public health policy. Chronic diseases such as diabetes, cardiovascular conditions, and neurodegenerative disorders have complex etiologies and require sustained, multidimensional care strategies. Here, digital health technologies and artificial intelligence (AI) play an increasingly pivotal role. With capabilities ranging from continuous health monitoring to predictive diagnostics, these technologies enable healthcare providers to intervene proactively. Furthermore, the shift from inpatient to community and home-based care settings is facilitated by these innovations, allowing for improved access, reduced hospitalization rates, and a more sustainable distribution of healthcare resources. However, the adoption of these tools necessitates careful regulation, data governance, and integration into existing clinical workflows.

In response to these demands, value-based care has emerged as a compelling alternative to traditional volume-based healthcare models. This framework reorients systems by incentivizing improved patient outcomes and cost-efficiency rather than service volume alone. Central to this shift is the acknowledgement that medical interventions must be evaluated not only for their clinical efficacy but also for their capacity to improve quality of life over time. The life-course model offers a valuable lens for operationalizing these

changes, positioning health as a dynamic continuum influenced by cumulative exposures, behaviors, and socio-economic conditions across an individual's lifespan. As a result, healthcare systems are being urged to shift investment toward early interventions and to develop metrics that reflect long-term population health outcomes rather than immediate clinical events.

In parallel with internal shifts within healthcare, external systemic frameworks such as One Health (OH) and planetary health have gained prominence. These perspectives recognize that human health is deeply entwined with animal and environmental health, necessitating a transdisciplinary response to complex global challenges. Emerging zoonotic diseases, antimicrobial resistance, biodiversity loss, and climate change are all interconnected issues that underscore the limitations of sector-specific health responses. OH frameworks promote collaborative governance and resource allocation across public health, veterinary, agricultural, and environmental sectors. In doing so, they create opportunities for shared surveillance systems, joint interventions, and unified communication strategies, which are particularly critical in managing crises that span national and disciplinary boundaries.

These frameworks move beyond monocausal explanations and linear intervention models, instead proposing a systems-thinking approach that accommodates complexity and uncertainty. Health, from this perspective, is conceived as a dynamic state of equilibrium, sustained through continuous interaction with social, ecological, and biological systems. This paradigm is particularly relevant in a world where pandemics, food insecurity, and environmental degradation present multifactorial and interrelated threats. OH offers a conceptual and operational model for building resilience, understood not only as the capacity to recover from shocks, but also to adapt and transform in the face of ongoing stressors. However, despite their concep-

tual strength, OH and related approaches face significant implementation barriers, including fragmented governance, lack of standardized evaluation metrics, and insufficient integration with national healthcare policies and financing mechanisms.

In conclusion, the shifting paradigms in medicine reflect a broader epistemological and organizational transformation in healthcare. The increasing emphasis on personalized, preventive, and systemically integrated care represents a necessary adaptation to contemporary health challenges. However, this vision can only be realized through targeted structural reforms, including revised financing models, improved intersectoral governance, and the incorporation of emerging technologies. By embracing these paradigm shifts, healthcare systems can evolve toward models that are more resilient, equitable, and aligned with the health needs of 21st-century populations. This calls not only for new scientific and clinical tools but also for a transformation in the cultural and institutional logics that guide healthcare delivery.

4. The Evolution of Healthcare Needs in Italy

Since the origin of the SSN in 1978, healthcare needs in Italy have undergone a profound transformation, shaped by significant demographic, epidemiological, and technological shifts. One of the most salient changes has been the marked aging of the population and Italy now ranks among the countries with the highest proportion of elderly citizens worldwide, with over 23% of its population aged 65 and older, a figure projected to rise further in the coming decades (ISTAT, 2023). This transition has a long story. According to

the United Nations estimates, in 1950 children and adolescents aged 0 to 19 made up 35.4 percent of the Italian population, whereas today they account for only 17.5 percent. The sharpest decline occurred between 1980 and 1995, when the under-19 population fell from 30 to 21 percent. People aged 20 to 39 have also declined, from 35 percent of the population to 21 percent, with a marked drop beginning in 1995. The 40–59 age group represented 22 percent of the population in 1950 and now accounts for 31 percent, with a nearly constant increase over time. Turning to the older age groups, individuals aged 60 to 79 made up less than 23 percent in 1950 and now represent about 31 percent, showing a continuous rise. Similarly, those over 80, who were around 1 percent of the population seventy years ago, now constitute approximately 7.5 percent.

More interestingly, as highlighted by ISTAT (2024), demographic changes have accelerated markedly since 2000, driven by a complex mix of socio-economic, technological, and cultural factors. Previously stable trends like birth and death rates have experienced significant shifts. The decline in birth rates, partly due to fewer potential parents after decades of fertility decline, illustrates this. The COVID-19 pandemic's impact on mortality, particularly among the elderly, further emphasizes the rapid pace of demographic transformation. The effects of population aging are now unmistakable. Between January 1, 2004, and January 1, 2024, the average age in Italy increased from 42.3 to 46.6 years. The old-age index—defined as the ratio of the elderly (aged 65 and over) to the young (aged 0–14)—has reached 199.8%, an increase of more than 64 percentage points over the past two decades. Meanwhile, the adult and youth population (aged 16–64) has declined by nearly 2 million individuals: as of January 1, 2024, there were 36.87 million residents in this age group, representing 62.5% of the total population—a 2.5% de-

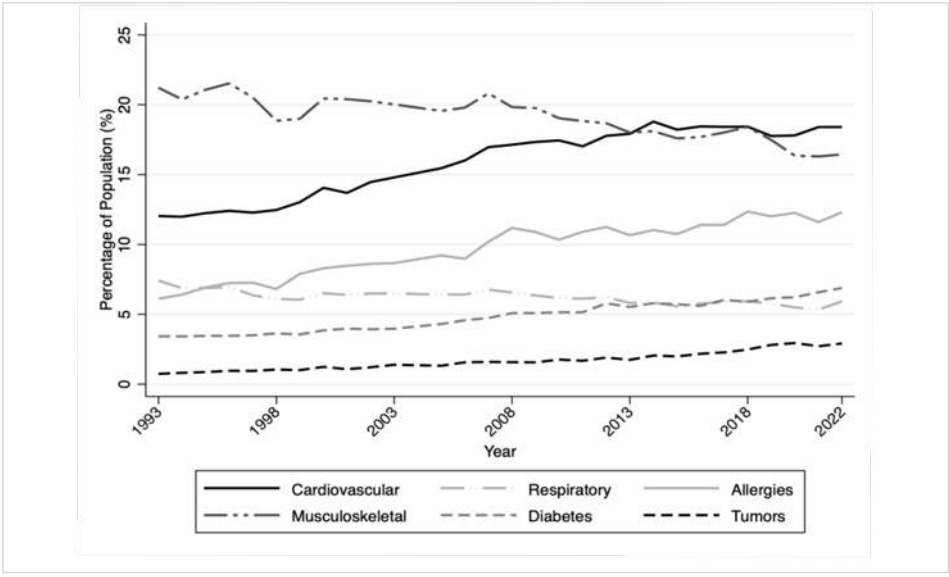
crease compared to 2004. Children and adolescents (0–15 years old) now number 7.77 million (13.2% of the population), nearly 1 million fewer than in 2004. Conversely, the population aged 65 and older has grown by more than 3 million people, reaching 14.36 million in 2024 (24.3% of the population), an increase of 5.1 percentage points over 20 years. More than half of this group is now aged 75 and over, accounting for 7.44 million individuals, or 12.6% of the total population—a 3.8 percentage point rise since 2004.

This demographic transition is accompanied by an epidemiological shift from acute infectious diseases to chronic, non-communicable diseases (NCDs) such as cardiovascular illnesses, diabetes, neurodegenerative disorders, and cancer, which now account for approximately 80% of total mortality (OECD, 2021). The burden of chronic diseases has intensified significantly. According to the *Health Search–CSD Foundation Report 2023*, approximately 40% of the adult Italian population is affected by at least one chronic condition, and nearly 20% suffer from multiple chronic diseases (multimorbidity). Hypertension, type 2 diabetes, chronic obstructive pulmonary disease (COPD), and ischemic heart disease represent the most prevalent conditions recorded in general practice databases (Health Search, 2023). Particularly concerning is the increasing trend in multimorbidity, especially among individuals aged 65 and older, but increasingly visible even in younger populations due to the rise of lifestyle-related risk factors such as obesity, sedentary behavior, and smoking. The report also highlights a persistent underdiagnosis of some chronic conditions, such as early-stage kidney disease and mild cognitive impairment, suggesting that the real burden might be even greater than currently estimated. These trends not only increase the complexity of clinical management but also escalate the demand for continuous care, integrated service delivery, and personalized interventions.

Another interesting set of evidence to understand the demographic and epidemiological evolution of the Italian population over a longer period (1993-2022) is the one provided by the ISTAT's Multiscopo surveys (see Figure 2).[4] The analysis of chronic disease prevalence reveals a general upward trend for several major conditions. Cardiovascular diseases, already a leading cause of death (Ojeda-Granados et Al., 2024), have shown a clear upward trend. Cardiovascular diseases increased steadily from the mid-1990s until around 2010, after which they stabilized at a higher prevalence level, indicating a long-term rise. Allergies show a particularly pronounced increase, nearly doubling from approximately 6% in the early 1990s to 12% by 2022, suggesting heightened incidence or improved recognition over time. This increase may be linked to environmental changes, lifestyle factors, and improved diagnostic practices (Nocerino et Al., 2024). Diabetes also displays a sustained upward trajectory, rising from around 2.5% to nearly 6% across the three decades. Tumors, while remaining the least prevalent condition among those examined, increased gradually from under 2% to around 3%, reflecting a slow but consistent growth. Overall, these diseases have exhibited persistent growth in prevalence, underscoring shifts in public health patterns and possibly changes in diagnostic practices, environmental exposures, or demographic dynamics. These patterns align well with the broader epidemiological transition toward chronic conditions.

4 The *Indagini Multiscopo dell'ISTAT* ("Multipurpose Surveys") are nationwide, cross-sectional household surveys first launched in 1993. Conducted every year on a sample of approximately 20,000 households, they combine a core set of questions with rotating modules on topics including health status, living conditions, employment, and social participation. Their broad scope and consistent methodology make them a cornerstone for monitoring long-term trends in demography, health, and socio-economic conditions across Italy's regions. Results from these surveys inform both national and regional policymaking, guiding interventions in public health, social services, and labor market programs. In 2004 the survey has not been conducted. However, it is worth mentioning that these prevalence estimates are based on self-reported data, which may be subject to reporting biases such as underreporting or misclassification. As a result, they may not align with patterns observed in clinically recorded datasets such as Health Search, which rely on general practitioners' diagnostic records and may capture different aspects of disease burden.

Figure 2 **Trends in Chronic Disease Prevalence in Italy (1993-2022)**

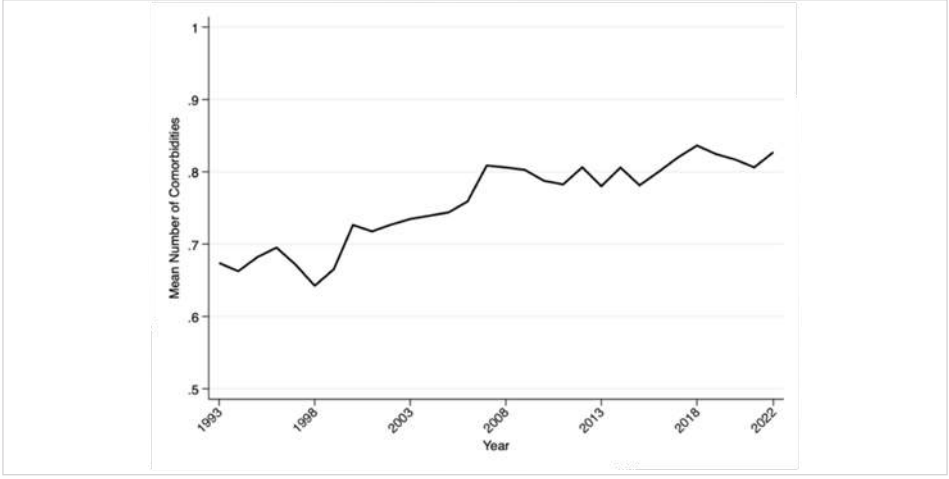


Source: Indagine multiscopo AVS, ISTAT, various years.

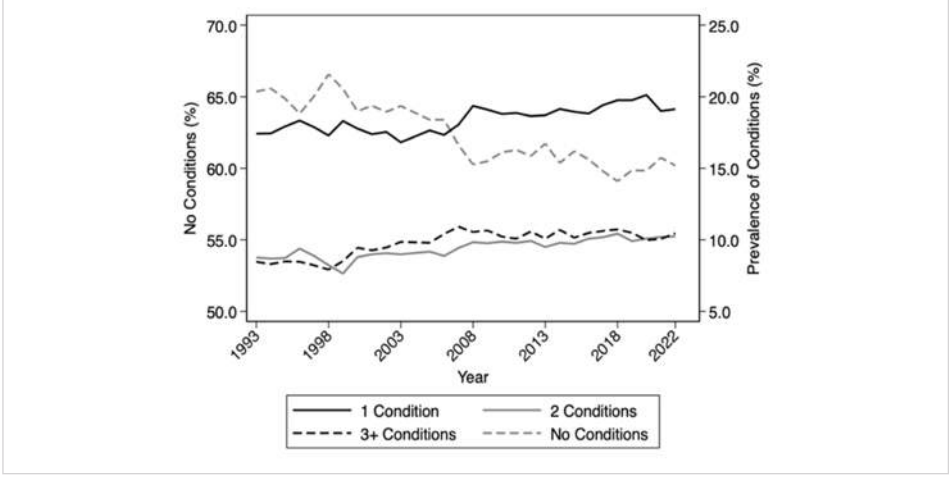
In contrast, respiratory diseases maintained a relatively stable prevalence throughout the period, fluctuating only slightly around 5–6%, suggesting a slight declined over time, possibly reflecting improvements in air quality and work safety measures such as the banning of asbestos in 1992 (Ferrante, 2024). Musculoskeletal disorders, despite being the most prevalent condition across the timeframe, show a decline beginning around 2010, following a period of relative stability. Since the survey only asks about "arthrosis/arthritis" and "osteoporosis", it may underestimate the full burden (e.g., back pain, tendinitis). The observed decline may reflect better prevention and management—expanded physical therapy, improved treatments, minimally invasive surgeries—and stricter ergonomic and workplace regulations.

Figure 3 **Average Number and prevalence of comorbidities in the adult population (≥18 years)**

Panel (a)



Panel (b)



Source: Indagine multiscopo AVS, ISTAT, various years.

The data collectively indicate a growing burden of chronic diseases within the population, characterized by an increasing number of individuals affected by multiple coexisting conditions, a phenomenon widely recognized as multimorbidity. This escalation is emblematic of deeper demographic and epidemiological shifts, notably population aging and increased life expectancy, compounded by the sustained prevalence of modifiable risk factors such as sedentary lifestyles, suboptimal nutrition, and environmental hazards. These factors jointly contribute to the complex health challenges confronting contemporary societies.

Empirically, this pattern can be seen using data derived from ISTAT's Multiscopo surveys. Figure 3 Panel (a) illustrates the trajectory of the average number of chronic diseases reported among the Italian population over the past three decades. Specifically, the mean number of chronic conditions per individual has risen from under 0.7 in 1993 to exceed 0.8 by 2023, signaling a measurable increase in disease burden at the population level. Furthermore, Panel (b) delineates the prevalence trends of individuals experiencing one, two, and three or more chronic conditions. To enhance interpretability, this panel employs a dual-axis format: the left vertical axis represents the proportion of individuals without any chronic condition, while the right vertical axis captures the prevalence of those with one or more chronic diseases. Over the analyzed period, the proportion of individuals free of chronic conditions has declined markedly from 66.6% in 1993 to approximately 58.5% in 2022, implying that a growing segment of the Italian population contends with at least one chronic illness. Concurrently, the prevalence of individuals with a single chronic condition has increased, from 17.1% in 1993 to 19.5% in 2022. More striking are the rises observed among those with multimorbidity: prevalence of individuals with two chronic diseases has more than doubled,

from 8.3% to 10.8%, while those with three or more conditions have increased from 4.2% to 5.7%. These trends underscore the intensifying complexity of health care needs and highlight the imperative for targeted public health interventions and resource allocation strategies aimed at managing multimorbidity effectively.

These findings align with the results reported by Atella et Al. (2019), who documented an increasing trend in the prevalence of major chronic diseases between 2005 and 2014. Specifically, their analysis revealed that the prevalence of chronic conditions such as dyslipidemia, vascular disease, acute ischemia, and arthritis more than doubled across the study population. Concurrently, the proportion of individuals reporting no chronic pathologies decreased from 25.8% in 2005 to 23.5% in 2014. While the proportion of patients reporting a single chronic disease remained relatively stable, the proportion exhibiting two or more comorbidities demonstrated a marked increase, rising from 20.2% in 2005 to 28% in 2014.

These numbers are also in line with evidence from epidemiological studies, administrative databases, and national health surveys that underscores the growing burden of chronic illness across the population. Gini et Al. (2013), analyzing chronic disease prevalence in the context of the VALORE project, compared estimates from Italian administrative health databases with data from general practice and national surveys. They found increasing prevalence rates for a wide array of chronic conditions—including diabetes, ischemic heart disease, heart failure, and chronic obstructive pulmonary disease (COPD). The study also revealed systematic underreporting in administrative datasets compared to general practice records, with diabetes prevalence estimates ranging from 6.1% to 8.8%, and higher rates observed in the latter. This suggests that the true burden of chronic illness may be significantly un-

derestimated by current surveillance systems.

Environmental factors have also played a significant role in shaping chronic disease trends. Conti et Al. (2023), in an analysis based on the Global Burden of Disease Study, investigated the health impacts of air pollution in Italy between 1990 and 2019. Although age-standardized mortality rates for pollution-related diseases have declined, the absolute number of cases has risen due to population aging, which increases susceptibility to cardiovascular and respiratory conditions. This reinforces the notion that demographic change, rather than improvements in environmental quality alone, is driving the growing chronic disease burden.

Complementing these findings, the Italian National Institute of Statistics (ISTAT) has reported a consistent rise in the proportion of older adults living with multiple chronic conditions. According to ISTAT (2020), the share of individuals aged 65 and over with at least one chronic disease has grown steadily, highlighting the increased demand for long-term care, specialized services, and integrated care models capable of addressing the complexities of multimorbidity in older populations.

Simultaneously, remarkable advances in medical science and technology have expanded therapeutic and diagnostic opportunities. Innovations in genomics, imaging technologies, remote monitoring, and personalized medicine have broadened the spectrum of possible interventions, offering more precise and individualized treatments (Collins & Varmus, 2015). However, these advances come with the dual challenge of managing higher care complexity and sustaining affordability.

Understanding these intertwined trends is essential for anticipating future pressures on the Italian SSN and for designing reforms that can sustain its founding principles of universality, equity, and solidarity. Without strategic

adaptation, the SSN risks facing growing mismatches between the healthcare services it provides and the evolving needs of its population. Future healthcare models must shift focus from disease-centered acute care to integrated, preventive, and chronic care management frameworks (Kruk et Al., 2018). Furthermore, investments in digital health solutions, strengthening of primary care networks, and the expansion of long-term care services will be critical to ensuring system sustainability.

Speculating forward, failure to adequately address the chronic disease burden could not only erode health outcomes but also exacerbate regional disparities, increase economic strain on families and the state, and diminish public satisfaction with the healthcare system. Conversely, reforms informed by a clear understanding of these trends offer an opportunity to build a healthcare system that is more resilient, efficient, and responsive to the needs of future generations.

5. The Transformation of Healthcare Systems into Complex Systems

National healthcare systems are shaped by two driving forces: the regulatory frameworks that govern service delivery, and the ongoing medical and technological advancements. While medical science evolves rapidly, healthcare systems often struggle to keep pace, creating gaps between what is technically feasible and what can be institutionally implemented. These misalignments can lead to rising costs and unequal access to care.

Originally built to manage stable demographics and linear health demands, healthcare systems are now challenged by aging populations, chronic diseases, and technological innovation. Consequently, these systems must evolve from

top-down, hierarchical models into adaptive networks that respond dynamically to complex societal needs.

Healthcare systems have historically been viewed as linear and mechanistic. However, current research recognizes them as complex systems characterized by non-linear interactions and emergent phenomena. Complexity here implies not just complication, but an intricate web of relationships requiring substantial cognitive and institutional resources to navigate effectively.

Digital technologies and interdisciplinary collaboration have further increased this complexity. As new actors and relationships emerge, healthcare systems become self-reinforcing ecosystems, requiring more integrative management approaches. Toth's (2010) framework identifies three phases of healthcare evolution since the 1980s: market liberalization, regulatory integration, and a focus on service quality and patient rights.

Today's health policies increasingly acknowledge that population health results from a convergence of financial, social, genetic, and environmental factors. Thus, healthcare systems must integrate not just public institutions, but also communities, third-sector actors, and private initiatives, forming an ecosystem governed by horizontal, networked interactions. This paradigm shift demands a move from hospital-centric models to community-based care. As Bertin (2014) notes, this transition adds complexity by involving diverse stakeholders—patients, professionals, local institutions—whose interactions are shaped by local social dynamics. These actors operate within open systems, requiring flexible, territorially grounded governance mechanisms.

Complex healthcare ecosystems rely on adaptive processes rather than linear inputs. Their performance is influenced by feedback loops, historical conditions, and cross-sectoral interactions. As such, standard managerial tools are insufficient; new organizational models are required to navigate evolving

healthcare landscapes. For example, healthcare platforms such as prevention require coordination among multiple sectors: education, regulation, industries, and civil society. A vaccination campaign, for instance, may involve schools, scientific societies, regulators, media, and industry stakeholders. This interconnectedness exemplifies how platforms integrate diverse actors in service delivery. Ultimately, healthcare systems must be understood as ecosystems composed of interdependent platforms and stakeholders. Recognizing this structure is critical to reforming service delivery, aligning innovation with institutional frameworks, and ensuring system sustainability.

6. The Need for Structural Reform in a System Lagging Behind Medical, Technological, and Socioeconomic Changes

Advances in medical treatments, digital health solutions, and personalized medicine have reshaped healthcare capabilities, while an aging population and rising healthcare costs have placed increasing strain on public resources. However, the institutional reforms introduced over the decades have failed to adequately incorporate these external forces, either by neglecting their impact entirely or by implementing changes too late. As a result, the Italian healthcare system remains structurally misaligned with modern healthcare demands, leading to inefficiencies, regional disparities, and growing concerns about long-term sustainability. Many policy interventions have either ignored the impact of technological and scientific progress or have been introduced with significant delays, making them ineffective in addressing evolving patient needs (Ferré et Al., 2014). While robotic surgery, AI-based diagnostics,

and digital health platforms have become standard in many advanced healthcare systems, Italy has struggled to implement these tools on a system-wide scale due to bureaucratic inertia, funding constraints, and regional disparities. Additionally, the adoption of telemedicine and remote monitoring, which could greatly improve access to care—especially in underserved areas—has been slow and inconsistent across regions (Ministero della Salute, 2021a,b).

Furthermore, economic and demographic pressures have intensified, yet the Italian NHS remains underfunded and understaffed, particularly in primary and elderly care. Italy has one of the oldest populations in Europe, with increasing demand for chronic disease management, home-based care, and geriatric services. However, the healthcare system has remained largely focused on hospital-based care, failing to adequately expand community and primary care networks to meet the growing burden of aging-related conditions (Ferré et Al., 2014).

Financial constraints have also contributed to the system's inefficiencies. The economic crises of the 2000s and austerity measures in the following years led to budget cuts, hiring freezes, and reduced investments in healthcare infrastructure.[5] These financial policies have made it even more difficult to integrate new medical technologies and innovative care models into the public healthcare system, further exacerbating delays in adaptation (De Belvis et Al., 2012).

Given these longstanding challenges, it is becoming increasingly clear that Italy's NHS requires a comprehensive and forward-thinking reform to align with modern healthcare realities. The country must prioritize investment in digital health, workforce expansion, and the integration of new treatment methodologies. Additionally, financing models should be restructured to en-

5 See Atella, Cincotti, D'Amico, et Al. (2025) in this special issue.

sure that innovation in healthcare delivery does not remain concentrated in wealthier regions while leaving others behind. Without such reforms, the Italian healthcare system will continue to struggle with inefficiencies, inequities, and growing financial instability. As healthcare systems worldwide continue to evolve, Italy must take decisive action to modernize its NHS, ensuring that it remains sustainable, equitable, and capable of meeting the health needs of future generations.

For many national healthcare systems that were initially designed over 40 years ago, the pace of external changes—demographic shifts, technological progress, economic pressures, and epidemiological transitions—has exceeded the ability of existing structures to adapt. As a result, the time has come to engage in serious discussions about comprehensive healthcare reforms. Governments and policymakers must begin rethinking healthcare financing, service delivery, and workforce planning to ensure that healthcare systems remain responsive, cost-effective, and equitable in the face of rapid medical advancements.

6.1. Key Features of a Future-Ready Healthcare System and Policy Reforms

A sustainable SSN must incorporate self-correcting mechanisms, allowing it to adapt dynamically to rapid changes. To protect population health, future reforms should prioritize *1)* integrative and preventive care models, *2)* adoption of dynamic "self-correction" mechanisms, *3)* widespread adoption of personalized medicine, *4)* robust digital health infrastructures and systematic strengthening of human resources, and *5)* building resilience against future shocks, such as pandemics.

Integrative and preventive care. Encouraging healthy behaviors like nutritious eating, regular exercise, and quitting smoking can prevent these diseases (Diez et Al., 2016). While there are evidence-based programs (EBPPs) to prevent chronic diseases, their real-world application is limited. Community settings such as churches, schools, social services, local institutions, and workplaces are integral to daily life and present opportunities for implementing these preventive programs. By focusing efforts in these areas, we can reach high-risk populations who face barriers to health improvement. Implementation research is vital to understanding how organizational contexts affect the success of these programs. Despite challenges, research shows opportunities for prevention beyond traditional healthcare settings, emphasizing stakeholder involvement, strategic partnerships, and customizing approaches to fit specific organizational needs (Mazzucca et Al., 2021).

In contemporary healthcare, prevention is increasingly recognized as a cornerstone for achieving sustainable health outcomes and improving population well-being. Many of the most prevalent chronic diseases—including cardiovascular diseases, type 2 diabetes, certain cancers, and neurodegenerative conditions—are largely preventable through early interventions targeting modifiable risk factors (Fontana, 2008). Dietary patterns, physical activity, and lifestyle modifications have a critical role in significantly reducing the incidence and progression of these illnesses by influencing metabolic and molecular pathways associated with aging and chronic disease development (Fontana & Partridge, 2015).

Moreover, prevention should be understood within a "life-course" perspective, where health interventions begin early and extend across all stages of life. Preventive strategies must focus not only on individual behavior but also on broader systemic factors such as food systems, urban planning, and public

health policies that can facilitate healthy living environments. This comprehensive vision moves beyond reactive models of care toward a proactive approach centered on maintaining physiological function, delaying biological aging, and reducing the cumulative burden of disease. Investing in preventive medicine has the potential to substantially decrease healthcare costs associated with managing chronic diseases, particularly in aging populations. Without a strong emphasis on prevention, healthcare systems risk becoming unsustainable under the growing weight of non-communicable diseases and associated disabilities (Atella et Al., 2019).

Dynamic "self-correction" mechanisms in governance. Future healthcare governance models must embed dynamic "self-correction" mechanisms. Traditional static governance approaches are insufficient to address the complexity and unpredictability of contemporary health challenges. Systems must develop real-time monitoring, feedback loops, and adaptive policymaking tools that allow for rapid adjustment of strategies based on emerging evidence (Frenk et Al., 2010). Embedding self-learning capacities into healthcare governance, akin to the concept of Learning Health Systems (Institute of Medicine, 2013), enables continuous quality improvement, error correction, and innovation adoption without systemic paralysis.

Adoption of personalized and precision medicine. Advances in genomics, proteomics, and data analytics now allow for the tailoring of medical interventions to individual biological profiles, improving effectiveness and minimizing adverse effects (Collins & Varmus, 2015). Personalized medicine transforms healthcare from a reactive, generalized model to one that is predictive, preventive, and precise. Future healthcare systems must integrate omics data with clinical practice,

supported by robust ethical frameworks and data governance structures to ensure patient trust and equity in access to these advanced therapies.

Investment in healthcare workforce development and digital infrastructure. The growing complexity of care demands a workforce trained in interdisciplinary skills, including digital health literacy, genomics, and chronic disease management (World Health Organization, 2022). Simultaneously, investments must focus on building digital infrastructures that guarantee data interoperability, cybersecurity, and the seamless integration of telemedicine and artificial intelligence tools (European Commission, 2021). Digital technologies have revolutionized remote healthcare by integrating telemedicine, telehealth, and mobile health, allowing medical services to be delivered across distances without physical visits (Chaturvedi et Al., 2025). The demand for accessible healthcare, especially in underserved areas, is driving growth in remote healthcare solutions. AI has further enhanced virtual healthcare by improving patient engagement, real-time monitoring, and diagnostic accuracy. Key AI applications, like AI-enabled diagnostics, predictive analytics, and teleconsultation platforms, are being evaluated for their ability to overcome traditional remote healthcare limitations (Esteva, et Al., 2019). Without empowering the workforce and upgrading digital capabilities, healthcare systems risk failing to deliver on the promise of innovation.

Strengthening resilience to future health crises. The COVID-19 pandemic has starkly illustrated the vulnerabilities of health systems globally. Building resilience involves reinforcing public health surveillance, ensuring surge capacity in hospitals, securing supply chains, and fostering cross-sectoral collaboration (Kluge et Al., 2020). Resilient systems must be capable of absorbing

shocks, maintaining critical functions under stress, and learning from crises to emerge stronger.

Together, these features form the foundation of a healthcare model that is proactive rather than reactive, capable of navigating complexity, technological advancement, and future uncertainties while maintaining a commitment to universal health coverage and equity.

6.2. Policy Recommendations and Reform Priorities for the SSN

Building a resilient, equitable, and sustainable Italian National Health Service (SSN) in the face of evolving demographic, epidemiological, and technological challenges requires a phased and strategic approach to reform. Based on current evidence and international best practices, five major priorities are proposed: (1) workforce development and retention strategies; (2) scaling up preventive health programs; (3) accelerating the digital transformation of healthcare services; (4) improving citizen engagement and healthcare quality transparency; and (5) revising financing models to ensure sustainable, equitable healthcare funding.

Short-Term Actions (within 3 years). In the immediate term, policy efforts should focus on legal and organizational adjustments necessary to create an enabling environment for broader reform. These include legislative updates to facilitate telemedicine adoption, health data interoperability, and regional harmonization of healthcare quality standards (European Commission, 2023). Pilot programs should be initiated to test integrated care models, particularly for chronic disease management, and to deploy digital health plat-

forms that link primary, secondary, and tertiary care providers. Furthermore, specific measures to address healthcare workforce shortages, such as fast-track hiring and upskilling programs in underserved regions, are urgent to stabilize service delivery (OECD, 2023).

Medium-Term Strategies (within 5–7 years). Over the medium term, reforms must aim at systemic integration. This includes the full operationalization of regional equity plans to reduce disparities in health outcomes and service accessibility between northern and southern regions of Italy (ISTAT, 2023). A national preventive health platform should be developed to scale up screening programs, vaccination coverage, and early detection initiatives, fully integrated into primary care services. Strategic investments in digital infrastructure must move beyond pilots to achieve nationwide interoperability of Electronic Health Records (EHRs) under the European Health Data Space (EHDS) framework, enhancing real-time information sharing and clinical decision support (European Commission, 2022). Finally, it is important to implement "Value-Based Healthcare" models to align incentives with health outcomes rather than service volume (Porter & Teisberg, 2006). Value-based healthcare models prioritize health outcomes over service volume, aligning incentives to enhance societal wellbeing (Smith, 2023). In health systems, societal wellbeing is seen as an aggregate measure of life satisfaction, integrating goals such as health improvement, responsiveness, financial protection, efficiency, and equity. A public economics perspective highlights how key actors—patients, providers, purchasers, and policymakers—contribute to this value at different levels. By shifting from narrow, actor-specific objectives to a holistic approach, value-based models ensure that policy levers align efforts across the system to maximize overall health system value and societal wellbeing.

Long-Term Vision (2030 and beyond). By 2030, the SSN must align itself with European health integration initiatives and embody a healthcare system that is resilient, equitable, and sustainable. This vision requires continuous investment in innovation—from precision medicine to AI-driven diagnostics—alongside sustainable financing models that reward value and outcomes rather than volume (Porter & Lee, 2013). Citizen engagement must evolve into institutionalized participatory governance, where patients contribute systematically to the design and evaluation of services. Preventive health must be deeply embedded across sectors, recognizing the critical interplay between social determinants, health behaviors, and medical care (Kruk et Al., 2018).

Ultimately, achieving a future-proof SSN demands a shift in paradigm: from reactive care to proactive health promotion, from fragmented services to integrated networks, and from short-term fixes to a long-term strategic commitment to public health as a fundamental societal pillar.

7. Conclusion

The Italian National Health Service (SSN) stands at a decisive crossroads. Although it has historically achieved impressive outcomes—particularly in terms of universal access and life expectancy compared to other OECD countries—the cumulative evidence presented in this article demonstrates that the system is increasingly strained by structural inefficiencies, growing inequalities, and changing external pressures. The demographic aging of the population, the rising prevalence of chronic diseases, the acceleration of technological innovation, and citizens' evolving expectations of care collectively

challenge the current organization, financing, and governance of the SSN.

What emerges clearly is that the SSN, designed in a markedly different historical context, is no longer fully aligned with Italy's contemporary health needs. Regional disparities, fragmented information systems, insufficient focus on prevention, and workforce shortages exacerbate vulnerabilities and threaten the sustainability of universal coverage. Without bold and coordinated reforms, the risk is a progressive deterioration in access, quality, and equity—core values that have underpinned the SSN since its inception.

The path forward requires an integrated and phased reform strategy. In the short term, legal adjustments, pilots for integrated care, and investments in digital health platforms must lay the foundation for change. In the medium term, systemic reforms are necessary to strengthen regional equity, reinforce preventive services, and embed citizen engagement and transparency into the health system's governance. Long-term efforts must aim to align Italy with broader European initiatives, such as the European Health Data Space, while ensuring a sustainable financing model that supports innovation, value-based care, and the management of chronic conditions.

Beyond technical adjustments, however, what is needed is a cultural shift: from a healthcare model centered predominantly on the treatment of illness to one that prioritizes health promotion, prevention, and active citizenship. This transformation will require not only policy leadership and political will but also broad societal engagement. Italy's future success will depend on its capacity to embrace a vision of health as a shared societal good—one that demands collective responsibility, continuous innovation, and a strong commitment to equity.

Reforming the SSN is not merely a technical or financial necessity; it is a societal imperative. If Italy can mobilize the resources, strategic vision, and

institutional coherence required for this transformation, it has the opportunity to secure a resilient, inclusive, and future-ready healthcare system that will serve generations to come. Seizing this moment for decisive reform will not only preserve the SSN's founding values but transform Italy's healthcare into a global benchmark for innovation, solidarity, and sustainability.

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Digital Disruption in Healthcare: What It Means for the NHS

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Abstract

This paper examines the transformative impact of digital technologies on healthcare systems, with a specific focus on the NHS. While earlier waves of medical innovation developed gradually over decades, the current digital disruption—driven by artificial intelligence, big data, genomics, and connected health devices—is unfolding at a much faster pace, reshaping how care is delivered, accessed, and organized. The paper traces the historical trajectory of health technologies, identifies key enabling innovations, and analyzes their maturity and readiness for adoption. It explores how digital tools are improving clinical outcomes, altering workforce structures, and influencing health expenditures. At the same time, the paper highlights the regulatory, ethical, and governance challenges posed by these technologies, including concerns around data use, algorithmic transparency, and equity. It argues for the urgent need to modernize regulatory frameworks and health technology assessment

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methods to keep pace with innovation. In doing so, it calls for anticipatory, adaptive, and inclusive approaches that support responsible innovation while safeguarding public trust and sustainability in the NHS and beyond.

Sintesi - La rivoluzione digitale nella sanità: cosa significa per il Servizio sanitario nazionale

Questo articolo esamina l'impatto trasformativo delle tecnologie digitali sui sistemi sanitari, con un focus specifico sul SSN (Servizio Sanitario Nazionale). Mentre le precedenti ondate di innovazione medica si sono sviluppate gradualmente nell'arco di decenni, l'attuale rivoluzione digitale — guidata da intelligenza artificiale, big data, genomica e dispositivi sanitari connessi — si sta svolgendo a un ritmo molto più rapido, ridefinendo le modalità con cui l'assistenza viene erogata, resa accessibile e organizzata. L'articolo traccia la traiettoria storica delle tecnologie sanitarie, identifica le innovazioni abilitanti chiave e analizza il loro grado di maturità e prontezza all'adozione. Esplora come gli strumenti digitali stiano migliorando gli esiti clinici, modificando la struttura della forza lavoro e influenzando la spesa sanitaria. Allo stesso tempo, l'articolo evidenzia le sfide normative, etiche e di governance poste da queste tecnologie, comprese le preoccupazioni relative all'uso dei dati, alla trasparenza degli algoritmi e all'equità. Sostiene la necessità urgente di modernizzare il quadro normativo e i metodi di valutazione delle tecnologie sanitarie per stare al passo con l'innovazione. In tal modo, auspica approcci anticipatori, adattivi e inclusivi che sostengano l'innovazione responsabile, salvaguardando al contempo la fiducia pubblica e la sostenibilità nel SSN e oltre.

JEL Classification: I1; O31; O32; O33; O38.

Parole chiave: *Tecnologie sanitarie; Innovazione; Intelligenza artificiale; Erogazione delle cure; Regolamentazione ed economia sanitaria.*

Keywords: Health technologies; Innovation; Artificial intelligence; Healthcare delivery; Regulation and health economics.

1. Introduction [1]

Health is central to individual well-being and societal advancement, yet it was not until the mid-20th century that economists began exploring its economic impacts. At that time, health standards in affluent countries were much lower than they are today, though significantly better than in the early 1900s. For example, in 1900, approximately 18% of newborn males in the U.S. did not survive their first year, a rate comparable to that of 63-year-old adults by 2000 (Topel, 2017). A similar pattern was seen in Europe, where child mortality dropped from double digits in 1900 to just 0.5% in industrialized nations by 2000 (Atella, Francisci & Vecchi, 2017). Over the past century, life expectancy at birth has significantly increased thanks to various factors. These factors encompass decreased infant mortality rates, higher living standards, healthier lifestyles, improved education, and advancements in healthcare and medicine. For example, advancements in sanitation and health technologies, particularly vaccines and antibiotics, played a crucial role in combating infectious diseases (Alsan et al., 2018), which decreased infant mortality rates.

Since the end of WWII, technological progress in the healthcare sector has driven a continuous increase in global life expectancy. Official data shows that, on average, in Europe, life expectancy has grown by more than two years each decade since the 1960s (Eurostat, 2025). More recently, these gains have been even larger. According to the World Health Organization (WHO), life

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expectancy at birth rose from 66.8 years in 2000 to 73.1 years in 2019, marking a gain of over six years. In Africa, life expectancy increased by 10.6 years, rising from 53 years in 2000 to 63.6 years in 2021. The role of pharmaceutical innovation in reducing premature mortality, especially in cancer treatment, underscores that medical progress is a key driver of human longevity (Lichtenberg, 2014, 2016, 2017). EUROSTAT projects that life expectancy in the European Union will reach 89.1 years for women and 84.6 for men by 2060, continuing the trend of extended lifespans.

Medical innovations have powered massive improvements in healthcare, transforming fatal conditions into manageable ones, expanding access to care, and revolutionizing clinical procedures. Premature infants, for instance, who had minimal survival chances before the 1950s, now benefit from life-saving technologies such as mechanical ventilators and neonatal intensive care units. These advancements have added roughly 12 years to the life expectancy of low-birthweight infants (Skinner, 2013). Cardiac care has also come a long way. From basic medications like beta-blockers and aspirin to advanced procedures like coronary bypass surgeries and implantable defibrillators, these innovations have slashed heart attack mortality in the United States by almost 50% between 1980 and 2000 (Skinner, 2013).

Until around the early 2010s, technological innovation in healthcare followed a relatively gradual path. Major breakthroughs—such as advanced imaging systems, minimally invasive surgical techniques, and new generations of pharmaceuticals—were undeniably transformative, but they evolved over decades through incremental improvements and long development cycles. This slower pace allowed time for adaptation across healthcare systems, regulatory frameworks, and medical training (Blumenthal & Dixon, 2012; Wachter, 2015; Dorsey & Topol, 2016). In stark contrast, the current wave of innova-

tion is advancing at an unprecedented speed, catalyzed by the sweeping digital transformation of healthcare. Today, progress is being driven by the rapid convergence of artificial intelligence, big data analytics, wearable biosensors, telemedicine, personalized genomics, and digitally enabled care processes. These technologies are not merely extending the capabilities of medicine; they are redefining the entire landscape of how care is delivered, analyzed, and experienced. Machine learning algorithms can now detect diseases such as diabetic retinopathy or certain cancers with diagnostic accuracy that rivals, or even surpasses, that of experienced clinicians (Topol, 2019a,b). Genomic sequencing, which once cost billions and took years to perform, can now be completed in days at a fraction of the cost, enabling a new era of precision medicine. The current digital revolution in medicine marks a pivotal turning point in the trajectory of technological innovation within the healthcare sector. Unlike previous waves of medical advancement, today's progress is not only redefining what is medically possible but also drastically accelerating the speed at which innovation reaches clinical practice. This shift signals a fundamental change in how we will understand, implement, and govern medical technology in the years to come.

This exponential acceleration also signals a groundbreaking change in the rhythm of medical progress. The boundaries between biomedical research, clinical practice, and digital technology are becoming increasingly porous, allowing innovations to move from concept to bedside with unprecedented speed. Moreover, this new landscape is not only about the tools we use but also about a paradigm shift in how healthcare systems operate: from reactive care to predictive and preventive models; from generalized treatments to personalized interventions; and from episodic visits to continuous, data-driven patient monitoring. The implications of this shift are profound. As we stand

on the brink of an era where artificial intelligence co-pilots diagnosis and treatment decisions and where vast health datasets inform policy and research in real-time, the question is no longer *if* digital technology will redefine medicine but *how quickly and how responsibly* it will be integrated. The digital revolution may not appear just as another chapter in the story of medical progress—it may be a rewriting of the narrative itself.

The need for this transformation is further amplified when considering the biopsychosocial model of health, which recognizes the intricate interplay between biological, psychological, and social factors in determining an individual's well-being (Engel, 1978).[2] This holistic perspective necessitates healthcare solutions that address the multifaceted needs of patients, extending beyond purely biological interventions to encompass their mental and social contexts. In the digital age, the influence of technology itself has become a significant determinant of health experiences and outcomes. Consequently, a "biopsychosocial-digital" approach has been proposed, advocating for the integration of the digital dimension into the traditional biopsychosocial framework (Ahmadvand et al., 2018). This expanded model acknowledges the profound impact of digital engagement on patients' choices, behaviors, and overall health journey. Digital tools present unique opportunities to collect and analyze data related to all three domains of the biopsychosocial model, enabling a more nuanced and personalized approach to care. By leveraging technologies that monitor biological parameters, support mental well-being, and facilitate social connections, healthcare can move towards a more comprehensive strategy for measuring, preserving, and improving the health and

2 The biopsychosocial model has transformed healthcare by emphasizing the connection between biological, psychological, and social factors in health and disease, providing a more holistic approach than the traditional biomedical model. It is particularly useful for chronic illnesses, pain disorders, and mental health. However, challenges like reductionist medical education, insufficient interdisciplinary collaboration, and financial constraints hinder its implementation (Seyed Alitabar, 2025).

quality of life of individuals. This includes recognizing the importance of an individual's ability to engage in activities and participate in society as key indicators of their overall well-being.

This transformation is inextricably linked to one of the most critical challenges confronting contemporary healthcare systems: the persistent increase in costs. While technological advancements have undeniably revolutionized medical practice, leading to improvements in diagnostics, treatments, and patient outcomes, they have also contributed substantially to the rising costs of healthcare. In contrast to other sectors where technological innovation typically reduces costs while simultaneously improving outcomes, in healthcare, these advancements often yield both enhanced outcomes and increased expenditures (often through higher prices). The introduction of cutting-edge medical technologies often entails substantial expenses, encompassing research and development, acquisition, maintenance, and the specialized training required for healthcare professionals. Moreover, the availability of advanced technologies can lead to increased utilization, sometimes extending beyond medically necessary applications, further driving up costs. Consequently, healthcare expenditures have grown faster than in any other economic sector, especially since the latter decades of the 20th century. These cost increases have been driven by factors such as the development of treatments for previously untreatable diseases, the expansion of treatment access, and enhancements in treatment quality (Cutler, McClellan& Newhouse, 1998; Eggleston et al., 2011).

The cost implications of new technologies depend on the type of innovation. Key considerations include whether the new treatment complements or substitutes existing ones, whether it is a standalone intervention or used in conjunction with others, and how it affects overall treatment costs. Ad-

ditionally, the degree of dissemination and population coverage is critical. Technological advancements often result in broader applications, which can increase total spending even if individual unit costs decline (Weisbrod, 1991; Cutler & Huckman, 2003). Furthermore, the temporal realization of health and economic benefits must be accounted for, as some technologies yield cost savings only in the long term. Many technologies embody several of these characteristics simultaneously, complicating the assessment of their overall financial impact. One of the major challenges in this domain is accurately capturing quality improvements embedded in new technologies. As Rosen and Cutler (2007) note, while some evaluations suggest reasonable aggregate productivity growth in healthcare, others highlight significant inefficiencies.

As digital tools become embedded across diagnostics, therapeutics, prevention activities, workforce management, and patient interaction, they challenge the economic models and institutional frameworks on which many national health systems—such as the NHS—are based. In this context, economic research is increasingly called upon to assess not only the effects of these technologies on efficiency and outcomes but also their distributional consequences, regulatory implications, and cost dynamics. This paper explores the economic dimensions of health system innovation considering the recent digital transformation. Drawing on developments in enabling technologies, digital health applications, and regulatory challenges, it offers a structured assessment of how innovation is reshaping healthcare systems and policy trade-offs.

The paper is organized into nine sections. Section 2 provides a historical overview of the evolution of medical technologies, tracing the transition from public health interventions and pharmaceuticals to highly specialized and resource-intensive innovations to digital technologies. Section 3 presents a horizon scanning exercise and offers a taxonomy of emerging digital

technologies with the potential to transform healthcare. Section 4 delves into the specific impact of artificial intelligence on healthcare systems, examining its role in clinical decision-making, resource optimization, and workforce planning. Section 5 expands the scope of analysis to a broader set of digital applications—such as telemedicine, digital therapeutics, and point-of-care diagnostics—and discusses how they are reshaping healthcare delivery and patient experience. Section 6 provides a maturity assessment of digital health solutions, evaluating the degree to which different technologies are ready for widespread adoption based on technical, regulatory, and systemic criteria. Section 7 discusses the broader impacts of these technologies on healthcare outcomes and the organization of the workforce, including their potential to improve productivity and reshape professional roles. Section 8 turns to the regulatory dimension, analyzing how institutions are managing the tension between rapid innovation and the requirements of safety, equity, and cost-effectiveness. Section 9 considers the economic implications of technological adoption for healthcare expenditure and explores whether digital innovation might alter the traditional cost-growth trajectory of health systems. Finally, Section 10 concludes by outlining future directions for research and policy, with an emphasis on anticipatory regulation, investment in digital infrastructure, and the need for coherent strategies to integrate innovation into health system reform.

2. The Evolution of Medical Technologies: Expected Innovations in Healthcare Services, Processes, and Delivery Models

In their 2019 article, "New Technologies and Costs," published in the *Oxford Research Encyclopedia of Economics and Finance*, Atella and Kopinska provided a comprehensive synthesis of the evolution of medical technologies and their impact on healthcare systems, with particular attention to cost dynamics and sustainability. This foundational work outlined the interplay between innovation, regulation, and expenditure in health systems like the UK's National Health Service (NHS), offering a crucial baseline for understanding the challenges and opportunities posed by new technologies in healthcare up to the end of the 2010s.

The authors traced the trajectory of technological change from the early public health revolutions of the 20th century—characterized by gains in sanitation, nutrition, and infectious disease control—to the pharmaceutical and procedural innovations of the post-war decades. The development and diffusion of antibiotics, vaccines, surgical techniques, intensive care, and pharmaceuticals led to sharp improvements in population health and longevity. These innovations were associated mainly with systemic public health gains and, in many cases, provided cost-effective solutions to widespread clinical problems.

However, from the 1980s onward, the authors noted a shift in the character of technological change. Innovations became increasingly specialized, sophisticated, and resource-intensive. In particular, the rise of biologic drugs, advanced diagnostic imaging, minimally invasive procedures, and, more recently, gene therapies and digital health tools marked a departure from earlier innovations that were typically mass-distributable and cost-scaling. These new technologies promised better patient outcomes but often did so at sub-

stantially higher costs, requiring significant investments in infrastructure, workforce training, and system reorganization.

Atella and Kopinska (2019) identified five main domains of technological innovation: pharmaceutical products, medical and surgical procedures, medical devices, support systems (such as telehealth and electronic records), and precision medicine. Each domain displayed its own set of cost, regulatory, and evaluation challenges. For instance, the pharmaceutical sector increasingly relied on targeted therapies—such as biologics and monoclonal antibodies—that, while clinically effective, drove up the costs of care. Meanwhile, surgical and procedural innovations often enabled faster recovery and reduced inpatient time but introduced equity and access issues due to uneven availability and skill requirements.

Since the publication of Atella and Kopinska's work, the pace of medical technological development has accelerated dramatically. The last decade has witnessed not only a continuation of earlier trends but also the emergence of entirely new technological trajectories. The COVID-19 pandemic catalyzed rapid advances in digital health infrastructure, mRNA vaccine platforms, remote care, and real-time health data analytics. Artificial intelligence and machine learning have moved beyond the experimental stage to influence diagnostics, clinical decision-making, and health system management. Meanwhile, wearable devices, home-based monitoring, and personalized medicine have become increasingly mainstream. These developments suggest that the dynamics described up to 2019 have shifted substantially. Some technological domains have evolved far beyond expectations, while others have seen entirely new directions emerge.

The continued advancement and integration of new technologies are now expected to drive significant innovations across various aspects of healthcare,

extending beyond just the development of new products to encompass novel services, transformative processes, innovative care pathways, and new healthcare delivery models (OECD, 2019), to also meet the demands of an evolving patient demographic and drive progress in public health systems (Cecconi et al., 2025). Some of these anticipated advancements include (OECD, 2019; Goldsack et al., 2020; Patel et al., 2023):

- New Services: Future healthcare is likely to see the emergence of AI-powered personalized health coaching and wellness programs that adapt to individual data and preferences. Remote rehabilitation services delivered through VR/AR platforms will allow patients to receive therapy conveniently in their own homes. Virtual consultations with medical specialists in remote or underserved areas will become more commonplace, significantly improving access to expert care.
- Transformative Processes: AI-assisted diagnostics are expected to become increasingly sophisticated, enabling faster and more accurate disease detection, particularly in fields like medical imaging analysis. The automation of data collection and analysis in clinical research will accelerate the pace of medical discovery. Robotic process automation will streamline administrative tasks within healthcare organizations, freeing healthcare professionals to dedicate more time to direct patient care.
- Innovative Care Pathways: Integrated digital and in-person care models will likely become the norm, offering a hybrid approach that combines the convenience of remote monitoring and virtual consultations with the necessity of in-person examinations and procedures when required. Proactive and predictive healthcare, driven by continuous monitoring through wearable sensors and AI-powered risk assessment, will enable early interventions and the development of highly personalized preven-

tion plans.

- Novel Healthcare Delivery Models: Decentralized clinical trials (DCTs), leveraging digital technologies to enable remote participation, are poised to become a more prevalent model for conducting clinical research, potentially leading to greater patient participation and the collection of more real-world data. Hospital-at-home models, supported by comprehensive remote monitoring, telehealth services, and AI-powered virtual assistants, will enable patients with certain acute conditions to receive high-quality care in the comfort of their own homes.

These digital transformations signal a paradigm shift in how healthcare is conceived, delivered, and experienced. For example, AI-driven triage systems in emergency departments are reducing wait times and optimizing resource allocation in real time. Predictive analytics platforms enable care teams to anticipate patient deterioration days before clinical signs emerge. Smart medication adherence tools, integrated with electronic health records, are improving outcomes in chronic disease management. Digital twins of patients—virtual replicas based on real-time data—are beginning to inform treatment simulations prior to intervention. These examples, illustrate how innovation is reconfiguring healthcare around proactive, patient-centered, and data-driven principles.[3]

3 For more details and for a horizon scanning on the existing and future technologies on the market see the online Appendix A1.

3. The Transformative Impact of AI on Healthcare: Preempting Illness, System Management, and Community Care

Amid the 4th Industrial Revolution, science and technology are reshaping healthcare and patient management in truly remarkable ways. These advancements promise not only improved patient care but also cost savings through early diagnosis and treatment options. They address talent shortages, ensure secure and seamless access to patient data, and facilitate treatments in more comfortable outpatient settings. To capitalize on these medical breakthroughs, healthcare organizations must identify inefficiencies and be willing to experiment with novel technologies. It is crucial to include all stakeholders, especially patients, in this process to ensure their needs and inputs are considered. We are witnessing a dramatic transformation in patient care management thanks to innovations like hyper-personalized medicine, 24/7 support bots, and systems that proactively alert physicians to potential issues. Advancements in AI, nanotechnology, biosensors, and digital health monitoring have significantly enhanced the capability to predict, prevent, and preempt illnesses before they manifest. The shift from reactive to proactive medicine is being driven by technologies that enable continuous health monitoring, early diagnosis, and personalized treatment plans.

3.1. AI's Dependence on Health Data Collection, Availability, and Usability: the role of blockchain technologies

Data-driven strategies will likely dominate healthcare provider decision-making in the coming decade. The aggregation and application of data—

encompassing patient information, IT infrastructure metrics, facility management data, and other diverse sources—will exert a significant influence on strategic discussions and organizational priorities. Similarly, the efficacy of AI in healthcare is contingent upon the availability of high-quality, comprehensive, and interoperable health data. AI models necessitate substantial datasets for training algorithms designed for disease prediction, treatment optimization, and patient risk stratification (Chen & Goldman, 2023). Nevertheless, challenges pertaining to data standardization, security protocols, and ethical governance persist.

The integration of blockchain technologies in healthcare is fundamentally altering the paradigms of medical data storage, sharing, and utilization. By providing a secure, decentralized, and immutable framework for managing electronic health records (EHRs), blockchain facilitates enhanced efficiency and streamlining of healthcare services. This technological advancement bolsters data reliability, interoperability, and security, resulting in improved patient care outcomes, cost reductions, and expanded access to outpatient services. As healthcare systems increasingly transition toward digital and cloud-based infrastructures, blockchain ensures data integrity, mitigates administrative inefficiencies, and strengthens the dynamics of patient-provider interactions (Agbo, Mahmoud& Eklund, 2019).

A salient contribution of blockchain technology in healthcare lies in its capacity to enable real-time, secure, and transparent data exchange among providers. Traditional EHR systems are often characterized by data silos, wherein information is stored in disparate and non-interoperable systems, thereby impeding healthcare professionals' access to a holistic view of a patient's medical history (Engelhardt, 2017). Blockchain technology addresses this limitation by establishing a decentralized ledger that permits authorized

stakeholders—including physicians, hospitals, laboratories, and insurers—to securely access and update records without compromising data integrity or patient privacy. Through cryptographic hashing and smart contracts, blockchain ensures that only authorized personnel can modify patient data, thereby minimizing errors, administrative delays, and redundancies in medical testing (Yue et al., 2016).

Another advantage of blockchain technology lies in its capacity to enhance the security and reliability of cloud-based healthcare services. With the increasing reliance on cloud storage for patient records, medical imaging, and genomic data, concerns regarding cybersecurity breaches, data manipulation, and unauthorized access have become increasingly salient (Zhang et al., 2018). Blockchain mitigates these risks through the encryption and decentralization of patient information, thereby precluding unilateral control over data by any single entity. This immutable ledger technology not only prevents fraudulent alterations but also fosters trust among healthcare providers and patients. Furthermore, blockchain-based solutions facilitate automated data reconciliation, enabling healthcare systems to maintain real-time, tamper-proof patient records, which significantly reduces medical errors and enhances the accuracy of diagnoses and treatment regimens (Kuo, Kim& Ohno-Machado, 2017).

From an economic standpoint, blockchain contributes to cost containment and enhanced operational efficiency within healthcare systems. Administrative processes, including insurance claims, billing procedures, and provider credentialing, are often characterized by complexity and protracted timelines. By leveraging blockchain-enabled smart contracts, healthcare organizations can automate these processes, thereby significantly reducing administrative overhead, eliminating fraudulent activities, and expediting insurance reimbursements (McGhin et al., 2019). This automation not only curtails

operational expenditures but also enables healthcare professionals to allocate a greater proportion of their time to patient care rather than administrative tasks.

Blockchain further facilitates a transition towards outpatient and telemedicine services, thereby promoting a more cost-effective and accessible healthcare delivery model. Through secure and transparent data exchange mechanisms, providers can confidently offer remote consultations, AI-driven diagnostics, and personalized treatment plans while ensuring patient confidentiality (Roehrs et al., 2019). Patients with chronic conditions, mobility impairments, or those residing in remote geographic areas benefit from continuous, high-quality care without necessitating frequent in-person consultations. Blockchain-powered telemedicine platforms also ensure seamless coordination between specialists and general practitioners, thereby facilitating more efficient case management and improved health outcomes.

Moreover, blockchain technology facilitates advancements in precision medicine and genomic research by providing a secure and traceable framework for the sharing of genetic and biomedical data among researchers and healthcare institutions (Haque et al., 2021). Personalized medicine relies on the integration of patient-specific data, encompassing genomic sequencing, lifestyle factors, and medical history, to tailor individualized treatments. Through the application of blockchain, researchers can access large, anonymized datasets while upholding patient privacy and adhering to regulatory compliance standards, thereby accelerating the development of targeted therapies and more effective medical interventions (Zhang, Schmidt & White, 2020).

Despite its transformative potential, widespread adoption of blockchain in healthcare still faces regulatory and technological challenges. Issues such as scalability, standardization of protocols, and compliance with data protection

laws (e.g., GDPR and HIPAA) must be addressed to fully realize its benefits (Esposito et al., 2018; Atella, Ganna & Lombardo, 2025, in this Special Issue). However, as governments, healthcare providers, and technology companies continue to invest in blockchain research and pilot projects, its integration into mainstream healthcare services is becoming increasingly viable.

In conclusion, blockchain technology presents a groundbreaking opportunity to enhance patient health through secure, efficient, and interoperable healthcare services. By providing reliable cloud-based infrastructures, enabling seamless record-sharing, reducing administrative costs, and expanding outpatient care options, blockchain is revolutionizing the way medical data is managed and healthcare is delivered. As the industry moves towards data-driven, patient-centric models, blockchain is poised to play an essential role in ensuring that healthcare systems remain resilient, cost-effective, and patient-focused.

3.2. How AI is pervading the world of incoming new technologies

AI is becoming an integral component of emerging technologies, shaping advancements across multiple domains, including healthcare, finance, transportation, and manufacturing. Its ability to process vast amounts of data, recognize patterns, and automate complex tasks has positioned it as a foundational element in the development of autonomous systems, predictive analytics, and human-machine collaboration (Russell & Norvig, 2021). In healthcare, AI enhances diagnostic accuracy, optimizes treatment plans, and streamlines administrative processes (Topol, 2019a,b; Brynjolfsson & McAfee, 2017). This is occurring in several new branches of medical innovation.

Below, we describe some interesting breakthroughs.

Nanotechnology and Nanobots. Nanotechnology has emerged as a breakthrough field in medicine, offering solutions that range from targeted drug delivery to cellular repair and tissue regeneration. Nanobots, which are microscopic robotic systems, can be programmed to navigate through the bloodstream and detect biochemical markers associated with early-stage diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions (Saini et al., 2021). Some researchers have developed nanobots coated with platelet and red blood cell membranes, enabling them to neutralize toxins and bacterial infections in the bloodstream more efficiently than traditional antibiotics (Han et al., 2022). Within this technology, AI facilitates targeted drug delivery, enabling nanobots to navigate the bloodstream and selectively attack malignant cells, improving cancer treatment while minimizing side effects (Santos et al., 2020). One of the most promising applications of nanomedicine is its ability to target malignant tumors at the cellular level. Unlike conventional chemotherapy, which affects both cancerous and healthy cells, nanobots can deliver highly localized treatments, reducing side effects and improving patient outcomes (Santos et al., 2020). Moreover, researchers have designed self-propelled nanobots that can travel through the cerebrospinal fluid, offering potential treatments for brain disorders and neurodegenerative diseases such as Alzheimer's and Parkinson's (Saniotis, et al., 2018; Krsek & Baticic, 2024).

Biosensors and Digital Tattoos. Biosensors represent another revolutionary advancement in preventive medicine. These wearable and implantable devices allow for continuous monitoring of vital physiological parameters, alerting

patients and physicians in real time about potential health risks. Biosensors integrated into smartwatches, patches, and digital tattoos are capable of detecting blood glucose levels, cardiac rhythms, hydration status, and oxygen saturation (Lopez & Sun, 2022; Trung & Lee, 2016). Biosensors and digital tattoos powered by AI provide continuous health monitoring, detecting early signs of chronic conditions and optimizing disease management through real-time data analysis. A breakthrough in biosensor technology has been the development of graphene-based wearable sensors, which can detect specific cancer biomarkers through sweat analysis. Recent research has shown promising developments in non-invasive detection methods for early-stage gastric cancer. For instance, a study introduced an integrated AI-enabled system using One Class Twin Cross Learning (OCT-X) for early gastric cancer detection, achieving a diagnostic accuracy of 99.70% (Tang et al., 2024). Another research utilized deep learning on non-contrast CT scans, achieving a sensitivity of 85.0% and specificity of 92.6% for detecting gastric tumors (Liu et al., 2023). AI-powered predictive analytics further enhances the effectiveness of biosensors by processing vast datasets to detect patterns that indicate pre-disease conditions. For example, AI algorithms used in continuous glucose monitoring (CGM) devices can predict hypoglycemic events in diabetic patients up to three hours before they occur, allowing for timely intervention and improved glucose control (Sharma et al., 2022).

Haptic Technology and Robotic Surgery. AI-powered robotic surgical systems have enhanced precision, minimized invasiveness, and shortened recovery times. One of the most widely adopted technologies is the Da Vinci Surgical System, which allows robot-assisted laparoscopic procedures, reducing surgical complications and hospital stays (Liu, Wu et al., 2024). Recent ad-

vancements in haptic feedback technology enable surgeons to perform remote surgeries with an enhanced sense of touch, even when operating at a distance. Researchers have developed haptic glove systems that provide real-time force feedback, improving tactile sensitivity in robotic-assisted surgeries. This innovation has the potential to expand surgical expertise to remote and underserved regions, addressing global disparities in healthcare access. AI-driven haptic technology and robotic surgery improve surgical precision and enable remote procedures, expanding access to specialized care and reducing post-operative complications (Liu, Wu et al., 2024; Tozsin et al., 2024).

AI in Mental Health and Virtual Assistants. In mental health, AI-powered virtual assistants support cognitive behavioral therapy and provide real-time psychological assessments, increasing accessibility to mental health services and alleviating pressure on healthcare professionals. AI-powered chatbots and virtual mental health assistants are now widely used in telepsychiatry and cognitive behavioral therapy (CBT) (Vaidyam et al., 2019). AI-driven platforms such as Woebot and Wysa provide psychological support, monitor mental health trends, and offer personalized cognitive therapy exercises (Fulmer et al., 2018; Inkster et al., 2018). Studies show that these digital interventions can reduce symptoms of depression and anxiety while reducing the burden on human mental health professionals (Ravindran et al., 2021).

AI in Drug Development and Clinical Trial Optimization. Artificial Intelligence (AI) is transforming drug discovery and the evaluation of pharmaceutical safety by significantly enhancing the ability to simulate and predict drug interactions. Traditional drug development relies on time-intensive and costly clinical trials, often requiring six to eight years of testing and investments

reaching hundreds of millions or even billions of dollars (Mak & Pichika, 2019). Moreover, nearly 80% of clinical trials fail to meet their enrollment targets, delaying the approval of new treatments and increasing financial risks (Huang et al., 2020). AI-driven approaches are now streamlining drug development, reducing the reliance on experimental assumptions, and expediting the research process while improving cost efficiency (Liu, Lu et al., 2024).

A notable example of AI's impact on pharmaceutical research is Decagon, an AI-based system developed by Stanford researchers to analyze protein-drug interactions. This system evaluates how approximately 5,000 existing pharmaceuticals interact with proteins in the human body, allowing researchers to identify potential side effects and adverse reactions with far greater speed and accuracy than traditional methods (Zitnik et al., 2018). By leveraging deep learning algorithms and vast biological datasets, AI tools such as Decagon offer a safer and more efficient alternative to animal testing and human trials, minimizing ethical concerns while improving predictive capabilities.

Beyond its applications in drug safety and efficacy analysis, AI is also revolutionizing patient recruitment for clinical trials. One of the most persistent challenges in clinical research is identifying and enrolling suitable participants, a process that is often hampered by inefficiencies in patient screening and eligibility matching. AI-driven systems are now being utilized to analyze electronic health records (EHRs) and genomic data, ensuring that patients who meet the specific criteria for a trial are identified in a timely manner (Topol, 2019a,b). By automating this process, AI enhances trial efficiency, increases patient participation, and ensures that individuals are matched to studies from which they are most likely to benefit.

The application of AI in drug research and clinical trial management marks a significant shift toward data-driven, precision medicine. By accel-

erating drug discovery, enhancing patient safety, and optimizing clinical trial workflows, AI is paving the way for a more efficient, cost-effective, and patient-centered pharmaceutical industry. As AI models continue to evolve, their role in drug repurposing, personalized treatment strategies, and the early identification of adverse drug reactions will become increasingly integral to the future of medical research.

3.3. AI's Role in Facilitating the Transition from Inpatient to Outpatient Care

AI is playing an increasingly pivotal role in transforming healthcare delivery by facilitating the transition of patients from inpatient to outpatient settings. As healthcare systems strive to enhance efficiency, reduce costs, and improve patient outcomes, AI-driven technologies are being leveraged to optimize post-discharge monitoring, personalized treatment plans, and remote patient management. These advancements support continuity of care, minimize hospital readmissions, and enable a more sustainable healthcare model focused on preventive and community-based care (Davenport & Kalakota, 2019).

One of the key areas where AI is making a substantial impact is in predictive analytics and early warning systems. AI algorithms analyze vast amounts of patient data to identify individuals at risk of complications, readmissions, or adverse events following hospital discharge. Machine learning models, trained on electronic health records (EHRs) and real-time physiological data, can detect subtle patterns indicative of deteriorating health, allowing clinicians to intervene proactively and prevent avoidable hospitalizations (Shameer et al., 2017). This predictive capability is particularly beneficial for man-

aging patients with chronic diseases such as heart failure, chronic obstructive pulmonary disease (COPD), and diabetes, where continuous monitoring and timely interventions significantly reduce the likelihood of acute exacerbations (Kwon et al., 2020).

AI-powered remote patient monitoring (RPM) systems are revolutionizing outpatient care by enabling real-time tracking of vital signs, medication adherence, and rehabilitation progress. Wearable biosensors, combined with AI-driven analytics, allow healthcare providers to monitor blood pressure, glucose levels, oxygen saturation, and cardiac function without requiring patients to remain in a hospital setting (Krittanawong et al., 2019). These devices facilitate the early detection of potential complications, prompting timely medical interventions that prevent rehospitalization and enhance patient well-being. Additionally, AI-based virtual nursing assistants and chatbots, such as those integrated into mobile health applications, provide patients with personalized health guidance, medication reminders, and symptom assessments, fostering greater self-management and reducing dependence on in-person clinical visits (Bini, 2018).

The implementation of AI-driven telemedicine platforms has further streamlined the transition from inpatient to outpatient care by ensuring continuous access to medical professionals. AI-enhanced virtual consultations enable specialists, general practitioners, and allied healthcare professionals to conduct follow-ups, adjust treatment plans, and address patient concerns remotely, reducing the need for unnecessary hospital visits (Anghel et al. 2025; Shaik et al., 2025). This approach has proven particularly valuable in rural and underserved areas where access to healthcare services is limited. Telehealth solutions integrated with NLP and computer vision can assess patient speech, facial expressions, and physiological cues during virtual visits, providing clini-

cians with additional insights into a patient's condition (Esteva et al., 2021).

AI also plays a crucial role in optimizing hospital discharge planning and care coordination. Machine learning models can predict the most appropriate discharge pathways based on patient-specific factors, ensuring a seamless transition to home-based or rehabilitation care (Sendak et al., 2020). AI-powered discharge management systems facilitate better communication between hospitals, primary care providers, and home healthcare teams, reducing delays in follow-up appointments and ensuring that patients receive the necessary post-discharge support. These systems enhance interdisciplinary collaboration by integrating automated alerts, shared medical records, and AI-driven decision-support tools, thereby reducing administrative burden and improving continuity of care.

From an economic standpoint, the integration of AI in the transition from inpatient to outpatient care has significant cost-saving potential. Prolonged hospital stays contribute substantially to healthcare expenditures, and reducing the length of hospitalization through AI-guided outpatient management strategies alleviates financial strain on both healthcare systems and patients. Studies indicate that AI-enhanced remote monitoring and telehealth programs reduce hospital readmission rates by up to 30%, underscoring the financial and clinical benefits of leveraging AI-driven interventions (Madrid-Cagigal et al., 2025).

Despite its transformative potential, the widespread adoption of AI in facilitating inpatient-to-outpatient transitions faces challenges related to data privacy, algorithmic bias, and technology accessibility (see Atella, Ganna & Lombardo, 2025, in this Special Issue). Ensuring that AI models are trained on diverse and representative datasets is essential to prevent disparities in care delivery, particularly for marginalized populations. Moreover, the successful

implementation of AI-driven solutions requires investment in digital literacy, clinician training, and regulatory frameworks that prioritize patient safety, transparency, and ethical AI deployment (Morley, Machado et al., 2020).

As AI continues to advance, its role in reshaping healthcare delivery, enhancing outpatient care, and reducing unnecessary hospitalizations will become increasingly pronounced. By leveraging predictive analytics, remote monitoring, telemedicine, and AI-driven care coordination, healthcare systems can transition towards a more patient-centered, efficient, and cost-effective model, ultimately improving population health and quality of life.

3.4. AI's Role in Healthcare System Management and Human Resource Optimization

Beyond direct patient care, the integration of AI in healthcare system management and human resource optimization is reshaping the workforce dynamics, particularly in workforce allocation, hospital logistics, and administrative efficiency, requiring new competencies and skills while simultaneously posing significant challenges for policymakers and healthcare administrators. As AI technologies enhance efficiency, diagnostic accuracy, and operational workflows, the demand for AI-literate healthcare professionals is increasing. To ensure that healthcare systems remain adaptive, sustainable, and capable of leveraging AI's full potential, decision-makers must proactively plan for workforce transformation, invest in skill development, and design policies that support AI integration while maintaining high standards of patient care (Jiang et al., 2017).

AI-powered solutions are streamlining clinical decision-making, predictive

analytics, and automated administrative processes, reducing the burden of routine tasks on healthcare professionals. In diagnostics, AI algorithms are demonstrating remarkable accuracy in medical imaging, detecting anomalies in radiology, dermatology, and pathology with sensitivity levels comparable to or exceeding human specialists (Topol, 2019a,b). The ability of AI-driven systems to process vast amounts of clinical data in real-time is enhancing early disease detection, risk stratification, and personalized treatment planning (Rajpurkar et al., 2018). This transformation necessitates that clinicians, nurses, and allied health professionals develop competencies in AI interpretation, data analysis, and digital literacy to ensure that AI-powered recommendations are effectively integrated into clinical workflows (Paranjape et al., 2019).

Beyond clinical applications, AI is significantly improving hospital resource management, workforce allocation, and operational efficiency. AI-driven predictive staffing models are optimizing workforce distribution, ensuring that hospitals allocate human resources efficiently based on patient flow trends and demand forecasts (Davenport & Kalakota, 2019). In emergency departments, machine learning algorithms analyze historical admission patterns to anticipate patient influxes, allowing administrators to allocate personnel and resources proactively (El Ariss et al., 2024; Vural et al., 2025). AI-powered scheduling systems are reducing physician burnout by balancing workloads and automating shift assignments, creating more equitable work environments while preserving staff well-being (Uhde et al., 2020; Choudhry, 2022).

One of the most profound shifts driven by AI is in medical education and training. The traditional methods of training healthcare professionals are evolving to accommodate AI-based simulations, augmented reality (AR), and virtual reality (VR) applications, which provide interactive and immersive learning experiences (Tang et al., 2020). AI-powered simulated patient cases

allow medical trainees to practice complex clinical decision-making scenarios, refining their diagnostic skills and procedural competencies in a risk-free environment (Tang et al., 2017). As AI continues to influence medical curricula, interdisciplinary education that integrates healthcare, computer science, and bioinformatics is becoming essential for future healthcare professionals (Tozsin et al., 2024).

In workforce planning, AI is also playing a key role in credentialing, recruitment, and professional development. AI-driven platforms analyze candidate profiles, clinical expertise, and historical performance data to match healthcare professionals with positions that align with their skills and career trajectories (Nguyen et al., 2021). Additionally, AI-powered learning management systems track individual competency development, offering personalized training pathways and upskilling opportunities based on evolving healthcare demands. This shift underscores the need for healthcare institutions to foster lifelong learning environments where practitioners can continuously refine their expertise in alignment with technological advancements (Meskó et al., 2018).

The integration of AI in healthcare management is also prompting new ethical, legal, and regulatory considerations. Policymakers must establish guidelines for AI-driven decision support systems, ensuring that clinical accountability, data security, and patient safety remain paramount. Ethical concerns regarding AI bias, algorithmic transparency, and equitable access to AI-driven care necessitate ongoing regulatory oversight and governance frameworks (Morley, Machado et al., 2020). Additionally, healthcare leaders must navigate the transition to AI-augmented care models by fostering interdisciplinary collaboration between healthcare professionals, AI developers, and policymakers to create systems that enhance, rather than replace, human

expertise (Char et al., 2020).

Preparing for this AI-driven transformation requires a multifaceted policy approach. Healthcare decision-makers must invest in workforce reskilling programs, AI-centric education, and organizational change management strategies to mitigate resistance and promote AI adoption. Strengthening public-private partnerships between academic institutions, healthcare providers, and technology firms can facilitate AI innovation, research, and skill development at scale. Governments and regulatory bodies must also adapt healthcare reimbursement models to recognize AI-assisted medical procedures and digital health interventions, ensuring that these technologies are sustainably integrated into routine care (Jiang et al., 2021).

As AI continues to redefine the healthcare landscape, the role of human expertise remains indispensable. The successful adoption of AI in healthcare hinges not only on technological progress but also on strategic workforce planning, comprehensive policy frameworks, and a culture of continuous learning. By aligning AI capabilities with healthcare workforce development, decision-makers can ensure that AI serves as an enabler of efficiency, accuracy, and accessibility rather than a disruptive force, ultimately improving patient outcomes and system-wide resilience.

AI is revolutionizing disease prevention, healthcare system efficiency, and community-based care models. From nanobots and biosensors to robotic surgery and telemedicine, AI-powered solutions are reshaping patient care, workforce management, and cost efficiency. However, the success of these technologies depends on ethical governance, data standardization, and equitable access. As AI continues to evolve, it has the potential to transform healthcare into a predictive, preventive, and patient-centric system. As AI continues to evolve, its ethical, regulatory, and socio-economic implications

require careful consideration to ensure responsible and beneficial deployment (Floridi et al., 2018).

4. Application Areas: Transforming Healthcare Delivery and Patient Experience

The rapid evolution of digital technologies is profoundly reshaping healthcare systems across the globe. Emerging innovations are not only improving the efficiency and quality of care delivery, but also redefining the patient experience through more personalized, accessible, and proactive health services. By integrating Artificial Intelligence (AI), telemedicine, wearable devices, and immersive technologies, the healthcare sector is transitioning from reactive treatment models to holistic, preventive, and participatory approaches. These technological transformations impact all dimensions of health—biological, psychological, and social—and are essential for creating resilient, equitable, and future-ready systems of care.

This section outlines the main domains in which these digital technologies are currently being applied, highlighting their implications for patients, healthcare professionals, and health systems as a whole.[4]

1. **Telemedicine**. Digital platforms facilitate remote consultations and monitoring, supported by AI, VR, and robotics. These tools help overcome geographic barriers, enhance access to care in underserved regions, and enable early intervention through continuous patient monitoring.
2. **Self-Assessment and Self-Management Tools**. Chatbots, mobile apps,

4 For additional technical details and references, please refer to the online Appendix A.2.

and wearable devices empower individuals to monitor symptoms, manage chronic diseases, and make informed decisions. These tools support behavioral change and health literacy while promoting patient agency.

3. **Preventive Medicine.** Predictive analytics, digital biomarkers, and public health surveillance systems enable early identification of disease risk and targeted intervention. This technology-driven approach supports proactive health behaviors and community-level prevention.
4. **Clinical Decision Support Systems (CDSS).** AI and Natural Language Processing (NLP) tools assist clinicians in diagnostics and treatment planning by synthesizing patient data and medical evidence, thereby enhancing accuracy, consistency, and confidence in clinical decisions.
5. **Point-of-Care Diagnostics.** Portable diagnostic devices, often enhanced with microfluidics and AI, offer real-time results at or near the site of care, reducing delays and expanding testing access outside of traditional clinical settings.
6. **Digital Biomarkers.** Data from wearables and sensors provide continuous insights into physiological and behavioral patterns, allowing for personalized health tracking and early detection of abnormalities.
7. **In Silico Medicine.** Computational models simulate biological systems and treatment responses, supporting precision medicine and the development of digital twins for patient-specific care planning.
8. **Digital Therapeutics (DTx).** Software-based interventions deliver cognitive behavioral therapies and chronic disease management tools, improving treatment adherence and mental health outcomes through personalized and scalable solutions.
9. **Pain Management.** Technologies such as VR therapy, AI-guided neuromodulation, and wearable stimulators offer innovative alternatives

for managing chronic and acute pain without pharmacological dependence.

10. **Health Literacy.** LLMs, multimedia platforms, and immersive tools enhance the accessibility of medical information, improving patient understanding and informed decision-making.
11. **Digital Consent.** Interactive and secure digital platforms modernize the informed consent process, making it more transparent, accessible, and compliant with ethical and legal standards.
12. **Digital Clinical Trials.** Remote recruitment, real-world data collection, and AI-enhanced data analysis improve the efficiency, inclusiveness, and scalability of clinical research protocols.
13. **Digital Surveillance Systems.** AI-driven systems integrate diverse data sources to detect outbreaks, assess public health risks, and support timely responses to emergencies.
14. **Virtual and Physical Assistants.** AI-powered virtual agents and assistive robotics support both patients and healthcare workers by reducing workloads and enhancing mobility, interaction, and care coordination.
15. **Age-Friendly Solutions.** Tailored technologies such as social robots, simplified telehealth platforms, and wearable monitors promote independence, safety, and social engagement among older adults.
16. **Innovative Health Data Representations.** Data visualization tools, 3D medical imaging, and digital twin technology improve the interpretation of complex health information for both patients and providers, enhancing clarity and shared decision-making.

5. Maturity Assessment of Digital Health Solutions

As digital technologies increasingly permeate healthcare, the concept of maturity assessment has emerged as a critical tool for evaluating the current development stage, adoption feasibility, and systemic impact of digital health solutions. Assessing the maturity of these innovations is essential for understanding not only their technical robustness but also their readiness for integration into clinical workflows, health system governance, and public acceptance. This multidimensional evaluation framework allows policymakers, investors, and healthcare managers to prioritize interventions, allocate resources efficiently, and foresee potential regulatory or economic challenges.

Maturity in digital health can be dissected into at least three interrelated domains: technological readiness, innovation diffusion, and societal acceptance. Technological readiness refers to the level of technical development and performance reliability of a solution. This includes the solution's functionality, interoperability, and scalability. For instance, while some AI-based diagnostic tools have achieved high levels of technical maturity and clinical performance (Esteva et al., 2019), others remain experimental and lack validation across diverse population groups (Topol, 2019a,b).

Innovation readiness refers to the extent to which a digital health solution is integrated into clinical and administrative processes. A highly innovative product may still fail to gain traction if health institutions lack the infrastructure or capacity to adopt it effectively (Greenhalgh et al., 2017). Meanwhile, societal readiness involves public trust, ethical acceptability, and cultural alignment. Technologies such as telemedicine, though technically viable for over a decade, experienced delayed widespread adoption in part due to concerns about data privacy, patient-doctor interaction, and reimbursement pol-

icies—concerns that only began to shift substantially during the COVID-19 pandemic (Whitelaw et al., 2020).

Understanding these varying levels of maturity is not merely an academic exercise. It has profound implications for regulatory strategy and healthcare expenditure. Technologies at a low maturity stage may require regulatory sandboxes, pilot testing, or conditional approvals to balance innovation with safety. In contrast, highly mature solutions may warrant accelerated pathways and systemic integration incentives. Moreover, maturity assessment informs cost-effectiveness analyses, as immature technologies often entail high initial costs, uncertain returns, and organizational disruption (Huang et al., 2019). In contrast, mature technologies with proven clinical utility can drive long-term cost savings through better disease management, prevention, and operational efficiencies.

The European Commission has also underscored the importance of technology readiness assessment as a prerequisite for large-scale investment and public-private collaboration in health innovation (European Commission, 2020b). In the UK, the NHS has adopted digital maturity indices to evaluate the readiness of healthcare providers to integrate technologies and support decision-making in national funding allocations (NHS England, 2019).

Below and in Table we report and discuss the maturity assessment of some key digital health applications:

- Technological Readiness Levels (TRL). This framework assesses the maturity of a technology based on a scale of 1 to 9, with 9 being the most mature (Mankins, 1995). Telemedicine is generally considered to be at TRL 9, as it is widely deployed and commercially available in many healthcare systems. mHealth apps for medication safety range from TRL 7 to 9, with various apps available to support clinical deci-

sions and enhance medication use monitoring, although their effectiveness is still under investigation (Willemse et al., 2024) . VR for anxiety reduction is estimated at TRL 6 to 7, having demonstrated efficacy in research settings and gradually moving towards broader clinical adoption (Donnelly et al., 2021). LLMs for virtual assistants are currently at TRL 5 to 7, showing promising results in research but still in the early stages of integration into clinical practice (Omar et al., 2024). Digital biomarkers, such as the DMOs being developed by the Mobilise-D consortium, are generally at TRL 4 to 6, indicating that they are under development and validation (Rochester et al., 2020).

- HealthTech Innovation Readiness (HIR). This level assesses the readiness of a health technology for adoption and scaling within healthcare systems, considering factors such as clinical validation, regulatory approval, and market viability (CIMIT, 2017). Telemedicine has a High HIR as it is well-integrated into many healthcare systems and has established reimbursement models. mHealth apps have a Medium to High HIR, with increasing adoption rates, but challenges remain regarding regulation and the need for robust evidence of their clinical impact. VR for anxiety reduction has a Low to Medium HIR, requiring further integration into clinical workflows and demonstration of cost-effectiveness to achieve widespread adoption. LLMs for virtual assistants currently have a Low to Medium HIR due to ongoing concerns around data privacy, accuracy, and the need for clear regulatory pathways. Digital biomarkers also have a Low to Medium HIR, facing challenges in standardization, validation, and seamless integration with existing clinical data systems.
- Societal Readiness Levels (SRL). This level reflects the societal accep-

tance, ethical implications, and regulatory frameworks surrounding a particular technology (Innovation Fund Denmark, 2015). Telemedicine has a High SRL, as it is generally accepted by both patients and healthcare providers, and regulatory frameworks are largely in place. mHealth apps have a Medium SRL, with some public concerns regarding data privacy, security, and the quality of health information provided. VR for anxiety reduction has a Medium SRL, with potential concerns related to accessibility, usability, and the immersive nature of the technology for some individuals. LLMs for virtual assistants currently have a Low to Medium SRL due to significant ethical considerations surrounding potential biases, the accuracy of information provided, and the potential for replacing human interaction in care; regulatory frameworks are still in the early stages of development. Digital biomarkers have a Medium SRL, with ongoing discussions around data ownership, privacy, and the appropriate interpretation of continuous data streams generated by these technologies.

Table 1 **Maturity Assessment of Key Digital Health Applications**

Application	Enabling Technology (ies)	TRL	HIR	SRL	Example/Source
Telemedicine	Digital technologies, IoT	9	High	High	Widely used for remote consultations.
mHealth apps for medication safety	Mobile health, AI	7-9	Medium-High	Medium	Apps providing medication reminders and information (Fang et al., 2023).
VR for anxiety reduction	VR	6-7	Low-Medium	Medium	Study showing reduced anxiety in cancer patients (Alvarado-Omenat et al., 2025) .
LLMs for virtual assistants	AI (LLMs, NLP)	5-7	Low-Medium	Low-Medium	Improved accuracy for complex health inquiries (Omar et al., 2024).
Digital mobility outcomes (DMOs)	Wearable sensors, AI	4-6	Low-Medium	Medium	Development by Mobilise-D consortium for remote monitoring (Rochester et al., 2020) .

In conclusion, assessing the maturity of digital health solutions is essential to aligning innovation trajectories with system-wide priorities and constraints. It enables a proactive, evidence-informed approach to health technology governance, ensuring that emerging solutions contribute meaningfully to clinical outcomes, system sustainability, and equitable access.

6. Potential Impacts: Transforming Healthcare Outcomes, the Organization, and the Healthcare Expenditure.

As seen in the previous sections, digital technologies are playing an increasingly transformative role in the healthcare sector, reshaping not only the quality of clinical outcomes but also the overall organization and the economic dynamics of health systems. As global healthcare systems contend with the mounting pressures of aging populations, rising chronic disease prevalence, and budgetary constraints, the adoption of digital innovations such as AI, telemedicine, remote monitoring, and integrated health platforms is enabling new models of care that are more personalized, efficient, and sustainable.

Table 2 **Potential Impacts of New Technologies in Healthcare**

Application Area	Impact Category	Specific Impact	Supporting Data/Examples
AI-powered diagnostics	Clinical Outcomes	Improved survival rates through early disease detection.	AI aiding in the interpretation of medical imaging.
Remote Patient Monitoring	Clinical Outcomes	Better management of chronic conditions, reduced hospital readmissions.	Continuous glucose monitoring for diabetes management.
VR for mental health	Clinical Outcomes	Reduction in anxiety and pain.	VR significantly decreased anxiety in cancer patients.
Decentralized Clinical Trials	Cost-Effectiveness	Lower costs and faster recruitment for clinical trials.	Digital platforms enabling remote participation.
Telemedicine	Social Benefits	Increased access to care for remote and underserved populations.	Telehealth improving patient access.
Digital Health Ecosystems	Workforce Shift	Emergence of new roles like telehealth coordinators and data analysts.	Integration of LLMs into VA platforms.
All Application Areas	Education/Reskilling	Need for training in using new technologies and interpreting digital data.	Healthcare professionals needing skills in telemedicine and AI-driven tools.

Table 2 summarizes some of the directions along which impacts are observed. Below, we discuss in more detail these impacts following the categories listed in Table.

Clinical Outcomes. From a clinical perspective, digital tools have significantly improved diagnostic accuracy, treatment personalization, and disease monitoring, leading to better health outcomes. AI algorithms are now capable of detecting conditions like diabetic retinopathy, breast cancer, and cardiac arrhythmias with levels of accuracy comparable to, or even exceeding, human specialists (Esteva et al., 2019; Topol, 2019a,b). Similarly, digital biomarkers and wearable devices allow for continuous, real-time monitoring of patients with chronic conditions such as heart failure or diabetes, enabling earlier interventions and reducing emergency hospitalizations (Insel, 2017; Steinhubl et al., 2015). Digital health platforms also foster greater patient engagement and adherence by delivering tailored health information and facilitating two-way communication with care teams (Murray et al., 2011). AI-driven diagnostic tools can lead to earlier and more accurate diagnoses, which can dramatically increase survival rates for diseases like lung cancer, potentially improving the five-year survival rate from 10% to 70% (Huang, Yang et al., 2023). AI-enhanced surgery tools, such as the Da Vinci Surgical System, can improve surgery accuracy by around 16.3% and reduce surgery times in over 57% of cases [9]. Remote patient monitoring systems, particularly those powered by AI, have been shown to decrease patient visits to physicians by 47% and reduce hospital admissions of elderly patients by 40% (Morrish et al., 2023). Predictive analytics can also forecast in-hospital mortality with an AUC-ROC of 0.86 (Li et al., 2025). AI-powered systems can detect early signs of diseases like Alzheimer's, COPD, and kidney disease years before

symptoms appear, allowing for timely interventions (Tang & Sirota, 2024). Furthermore, AI-driven systems have demonstrated the ability to detect diseases like skin cancer and diabetic retinopathy with accuracy comparable to that of experienced clinicians (Esteva et al., 2017). These advancements support the shift toward more personalized and preventive care models, allowing for timely, data-informed decisions that improve the trajectory of treatment and recovery. Additionally, wearable devices and mobile health applications have empowered patients—particularly those with chronic conditions—to monitor and manage their health actively, leading to better adherence to care plans and fewer hospital readmissions (Kvedar et al., 2016).

Cost-Effectiveness. The implementation of new technologies in healthcare also shows promise in terms of cost-effectiveness. AI-driven automation of administrative tasks, such as managing patient records and scheduling appointments, has the potential to save billions annually (Lavoie-Gagne et al., 2025). AI can also improve the speed and accuracy of detecting fraudulent Medicare claims, leading to significant financial savings (Florida Atlantic University, 2023). Predictive analytics can optimize resource allocation in hospitals, improve the accuracy of health insurance rate calculations, and prevent fraudulent insurance claims, contributing to overall cost reduction (Nwosu, 2025). Telemedicine has been found to be a cost-effective alternative for delivering outpatient care, reducing costs for both patients and the healthcare system.

Workforce Shift. These technological changes are also reshaping the healthcare workforce. The integration of new technologies will inevitably lead to a shift in the healthcare workforce, requiring new skills and professions. While

technology is not expected to replace healthcare professionals entirely, it will augment their capabilities and change the nature of their tasks (World Economic Forum, 2023). Tasks traditionally performed by physicians or nurses—such as triaging patients, interpreting test results, or providing follow-up instructions—can now be supported or automated by intelligent systems. The automation of administrative processes such as scheduling, billing, and documentation has reduced the burden on clinical staff, freeing up time for patient interaction and care delivery. In fact, AI will likely minimize the time physicians and nurses spend on routine administrative tasks, allowing them to focus more on direct patient care (Bundy et al., 2024). This shift allows human resources to be reallocated to more complex, relational, or supervisory roles, contributing to a more flexible and resilient workforce model (OECD/European Union, 2020). Moreover, remote care models and telemedicine have the potential to redistribute workloads geographically, reduce provider burnout, and expand access to underserved areas (Whitelaw et al., 2020). New tech-based roles are expected to emerge, such as telemedicine specialists, healthcare data analysts, AI and robotics technicians, and cybersecurity experts. While some roles may evolve or be replaced by automation, digital technologies are more likely to augment human capabilities rather than eliminate them. The effective use of AI and data analytics can enhance clinical decision-making and operational efficiency, but human judgment, empathy, and communication remain essential in patient care. This balance between technology and the human element will be central to the success of digital transformation in healthcare.

Education and Reskilling. Healthcare professionals will need to develop new skills and training, particularly in data literacy, human-machine interaction,

and ethical oversight, including skills in using EHR systems, telemedicine platforms, and AI and data analytics applications (Doll et al., 2024). Continuous professional development programs will need to evolve to incorporate training on these new technologies and skills. To prepare the healthcare workforce for the digital future, significant efforts in education and reskilling will be required (Ferreira et al., 2025). Healthcare professionals must now collaborate across interdisciplinary teams in increasingly complex digital ecosystems. As Topol (2019a,b) notes, this transformation necessitates a rethinking of medical education and continuous professional development to prepare workers for a technology-augmented clinical environment. Healthcare institutions will need to offer comprehensive training programs catering to various skill levels, from basic digital literacy to advanced specialist programs in areas like clinical informatics and data science. Governments can play a key role by creating policies and incentive schemes to support the digital transformation of healthcare services and promote digital upskilling and retraining of healthcare professionals (McKinsey & Company, 2019). Partnerships between academia and industry will be crucial for developing relevant curricula and ensuring that healthcare professionals acquire the necessary skills to work effectively with new technologies (Brooks, 2023). To fully realize the potential of digital health innovation, healthcare systems must invest not only in new technologies but also in the training and support of their workforce. Infrastructure development, equitable access to digital tools, and ethical considerations around data use are equally crucial to ensuring that these innovations translate into meaningful and inclusive improvements. In the years ahead, the synergy between technological advancement and human-centered care will be a defining feature of successful healthcare systems.

Social Benefits. The social benefits of new technologies in healthcare are wide-ranging. Telemedicine can improve access to care for underserved rural areas and vulnerable populations, breaking down geographical barriers and reducing health inequities. AI-assisted medical services can also benefit these underserved areas (Cruickshank, Wade & Bajwa, 2024). AI can help overcome language barriers in healthcare settings through translation capabilities (Genovese et al., 2024). Digital health interventions can empower patients to actively manage their health and boost their participation in shared decision-making (Pierce et al., 2025). AI-driven tools can also help to assess ambulance needs and optimize resource allocation, ensuring timely medical assistance (Selvan et al., 2025). Furthermore, AI has the potential to reduce human decision-making biases in healthcare, contributing to more equitable care.

The integration of digital technologies also brings important implications for healthcare expenditure. While some innovations entail high upfront investments in infrastructure, software, and training, their long-term use may yield cost savings through reduced hospitalizations, better disease management, and improved workflow efficiencies (Meskó et al., 2017). For instance, predictive analytics can help optimize resource allocation and identify at-risk populations early, thereby reducing unnecessary procedures and admissions (Rajkomar et al., 2019). Nonetheless, there is a risk of widening disparities if these technologies are unevenly adopted or if cost savings are not reinvested equitably.

Finally, while the potential benefits of digital health are substantial, their realization depends on appropriate regulatory frameworks, interoperability standards, and governance mechanisms. Ensuring the safe, equitable, and effective deployment of these tools requires cross-sector collaboration and

strong leadership from both health institutions and policymakers. In sum, digital technologies are catalyzing a fundamental transformation in how care is delivered, measured, and experienced. They hold promise not only for improving clinical outcomes but also for reshaping the healthcare workforce and promoting financial sustainability. Realizing this potential, however, requires thoughtful planning, inclusive design, and continuous evaluation to ensure that innovation supports both efficiency and equity in healthcare systems.

7. Regulating Innovation in the Healthcare Sector

As we have seen above, digital medicine is at the forefront of a profound transformation in healthcare delivery. The rapid acceleration of digital innovation in healthcare presents a profound challenge to existing regulatory frameworks, particularly in national health systems such as the NHS. By integrating technologies such as artificial intelligence, mobile health applications, wearable sensors, telemedicine platforms, and genomics into everyday clinical practice, digital medicine promises to radically improve how care is delivered, accessed, and experienced. While these tools hold immense promise for improving patient outcomes, system efficiency, and equity, they also introduce significant risks related to safety, accountability, data governance, and ethical compliance. However, the swift and disruptive nature of these innovations has outpaced the capacity of traditional regulatory frameworks to ensure their safe, equitable, and ethical deployment.

Regulation plays a dual role in this context: it must safeguard public trust and patient safety while also enabling innovation and system responsiveness.

In the NHS, this balancing act has become increasingly complex as digital technologies blur the boundaries between medical devices, consumer health tools, and data platforms (Nuffield Council on Bioethics, 2018). Traditional regulatory models—designed mainly for pharmaceuticals and hardware-based devices—struggle to accommodate the iterative nature of AI algorithms, the decentralized nature of digital platforms, and the shifting locus of care from hospitals to homes and smartphones (Topol, 2019a,b).

Historically, healthcare regulation has evolved to address the safety, efficacy, and quality of more conventional technologies, such as pharmaceuticals and medical devices. These tools are typically well-defined, subject to lengthy clinical trials, and relatively stable in their behavior once approved. In contrast, digital technologies often function in real-time, involve adaptive machine learning systems, and operate in highly data-rich environments. As such, regulating digital medicine requires rethinking not just the tools of oversight but the very principles underpinning health governance in the digital age.

The role of regulation in digital medicine is more critical than ever, given the complex, interconnected nature of these technologies and the potential risks they pose to patients and health systems if left unchecked. The principal aims of regulation—ensuring public safety, promoting transparency, securing data integrity, and fostering public trust—must be maintained and extended to new areas introduced by digital innovation. Without appropriate regulatory mechanisms, the benefits of digital medicine may be undermined by unintended harms, including the misuse of personal data, exacerbation of health disparities, or the deployment of untested or ineffective technologies.

7.1 Emerging Regulatory Frameworks and Approaches

In response to these emerging needs, regulators in various jurisdictions have begun to adapt their approaches. In the European Union, the proposed Artificial Intelligence Act represents one of the most comprehensive efforts to date to regulate AI technologies, including their use in health. This proposal introduces a risk-based framework in which AI applications are categorized according to the level of risk they pose to users. Medical AI tools are typically classified as high-risk, which subjects them to stricter regulatory scrutiny, including requirements for transparency, human oversight, and post-market monitoring (European Commission, 2021).

In the United States, the Food and Drug Administration (FDA) has established the Digital Health Center of Excellence, an initiative aimed at developing regulatory science and guidance for the safe and effective use of digital health tools. The FDA has also explored the use of "software precertification" models that streamline the approval process for developers with proven track records of quality and responsibility while still maintaining rigorous safety standards (FDA, 2020).

In the United Kingdom, the Medicines and Healthcare products Regulatory Agency (MHRA) has updated its approach to covering Software as a Medical Device (SaMD), including AI-driven tools. Concurrently, the National Institute for Health and Care Excellence (NICE) has issued a comprehensive evidence standards framework for evaluating digital health technologies. This framework assesses both the clinical and economic value of digital interventions, aiming to ensure that innovations deliver meaningful benefits to patients while representing an efficient use of public resources (NICE, 2022).

One of the key regulatory challenges is the assessment of safety and effec-

tiveness in real-world settings. AI-driven clinical decision tools, for instance, may evolve through machine learning after deployment, raising questions about how to ensure continued compliance with safety standards (Hatherley, 2020). Regulatory bodies such as the MHRA and NICE are increasingly tasked with developing agile frameworks that can account for "adaptive algorithms" and software as a medical device (SaMD). The recent establishment of the NHS AI Lab and its Regulatory Sandbox initiative reflects a growing institutional recognition of the need for collaborative, flexible, and anticipatory regulatory models (NHSX, 2021).

In parallel, data governance has emerged as a cornerstone of digital health regulation. One of the defining features of digital medicine is its reliance on real-time data collection and analysis. Many digital health tools function continuously and adaptively, drawing on user inputs, environmental data, or system feedback to modify their outputs. This continuous evolution means that regulatory assessments must also be continuous, capable of tracking post-deployment behavior and ensuring long-term reliability and safety. Static models of regulatory approval, based on pre-market evaluation alone, are increasingly inadequate for overseeing the dynamic nature of digital technologies. With increasing reliance on large-scale patient data—often stored in cloud-based systems or shared across providers—ensuring the integrity, security, and privacy of health information is paramount. The UK General Data Protection Regulation (UK GDPR), which aligns with the EU's framework, mandates strict rules around data processing, consent, and patient rights. However, operationalizing these principles in dynamic, data-rich environments like those generated by real-time health monitoring or predictive analytics remains a significant challenge (Morley, Machado et al., 2020).

Furthermore, the sensitive nature of health data, which is central to the

functioning of most digital health applications, raises urgent questions about privacy and data protection. Regulations must, therefore, address not only the performance of technologies but also the ethical and legal dimensions of data governance. This includes the way in which data are collected, stored, shared, and interpreted, particularly when algorithms are involved in making or supporting clinical decisions. As digital medicine becomes more reliant on predictive analytics and AI-driven recommendations, the need for stringent, clearly defined regulatory standards becomes paramount.

7.2 Persistent Regulatory Challenges

Despite these promising developments, a number of unresolved challenges persist. One of the most pressing is the discrepancy between the speed of innovation and the pace of regulatory adaptation. Technological change, particularly in digital health, is moving rapidly. New applications, updates, and iterations regularly emerge, while regulatory processes often remain slow, deliberative, and reliant on lengthy evidence-generation cycles. This mismatch can result in delays in the deployment of beneficial technologies or, conversely, the premature release of insufficiently vetted tools into clinical practice.

Another significant challenge is the lack of transparency in algorithmic processes. Many AI-driven systems function as "black boxes," offering little visibility into how outputs are generated. This opacity complicates regulatory evaluation, especially in clinical contexts where the rationale behind a recommendation or diagnosis must be clear and defensible. When clinicians are expected to trust or act upon AI-generated insights, regulators must ensure that these systems are not only accurate but also explainable and accountable

(Hatherley, 2020; Leslie, 2021). In addition to technical and procedural challenges, the regulation of digital medicine must contend with profound ethical concerns. These include questions about equity and access, particularly for populations that may lack digital literacy, reliable internet connectivity, or access to smart devices. Regulators must ensure that digital innovation does not deepen existing health inequalities but rather contributes to more inclusive and equitable health systems.

Moreover, the globalization of digital health technologies raises questions about harmonization. While some jurisdictions move quickly to regulate, others lag behind, resulting in regulatory fragmentation. This inconsistency can hinder the development of international markets, reduce clarity for developers, and complicate the implementation of cross-border digital health solutions. Greater alignment in international standards and regulatory cooperation is urgently needed to support the responsible globalization of digital medicine (WHO, 2021).

Looking ahead, the future of regulation in digital medicine will depend on the ability of institutions to embrace adaptive governance—a model that allows for regulatory flexibility while maintaining core principles of safety, efficacy, and equity. Adaptive governance involves continuous learning, feedback loops, stakeholder engagement, and iterative policymaking. Mechanisms such as regulatory sandboxes—controlled environments where new technologies can be tested under supervision—offer valuable models for balancing innovation with oversight. Equally important is the integration of ethics into regulatory design. As digital health tools become more pervasive, regulators must consider not only how these tools function technically but also how they shape relationships between patients and providers, affect autonomy and consent, and influence clinical judgment. Ethical frameworks, such as those pro-

posed by the Alan Turing Institute and others, can provide foundational principles for responsible regulation and guide the development of policies that reflect both technological realities and societal values (Floridi et al., 2018).

In conclusion, regulation in digital medicine is not an afterthought; it is a central pillar of sustainable innovation. As healthcare systems increasingly rely on digital tools to address challenges of access, efficiency, and quality, the need for thoughtful, robust, and future-oriented regulation becomes more urgent. Regulatory institutions must evolve alongside the technologies they oversee, adopting adaptive models of oversight, fostering transparency, protecting individual rights, and ensuring equitable access to the benefits of digital health. Only through such a coordinated and principled approach can digital medicine fulfill its promise to transform healthcare for the better.

7.3 Regulation of Large Language Models in Healthcare: Navigating Emerging Challenges

The rapid advancement of large language models (LLMs) has spurred considerable excitement about their potential to transform healthcare delivery. LLMs—sophisticated artificial intelligence systems that generate human-like text—are being explored for an array of applications, ranging from patient education and communication to clinical documentation and decision support. Specifically, LLMs are being explored for tasks such as answering patient queries, summarizing or translating complex medical texts, and supporting documentation processes (Rathnayake et al., 2023). Their capacity to interpret and produce natural language aligns closely with patient-centered care

goals, including accessibility, personalization, and informed decision-making. However, as these technologies become more integrated within healthcare systems, significant regulatory challenges have emerged that demand scrutiny. These challenges encompass issues of safety, accuracy, transparency, data privacy, and the ethical use of patient information, calling for the development of adaptive and robust regulatory frameworks.

It is important to distinguish between regulatory frameworks developed for artificial intelligence (AI) broadly and those that are (or should be) tailored to LLMs specifically. General AI regulation often focuses on risk classification, transparency, and explainability in algorithmic decision-making. However, LLMs present unique regulatory concerns due to their generative nature, probabilistic outputs, and unpredictability in language generation. Unlike AI systems trained for narrow, rule-based tasks (e.g., image classification), LLMs operate with vast, generalized language corpora and can produce unstructured text that mimics human discourse without providing verifiable reasoning or clinical grounding (Leslie, 2021). This introduces regulatory blind spots around the authorship, reliability, and legal accountability of outputs—especially when LLMs are embedded in clinical decision support tools or used directly in patient communication. Regulatory frameworks must, therefore, include content auditing, usage boundaries, and domain-specific fine-tuning requirements that account for the distinctive risks LLMs pose in healthcare contexts.

According to Meskó & Topol (2023), LLMs in healthcare face unique regulatory hurdles compared to more traditional AI applications. Their generative nature means that LLMs do not simply classify or predict outcomes but actively produce text-based content. These characteristics raise concerns over the accuracy and completeness of the information provided, especially when

the language output informs clinical decisions or patient self-management. As highlighted in the article, cases of biased, incomplete, or even potentially misleading outputs underscore the risk that LLMs pose if their use is not adequately controlled. Busch et al. (2025) have conducted a recent systematic review of 89 studies across 29 medical specialties (conducted between 2022 and 2023) where they find that while LLMs are already being tested in clinical and patient-facing contexts, most are not optimized for medical environments. Critical concerns include a lack of transparency in data provenance, limited adaptation to clinical language, and insufficient safeguards to ensure output accuracy. These issues raise ethical and safety questions, particularly as LLMs may generate content that is inaccurate, incomplete, or biased, potentially misleading both patients and clinicians (Hatherley, 2020; Morley et al., 2020).

Moreover, the opacity of LLMs—often described as the "black box" problem—complicates the regulatory process. Traditional regulatory frameworks are typically geared toward static, well-understood technologies. In contrast, LLMs are dynamic, frequently updated systems that continuously learn from new data inputs. This fluidity challenges existing approval processes and demands continuous monitoring and post-deployment audits (Leslie, 2021). Furthermore, the data used to train these models often include sensitive patient health information, making compliance with existing data protection regulations, such as the UK GDPR and HIPAA in the United States, a critical but complex issue (Morley, Floridi et al., 2020; Morley, Machado et al., 2020).

Given these challenges, regulation must play a multi-faceted role, and it is pivotal in governing the development and deployment of LLMs in healthcare. Regulatory oversight must address not only traditional dimensions of medical device safety and efficacy but also novel considerations such as algorith-

mic bias, explainability, and dynamic learning. Unlike conventional medical technologies, LLMs may evolve post-deployment—changing their behavior in response to new data or updates—which challenges static approval models and demands continuous monitoring mechanisms (European Commission, 2020b).

First and foremost, regulation should ensure that LLMs deployed in healthcare are safe and effective. This involves not only the initial approval based on technical performance and clinical validation but also establishing mechanisms for ongoing monitoring to capture any deviations from approved behavior as the models evolve. Regulatory bodies need to implement guidelines that require transparency in the training data and decision-making processes of LLMs, along with clear accountability for any errors or adverse outcomes (European Commission, 2021).

Second, regulatory frameworks should address issues of data governance. With the increasing reliance on vast datasets, proper handling of patient data becomes paramount. Regulations must stipulate robust data anonymization techniques and secure data-sharing protocols. Furthermore, ethical oversight is required to ensure that the benefits of LLMs—such as improved patient education and streamlined clinical workflows—do not come at the expense of patient autonomy or privacy (WHO, 2021).

Third, the regulation of LLMs needs to be adaptive. Because these models can evolve post-deployment, static regulatory approval is insufficient. Instead, regulators should consider adaptive regulatory frameworks—such as regulatory sandboxes and real-time performance audits—that allow experimentation under controlled conditions while ensuring patient safety (Hatherley, 2020). This adaptive approach also provides a mechanism for the periodic re-evaluation of LLMs to keep pace with technological advancements and evolving

clinical contexts.

Moreover, LLMs pose complex challenges related to data privacy and consent, particularly when trained on or applied to sensitive health data. Compliance with data protection laws such as the UK GDPR and HIPAA in the U.S. is not always straightforward, especially when model training involves indirect exposure to identifiable information (Leslie, 2021). In this context, frameworks such as the EU's proposed AI Act and the WHO's guidance on trustworthy AI in health are essential in shaping future regulatory responses (European Commission, 2021; WHO, 2021).

In summary, the integration of LLMs into healthcare holds transformative promise but also presents significant regulatory challenges. A comprehensive regulatory framework must not only ensure safety, efficacy, and transparency but also be dynamic enough to respond to the continually evolving nature of these technologies. Policymakers, regulatory agencies, and healthcare providers need to work in tandem to develop adaptive regulatory models that balance the benefits of innovation with the imperatives of patient safety, data governance, and ethical use. As the digital revolution accelerates, the ongoing evolution of regulation will be critical in shaping how LLMs and other digital health technologies ultimately contribute to improved healthcare outcomes and more efficient healthcare systems. Ultimately, effective regulation must strike a balance between innovation enablement and risk mitigation. Regulatory sandboxes, algorithmic impact assessments, and interdisciplinary oversight bodies may offer pathways for safe experimentation and iterative improvement. Given their far-reaching implications, LLMs should be subject to a robust, context-sensitive regulatory regime that evolves alongside the technologies themselves, prioritizing transparency, accountability, and patient safety.

7.4 The Role of Health Technology Assessment in Digital Medicine

The evaluation of value for money and cost-effectiveness in digital health interventions requires new approaches. Traditional health technology assessment (HTA) methods, which are often based on static clinical trials and fixed pricing models, may not be well-suited to rapidly evolving technologies with complex pricing structures or data-driven value creation (Drummond et al., 2020). The rapid rise of digital medicine and diverse functionalities pose unique challenges to traditional methods of evaluating medical technologies. In this evolving context, Health Technology Assessment (HTA) must adapt to ensure that digital health interventions are rigorously assessed for their safety, effectiveness, value for money, and broader ethical and societal impacts. HTA is a multidisciplinary process that systematically evaluates the medical, social, economic, and ethical implications of the development, diffusion, and use of health technologies. Historically, HTA has focused on pharmaceuticals, medical devices, diagnostic tests, and surgical procedures. The core objectives have remained consistent: to inform decision-making by payers, policymakers, and clinicians, ensure the optimal allocation of limited resources, and promote evidence-based adoption of new technologies (Drummond et al., 2015).

With the expansion of digital medicine, HTA now faces new frontiers. Unlike conventional health technologies, many digital interventions are software-based, data-intensive, and iterative in nature, often updated in real-time or through machine learning mechanisms. These characteristics challenge static, one-time assessments and call for more dynamic and lifecycle-based HTA frameworks. Assessing digital health technologies requires expanding the methodological scope of HTA in several key ways. First, traditional clin-

ical trials may be ill-suited to evaluate many digital tools, particularly mobile apps or AI-driven systems that evolve rapidly or operate in decentralized care settings. Alternative methodologies—such as real-world evidence (RWE) studies, pragmatic trials, or adaptive designs—may be more appropriate, though they also introduce complexity in data interpretation and generalizability (Husereau et al., 2022).

Second, the value proposition of digital medicine often lies not solely in clinical outcomes but in improvements to care pathways, workflow efficiency, patient empowerment, or remote accessibility. These domains are less readily captured by standard measures such as quality-adjusted life years (QALYs) or cost-per-case avoided. As such, HTA must increasingly integrate patient-reported outcomes, user experience metrics, and qualitative evidence to fully appraise the utility of digital interventions (Taylor et al., 2021).

Third, digital health technologies pose distinct implementation and scalability challenges, including issues related to interoperability, cybersecurity, workforce readiness, and regulatory compliance. An effective HTA of digital medicine must, therefore, consider not only the intrinsic merit of a given technology but also the contextual conditions necessary for its successful deployment and sustained impact within health systems.

Economic evaluation—a central component of HTA—must also evolve to accommodate digital medicine. Traditional models of cost-effectiveness may be constrained when applied to technologies with non-linear cost structures, such as those involving subscription models, cloud-based storage, or variable costs tied to usage levels. Moreover, many digital tools may exert indirect or long-term benefits, such as reduced hospital readmissions or improved chronic disease management, which are difficult to quantify within conventional evaluation timeframes. In light of these complexities, HTA agencies such as

NICE in the UK have introduced modified evidence frameworks for digital health technologies. These frameworks propose tiered levels of evidence requirements depending on the potential risk, complexity, and intended purpose of the technology (NICE, 2022). They also emphasize the importance of early dialogue between developers and regulators to align evaluation standards with innovation cycles.

HTA in digital medicine must also engage with ethical, legal, and societal dimensions that are increasingly central to public and policy debates. This includes algorithmic transparency, bias mitigation, equitable access, and the preservation of the clinician-patient relationship in increasingly automated contexts (Floridi et al., 2018). For example, AI-based clinical tools raise concerns about algorithmic bias, explainability, and the shifting boundaries of clinical responsibility. Digital therapeutics and mental health apps raise questions about privacy, surveillance, and the digital divide. These issues necessitate the inclusion of ethical impact assessments and stakeholder engagement processes within the HTA framework (Refolo et al., 2021). Furthermore, all public healthcare systems, as public institutions with a strong equity mandate, must ensure that digital innovation does not exacerbate existing health disparities or create new forms of exclusion due to digital illiteracy, infrastructure gaps, or algorithmic bias. In addition, the distributional consequences of digital innovation must be assessed. While digital tools may expand access for some populations, they may simultaneously exclude others—particularly those with limited digital literacy, language barriers, or inadequate internet access. A comprehensive HTA should examine the equity implications of digital technologies and offer guidance on mitigating health disparities.

Given the dynamic and multidimensional nature of digital health interventions, HTA is increasingly being reconceptualized as a continuous and

iterative process rather than a single decision point. This approach, sometimes referred to as "lifecycle HTA", emphasizes early dialogue, ongoing monitoring, and post-market reassessment as key components of responsible health innovation governance (Oortwijn et al., 2017). Such models recognize that the performance and value of digital technologies can evolve significantly over time and that their successful integration into healthcare systems depends on contextual, behavioral, and infrastructural factors. This shift also aligns with the growing emphasis on adaptive regulation, in which HTA is integrated with real-time data collection, stakeholder feedback, and conditional approval mechanisms. By embedding HTA within broader digital governance structures, health systems can more effectively balance innovation with oversight, fostering environments that encourage both experimentation and accountability.

One of the distinguishing features of DTx is their dependence on sustained user engagement for therapeutic efficacy. Factors such as user interface design, personalization, feedback mechanisms, and digital literacy can all influence adherence. HTA must, therefore, consider behavioral science and usability studies as part of the clinical assessment process (Kumar et al., 2013). High attrition rates may significantly reduce real-world effectiveness even when trial results are positive.

Digital therapeutics often process sensitive health data, raising concerns about privacy, data governance, and interoperability with existing health information systems. These dimensions are increasingly incorporated into HTA, particularly under frameworks like the EU GDPR, which mandates strict data protection protocols (European Commission, 2020a). Ethical issues such as algorithmic bias, unequal access, and the commercialization of health data also require scrutiny. Some HTA bodies have begun to develop

tailored frameworks for DTx evaluation. In Germany, the Federal Institute for Drugs and Medical Devices (BfArM) has introduced the DiGA fast-track process, which allows temporary reimbursement of DTx pending further evidence of benefit. Similarly, NICE in the UK has developed the Evidence Standards Framework for Digital Health Technologies, which outlines tiered evidence requirements based on clinical risk and intended purpose (NICE, 2022). These frameworks signal a shift toward more adaptive and iterative HTA models, which recognize the dynamic nature of software and the need for continuous data collection and evaluation post-launch.

Despite progress, significant challenges remain. The heterogeneity of DTx, the lack of standardized outcome measures, and the need for long-term data complicate comparative assessments. Furthermore, capacity gaps within HTA organizations—particularly regarding digital literacy and software evaluation expertise—may hinder effective appraisal. To address these issues, there is a growing call for international harmonization of HTA methodologies, greater investment in HTA workforce development, and stronger collaboration between regulators, payers, developers, and patients. Real-time data-sharing platforms, post-market monitoring systems, and hybrid evaluation models may offer pathways toward more responsive and informed decision-making. As digital innovations proliferate and diversify, HTA methodologies must evolve to capture their unique characteristics, assess their real-world performance, and respond to the ethical, societal, and economic questions they raise. Through the development of adaptive, inclusive, and interdisciplinary frameworks, HTA can continue to provide a robust foundation for evidence-informed decision-making in the digital age of medicine.

8. Healthcare Technologies and Costs

Health technology has long been blamed for its important impact on rising healthcare costs. With its increasing complexity in recent decades, accompanied by unprecedented scarce public finances, it will continue to receive much attention from economists. While healthcare sustainability is at risk, health technology may represent both the source and the solution to the problem of mounting costs. An overwhelming number of health innovations have proven to be cost-effective and game-changing for vast portions of the world's population. However, it is less clear to what extent their introduction has indeed delivered enough value to patients and societies. The challenges for policymakers will evolve around the proper identification of technologies with adequate benefits vs. affordability, conditional on safety. On the one hand, identification is likely to be more productive if scanning of the possible technologies under development is undertaken. On the other hand, policy efforts will have to provide incentives to invest in technologies that are relevant from the social welfare point of view. Among the most innovative health technology domains, such as health information technology and precision medicine, it is utterly unclear how their evolution will shape future healthcare. Nevertheless, already acknowledged promises of digital health are likely to provide important cost reductions in the provision mechanisms of many services.

A substantial body of economic literature identifies technological advancement as a primary determinant of increasing healthcare expenditures. Building upon the seminal work of Newhouse (1992), researchers have extensively investigated this relationship. The adoption and rapid diffusion of medical technologies are widely recognized as key drivers of expenditure growth

(Cutler & McClellan, 1998; Newhouse, 1992; Okunade & Murthy, 2002; Weisbrod, 1991), with estimates attributing between 30% and 70% of cost increases to novel technologies (Australian Productivity Commission, 2005; Barros, 1998; Congressional Budget Office, 2008; Pestieau, 2006). Empirical evidence suggests that spending growth exhibits a stronger correlation with the introduction of innovative, high-cost technologies than with the escalating costs of existing treatments (Cutler & McClellan, 1996; Cutler et al., 1998).

While some scholars, including Berndt et al. (2002), Cutler (2004), and Lichtenberg (2014, 2016, 2017), have demonstrated that even costly innovations can yield significant improvements in survival rates and overall health outcomes, a more nuanced perspective is warranted. Cutler, Rosen & Vijan (2006) concluded that healthcare spending prior to 1960 generally represented a judicious allocation of resources, whereas expenditures on the older population after 1980 incurred exceedingly high costs per life-year gained. Furthermore, Skinner & Staiger (2015) emphasize that even subtle variations in technology adoption patterns can exert a substantial influence on outcomes and productivity, particularly in instances where innovations exhibit cost-effectiveness.

The Organization for Economic Co-operation and Development (OECD) has similarly observed that technological advancements contribute to escalating healthcare costs (OECD, 2017). New technologies not only command higher prices but also tend to expand the volume of services provided rather than merely substituting for existing procedures, thereby sustaining expenditure growth. Since the 1970s, healthcare spending in OECD countries has grown at a rate exceeding GDP growth by 2%, with healthcare accounting for 17.6% of GDP in the US in 2023. Projections indicate that this figure may

approach 20% by 2032. Research from the Kaiser Family Foundation has further revealed that greater availability of medical technologies is frequently associated with heightened utilization rates and increased healthcare spending (Kaiser Family Foundation, 2007). For instance, an increase in the number of MRI units has been correlated with higher utilization and spending on diagnostic imaging services. Moreover, the integration of new technologies into healthcare systems often necessitates substantial upfront investments and can lead to increased operational costs.

Although these technologies hold the potential to enhance patient care and outcomes, they concurrently contribute to the overall rise in healthcare expenditures. However, scholarly work by Becker (2007), Becker, Philipson & Soares (2005), Murphy & Topel (2003), and Nordhaus (2002) suggests that the economic benefits accruing from increased life expectancy and improved health status outweigh the costs associated with technological investment. From this vantage point, the economic value of health innovation appears to supersede its financial burden. Nevertheless, the challenges of overuse and inefficiencies in the adoption of new technologies remain salient.

According to Chandra & Skinner (2012) and Skinner & Staiger (2015), the health benefits derived from technological adoption are contingent upon the cost-effectiveness of individual innovations. Not all technologies yield proportional gains in outcomes or efficiency (Cutler, 2004). Chandra & Skinner (2012) proposed a framework categorizing technologies into (1) universally effective innovations offering high value at low cost (e.g., antibiotics); (2) targeted, high-cost innovations that are efficient when properly applied (e.g., angioplasty); and (3) marginally effective technologies incurring high costs with limited benefits (e.g., proton beam therapy for prostate cancer).

The inherent difficulties in evaluating cost-effectiveness, coupled with the

often-generous reimbursement models prevalent in both public and private healthcare systems, have contributed to the widespread diffusion of technologies based on novelty rather than demonstrated value. As technology simultaneously stimulates supply (by offering new treatment options) and demand (particularly when patient costs are subsidized), it frequently drives up total expenditures in ways that may not be commensurate with improvements in patient outcomes. To ensure the long-term sustainability of healthcare systems, it is imperative to rigorously assess the clinical value of treatments, particularly in the context of aging populations and escalating healthcare needs. Rigorous evaluation tools—such as clinical trials, health technology assessments, cost-effectiveness analyses, and real-world evidence—are indispensable for understanding the population-level impact of innovations and guiding optimal resource allocation. The OECD (2017) has observed that the cost-effectiveness of new medical technology has diminished over the past century, with rising prices and declining incremental benefits.

In the context of emerging digital technologies, the central question revolves around whether these innovations offer not only the promise of improved outcomes but also enhanced efficiency. AI-driven diagnostics, remote monitoring, and predictive analytics have the potential to streamline clinical decision-making, reduce unnecessary hospital admissions, and optimize the utilization of medical resources, thereby potentially alleviating the financial burden on both healthcare systems and patients. However, the realization of these cost-saving benefits is not guaranteed. The deployment of such technologies necessitates thoughtful planning, robust infrastructure, and regulatory oversight to ensure that efficiency gains do not compromise equity, access, or quality. Without deliberate policy interventions, there exists a tangible risk that innovation could exacerbate existing disparities rather than ameliorate

them.

Empirical research tackling this issue has followed several methodological directions. One widely used approach involves macro-level observational and econometric analyses that correlate aggregate digitalization indicators with national health spending outcomes. For instance, Ndubizu et al. (2011) analyzed data from 148 countries to examine how internet and personal computer use influenced healthcare expenditures in both public and private healthcare sectors, highlighting that the impact of digital infrastructure on health costs is not uniform but is instead significantly mediated by institutional features such as corruption and investor protections. Building on this international perspective, Kuzior et al. (2024) utilized panel regression models for 31 European countries to quantify the influence of digital determinants, such as internet access and innovation indices, on public health indicators and some aggregate expenditure measures. Although their primary dependent variables included life expectancy and self-rated health status, their application of macro-panel data reflects the field's increasing ability to capture system-level digital impacts.

Complementing these observational studies are simulation-based and cost-benefit analyses, which are particularly prominent in European research consortia. Stroetmann et al. (2007) conducted cost-benefit analyses of ten e-health applications implemented in various European countries, reporting that positive net benefits materialized over an average of five years—a timeline that highlights the necessity of medium- to long-term investment perspectives when assessing digitalization efforts. Notably, the return on investment varied by intervention, taking as little as two years for teleradiology and as long as seven years for national electronic patient records. Zamora (2012) advanced this approach with an international impact assessment of telehealth

for chronic conditions, applying break-even modeling to assess when hospitalization savings would offset daily monitoring costs and synthesizing evidence from leading country exemplars such as the UK and Italy.

At the national level, risk-oriented and simulation models further illuminate the financial implications of digital medicine. Sendek (2014), focusing on Slovakia, integrated both empirical data and projected financial scenarios to estimate the ten-year net present value of an e-health system encompassing EHRs, e-prescribing, e-referrals, and a national health portal. Cumulative projections suggested notable system-wide savings, but the specificity to one country and focus on conventional e-health functions limited the generalizability to broader definitions or international contexts. In a more recent contribution leveraging quasi-experimental techniques, Han et al. (2023) examined the effect of China's Broadband policy on healthcare expenditures using a difference-in-differences approach. Their analysis of microdata from 2010 to 2018 found that digital infrastructure investment was associated with an 18.8% reduction in healthcare spending among urban populations in pilot cities, with mechanisms likely related to improved insurance access and greater efficiency. While powerful, such single-country analyses emphasize the contingent nature of outcomes and their dependence on policy context. Similarly, studies from England utilizing randomized controlled trials have evaluated the cost-effectiveness of telehealth and telecare at a system level, finding only limited evidence for cost savings without more integrated service redesign (Henderson, 2018).

To synthesize and interpret the economic evidence at a broader scale, recent reviews and meta-analyses have aggregated cost-effectiveness data across multiple digital health interventions. Shah (2024) employed a mixed-methods and random-effects meta-analytic approach, pooling incremental cost-ef-

fectiveness ratios (ICERs) and benefit-cost ratios (BCRs) from global studies examining telemedicine, AI-health, and EHR-related interventions. While these reviews highlight both potential efficiency gains and challenges related to equity and access, most do not provide direct quantitative projections of macro-level health expenditure impacts. Sülz et al. (2021) conducted a scoping review of economic evaluations supporting independent living among older people, cataloging the range of direct and indirect cost categories considered. However, the review focused primarily on intervention-level analyses and did not attempt to quantify system-wide expenditure effects or offer forward-looking projections. Policy and modeling frameworks, such as those put forth in Codagnone et al. (2011), underline the urgent need for more sophisticated system dynamics and microsimulation methods to bridge the gap between conceptual benefit and validated macroeconomic impact—an agenda further complicated by persistent data and definitional limitations.

Finally, the study by Sapanel et al. (2025) offers an innovative approach to addressing the growing concern over rising healthcare costs driven by the integration of digital technologies. Focusing on digital therapeutics (DTx)—software-based medical interventions—the authors present a comprehensive examination of the factors that influence the economic value of DTx, which are software-based medical interventions designed to treat or manage a variety of health conditions. In the context of escalating global healthcare costs, aging populations, and increasing burdens of chronic disease, DTx technologies hold significant promise for improving health outcomes while potentially containing costs. However, their widespread adoption is hindered by the need for robust evidence demonstrating their clinical efficacy and economic value. This article employs a group concept mapping (GCM) methodology to capture the collective perspectives of 62 stakeholders—including healthcare

professionals, researchers, industry leaders, and public policy experts—across all stages of the DTx lifecycle, from development and validation to implementation and commercialization. The research identifies 59 specific factors grouped into eight thematic clusters that are perceived to impact DTx economic value. These clusters span early development stages, pre-implementation planning, and real-world deployment. Stakeholders identified two clusters—DTx Impact on Patient Outcomes and DTx Implementation—as the most critical drivers of economic value, though notably, the DTx Associated Costs and DTx Monetization Models clusters were underappreciated in actual decision-making practices, particularly among researchers. This gap suggests a misalignment between what is considered important for DTx success and what is addressed during development and implementation. The study introduces a conceptual framework that visually maps these clusters, illustrating that factors influencing DTx value are multidimensional and distributed throughout the product lifecycle, thus requiring integrated attention from all stakeholders. It also highlights the divergence of perspectives across stakeholder types; for instance, public sector respondents placed a higher emphasis on technology considerations and overall economic impact than their industry counterparts. Moreover, researchers often focused primarily on early development issues while underestimating the importance of costs and monetization strategies—factors that are crucial for achieving market viability. This discrepancy underscores a structural weakness in the current development pipeline for digital health technologies, where insufficient early attention to economic factors can limit eventual adoption and reimbursement. The article suggests that bridging this gap will require interdisciplinary collaboration, particularly involving public-private partnerships, to integrate commercialization expertise earlier in the innovation cycle. From a methodological standpoint, the

use of GCM enabled the authors to create a shared conceptual space where diverse stakeholders could articulate and organize complex ideas. This participatory and structured approach yielded not only thematic insights but also a go-zone analysis that identified priority clusters: those that are both highly important and under-considered in current practice. These insights are critical for informing the policy and strategic frameworks that underpin investment in digital health, especially as healthcare systems worldwide confront increasingly constrained resources and seek high-value interventions. The study's implications extend beyond DTx to the broader question of how new healthcare technologies can be designed, evaluated, and implemented in ways that maximize their contribution to health system sustainability. Given the high costs associated with chronic disease management and the inefficiencies in traditional care delivery models, digital therapeutics represent a potentially transformative solution—provided they are developed with a clear understanding of the economic value drivers across diverse health system contexts. The article, therefore, contributes significantly to the emerging literature on the economic assessment of digital health and underscores the importance of early, multidimensional evaluation frameworks that align technological innovation with real-world health system needs and priorities.

Overall, the current literature reveals that while digital medicine interventions are frequently associated with increased short-term costs due to infrastructure, training, and transition requirements, the realization of net system-level savings is conditional upon comprehensive and integrated implementation, favorable institutional environments, and sufficient time horizons. Causally robust, globally comparative analyses remain rare, and effects are often highly heterogeneous by country, intervention, and adoption context. The field continues to move toward richer empirical designs—incor-

porating quasi-experimental natural experiments, large-scale panel data, and meta-analytic syntheses—but the balance of evidence remains cautious regarding immediate and universal cost-saving claims.

Furthermore, despite this growing interest in the macro-level economic impacts of digital medicine, several key research gaps remain. Existing studies frequently rely on proxies for digital adoption and predominantly employ observational designs, limiting the ability to make robust causal inferences about the effect of digital medicine on health expenditures at national or global scales (Ndubizu et al., 2011; Kuzior et al., 2024). While some recent single-country analyses utilize quasi-experimental approaches to strengthen causal claims Han et al. (2023), there remains a lack of comparative, harmonized studies across diverse health systems, particularly in low- and middle-income countries (Stroetmann et al., 2007; Ndubizu et al., 2011; Zamora, 2012; Kuzior et al., 2024). Furthermore, the mechanisms through which digital medicine influences health expenditure—such as reductions in hospitalizations versus rising demand from improved access—are not fully elucidated, especially in contexts of partial or fragmented digitalization (Sülz et al., 2021; Han et al., 2023). Although simulation and projection models anticipate long-term cost savings, these claims are rarely validated using longitudinal real-world data, and short-term cost increases are commonly observed (Zamora, 2012; Sendek, 2014). Many studies also face challenges in measurement, often utilizing broad or indirect indicators of digital health and lacking advanced macroeconomic modeling frameworks (Ndubizu et al., 2011; Kuzior et al., 2024; Codagnone et al., 2011). Finally, the equity implications of digital medicine adoption remain underexplored at the macro level, with limited evidence regarding how digital health may reduce or exacerbate disparities in health spending across populations (Sülz et al., 2021; Han et al., 2023). Addressing

these gaps will require the application of stronger causal methods, the development of specific and standardized adoption indicators, the expansion of research to underrepresented regions, rigorous model validation, and systematic analysis of the mediating pathways and distributional consequences of digital health interventions.

9. Conclusions

The digital transformation currently underway in healthcare marks a critical juncture in the evolution of health systems, with implications that extend far beyond the adoption of individual technologies. Unlike previous waves of medical innovation—such as the development of antibiotics, imaging technologies, or minimally invasive surgery—which followed relatively linear trajectories and were integrated over decades, the present era is characterized by the rapid and widespread introduction of digital tools. These include artificial intelligence, big data analytics, wearable biosensors, telemedicine platforms, and personalized genomics. Together, they are reshaping not only how care is delivered and organized but also how it is conceptualized, measured, and experienced by both patients and providers.

For all healthcare systems, this digital disruption presents a dual reality. On the one hand, it offers the potential to dramatically improve health outcomes through earlier diagnosis, more accurate treatment, and better patient engagement. Digital tools can also enable more efficient use of resources, support population health management, and enhance system resilience in the face of growing demand and workforce pressures. On the other hand, these

same technologies pose significant risks and challenges. Concerns over data privacy, algorithmic bias, transparency, and uneven access raise urgent ethical and operational questions. Furthermore, many digital solutions have not yet demonstrated consistent clinical effectiveness, nor have they been thoroughly evaluated for their economic and social impacts.

A central conclusion of this analysis is that the existing structures for assessing, regulating, and scaling health technologies are not fully equipped to handle the complexity and speed of digital innovation. Traditional health technology assessment (HTA) frameworks, which rely heavily on controlled trial data and long evaluation timelines, are often ill-suited for dynamic, iterative technologies that evolve post-deployment. Similarly, static regulatory models struggle to keep pace with the adaptive nature of machine learning algorithms and the global distribution of digital health platforms.

To navigate this shifting landscape, healthcare systems must adopt more flexible, responsive, and anticipatory approaches. This includes updating HTA methodologies to incorporate real-world evidence, patient-reported outcomes, and qualitative measures of user experience. It also involves developing regulatory mechanisms that can accommodate continuous updates and enable responsible innovation without compromising safety and equity. At the same time, investments in digital infrastructure, workforce training, and institutional capacity are essential to ensure that technological benefits are not concentrated in a few areas but are distributed equitably across regions and populations.

Crucially, digital transformation should not be understood as a purely technical evolution. It represents a broader governance challenge that requires coordinated action across policy, clinical practice, ethics, and public engagement. If approached strategically, digital technologies can serve not only to

modernize care but also to reorient health systems around values of inclusivity, transparency, and sustainability.

In conclusion, the digital disruption of healthcare is both inevitable and transformative. The challenge for the healthcare systems—and health systems globally—is to ensure that the pace of innovation is matched by the development of governance structures capable of harnessing its benefits while mitigating its risks. This calls for a shift in mindset: from passive adoption to proactive stewardship, from fragmented initiatives to systemic integration, and from reactive regulation to anticipatory strategy. Only through such an approach can digital medicine become a driver of not just better care but better health systems.

More critically, policy discussions should shift from justifying rising expenditures to exploring alternative resource allocations. Would investing in education, prevention, or lifestyle interventions yield better health outcomes than expanding high-cost medical treatments? The key question should no longer be "Has increased spending been worth it?" but rather "Could we achieve greater value by reallocating resources?" This debate is particularly relevant given fiscal constraints, demographic shifts, and rising societal expectations for better healthcare. Answering this requires a robust economic framework to evaluate the impact of medical research and innovation on mortality and morbidity —one that is grounded in strong multidisciplinary partnerships across health economics, clinical and technological research, public health, and policy analysis to ensure comprehensive and actionable insights.

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Appendix

A.1. Horizon Scanning: Enabling Technologies Revolutionizing Healthcare

In the context of rapid technological change, shifting demographics, and evolving disease burdens, healthcare systems must become increasingly strategic and anticipatory in their planning. Horizon scanning has emerged as a critical tool for achieving this goal. Defined as a systematic process for identifying emerging trends, technologies, and potential threats before they become widely recognized or adopted, horizon scanning allows health systems to prepare proactively rather than reactively (National Academies of Sciences, Engineering, and Medicine, 2020).

In the healthcare sector, horizon scanning plays a key role in informing policy, research prioritization, and resource allocation. By monitoring early signals of innovation in fields such as biotechnology, artificial intelligence, personalized medicine, and digital health, it supports timely decision-making regarding health technology assessments (HTA), reimbursement models, and service redesign (Oortwijn et al., 2018). For example, many national HTA agencies in Europe, such as those coordinated through the European Network for Health Technology Assessment (EUnetHTA), have integrated horizon scanning into their early dialogue processes to inform future evaluations and guide the adoption of new technologies (EuroScan International Network, 2020).

For these reasons, we have run a horizon scanning exercise to understand what are the main technological trends that are nowadays pervading the

healthcare sector, with the aim to anticipate disruptive developments and enable governments and health organizations to invest in infrastructure, workforce development, and regulatory frameworks that are aligned with future needs. Moreover, horizon scanning contributes to a more transparent and participatory planning culture. By incorporating multidisciplinary perspectives—spanning clinical, technological, social, and ethical domains—it promotes comprehensive foresight and builds consensus around strategic priorities (Miles, 2010). In doing so, it supports the development of resilient health systems capable of adapting to complex and uncertain futures. As healthcare becomes more data-driven and interdependent with other sectors, such as technology and environmental planning, the systematic use of horizon scanning is becoming an essential component of sustainable health system governance. Its integration into national and institutional planning frameworks offers a path toward more agile, informed, and forward-looking healthcare decision-making.

The result of this exercise is summarized in Table A.1, where we report a comprehensive overview of the current and future landscape of digital enabling technologies in healthcare, presenting a taxonomy to categorize these diverse innovations and exploring their applications, potential, market impact, and the challenges associated with their implementation. While there is often overlap and synergy between different technologies, this classification helps in understanding the distinct contributions and potential of each category. The categories covered include Connectivity & Infrastructure, Data & Analytics, Devices & Wearables, Advanced Technologies, Advanced Computing, and Digital Therapeutics & Interventions.

Table A.1 **Taxonomy of Enabling Technologies in Healthcare**

Category	Technology	Description	Current Applications in Healthcare	Future Potential in Healthcare
Connectivity & Infrastructure	Telemedicine & Telehealth	Provision of healthcare services remotely using telecommunications technology.	Virtual consultations, remote monitoring, telediagnosis, telementoring.	Seamless integration into hybrid care models, advanced telepresence, AI-assisted remote diagnostics.
	Mobile Health (mHealth)	Healthcare supported by mobile devices.	Wellness/fitness apps, medication reminders, remote data collection, patient portals.	Personalized health management apps, integration with wearables, chronic disease management.
	Internet of Medical Things (IoMT)	Network of connected medical devices and sensors.	Remote patient monitoring, connected medical devices in hospitals, asset tracking.	Real-time continuous monitoring, predictive alerts, connected hospitals, personalized treatment adjustments.
Data & Analytics	Electronic Health Records (EHRs)	Digital versions of patient charts.	Storing/accessing patient history, streamlining workflows, care coordination, basic analytics.	True interoperability, AI integration for decision support, population health management, patient data access.
	Big Data Analytics	Analysis of large and complex healthcare datasets.	Identifying trends, analyzing treatment outcomes, managing operations, public health surveillance.	Predictive modeling for outcomes, personalized medicine cohorts, clinical trial optimization, insights into health determinants.
	Artificial Intelligence (AI)	Computer systems performing tasks requiring human intelligence.	Medical image analysis, drug discovery assistance, potential diagnosis identification, administrative automation, chatbots.	Highly accurate/ rapid diagnostics, personalized treatment plans, predictive analytics for risk, AI virtual assistants, robotic surgery enhancement.

Category	Technology	Description	Current Applications in Healthcare	Future Potential in Healthcare
	Machine Learning (ML) and Deep Learning (DL)	Algorithms allowing systems to learn from data.	Predicting patient risk, analyzing genomic data, personalizing treatment protocols, improving diagnostic accuracy, clinical decision support.	More sophisticated predictive models, continuous learning from real-world data, identifying complex patterns, adaptive therapeutic interventions.
	Natural Language Processing (NLP)	Enabling computers to understand human language.	Analyzing clinical notes, extracting information from text, powering medical chatbots.	Automated medical literature summarization, sophisticated conversational agents, automated clinical documentation, analyzing patient narratives.
Devices & Wearables	Wearable Devices	Electronic devices worn on the body collecting health data.	Tracking activity/ heart rate/sleep, consumer health monitoring, some remote patient monitoring.	Continuous passive monitoring of wide parameters, seamless integration with healthcare platforms, early detection, diagnostic capabilities.
	Connected Medical Devices	Medical devices with connectivity features.	Connected glucose meters, smart blood pressure cuffs, remote monitoring of infusion pumps/ inhalers.	Real-time adjustment based on data/AI, predictive alerts, enhanced data sharing, closed-loop systems.

Category	Technology	Description	Current Applications in Healthcare	Future Potential in Healthcare
Advanced Technologies	Blockchain	Decentralized, distributed ledger technology.	Securely storing/ sharing patient data, supply chain management, professional credential verification, clinical trial data management.	Interoperable patient-controlled records, healthcare data marketplaces, streamlined claims processing.
	Augmented Reality (AR)	Overlaying digital information onto the real world.	Surgical planning/ visualization, medical training/ education, assisting nurses (e.g., vein finding).	Image-guided surgery with real-time overlays, interactive anatomy learning, remote expert guidance, AR rehabilitation.
	Virtual Reality (VR)	Creating immersive, interactive simulated environments.	Medical training simulations, pain management/ therapy, exposure therapy, patient education.	Highly realistic surgical training, immersive rehabilitation, VR telemedicine, advanced pain/psychological therapies.
	Robotics	Use of robots to perform tasks.	Surgical robots, automated medication dispensing, laboratory automation, internal logistics.	More advanced/ autonomous surgical robots, increased role in direct patient care, sophisticated automated logistics.
	3D Printing	Creating three-dimensional objects layer by layer.	Patient-specific prosthetics/ implants, anatomical models for planning/ training, customized medical devices/ guides.	Bioprinting tissues/ organs, on-demand personalized medications, point-of-care device printing.

Category	Technology	Description	Current Applications in Healthcare	Future Potential in Healthcare
	Digital Twins	Virtual replicas updated with real-time data.	Simulating organs/systems, optimizing hospital workflows/resources.	Patient-specific digital twins for personalized treatment simulation, optimizing healthcare networks, revolutionizing clinical trials.
Advanced Computing	High-Performance Computing (HPC)	Use of supercomputers and parallel processing.	Processing large genomic datasets, molecular simulations for drug discovery, complex medical imaging analysis.	More sophisticated genomic analysis, accelerating drug discovery, advanced imaging analysis/reconstruction, large-scale public health modeling.
	Quantum Computing	Computing using quantum mechanics principles.	Research into drug discovery simulation, exploring optimization for complex healthcare problems (currently R&D).	Revolutionizing drug discovery/molecular simulation, highly personalized treatment planning, enhancing AI capabilities.
Digital Therapeutics & Interventions	Digital Therapeutics (DTx)	Software delivering evidence-based therapeutic interventions.	Managing chronic conditions (diabetes, mental health), substance abuse disorders.	Integration into clinical workflows, personalized/adaptive interventions, expansion to wider conditions, remote monitoring/adjustment.
	Digital Care Programs	Comprehensive digital platforms supporting patient care/management.	Remote monitoring programs, virtual rehabilitation, care coordination platforms, patient engagement tools.	Highly integrated/personalized care pathways, AI-powered coordination/support, remote management of complex conditions.

A1.1. Connectivity & Infrastructure

Technologies in this category focus on enabling communication, data exchange, and service delivery across geographical distances and between different stakeholders in the healthcare ecosystem.

A1.1.1. Telemedicine & Telehealth

Telemedicine and telehealth encompass the use of electronic information and telecommunications technologies to support and promote long-distance clinical healthcare, patient and professional health-related education, public health, and health administration. This includes a wide range of services such as virtual consultations, remote patient monitoring, transmission of medical images, and remote medical education.

Current Applications: Currently, telemedicine is widely used for routine consultations, follow-up appointments, managing chronic conditions, and providing access to specialists in remote or underserved areas (Ezeamii et al., 2024). It gained significant traction during the recent global pandemic, becoming an essential tool for maintaining access to care while minimizing physical contact. Telediagnosis, teleradiology, and telepathology are established applications that allow remote expert analysis of medical data.

Future Potential: The future of telemedicine involves seamless integration into hybrid care models, where virtual and in-person care are combined based on patient needs. Advanced telepresence technologies, including high-definition video and haptic feedback, could enable more complex remote examinations and procedures. AI could be integrated to assist with remote diagnostics

and triage, further increasing efficiency and accessibility. The expansion of 5G networks will provide the necessary bandwidth for more sophisticated telemedicine applications.

Quantitative Data: The global telemedicine market size was estimated to be valued at over $100 billion in recent years and is projected to grow significantly, with some reports predicting a compound annual growth rate (CAGR) of over 20% in the coming years (Grand View Research, 2024). The socio-economic impact includes reduced travel costs and time for patients, increased access to care for rural populations, and potentially lower healthcare costs by reducing hospital visits and admissions.

Open Challenges: Challenges include ensuring equitable access to necessary technology and internet connectivity, addressing regulatory and reimbursement complexities across different regions, maintaining data privacy and security during transmission, and ensuring the quality and effectiveness of remote consultations compared to in-person visits. Clinician training and patient acceptance also remain important factors.

A1.1.2. Mobile Health (mHealth)

mHealth refers to the practice of medicine and public health supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. It leverages the ubiquitous nature of mobile technology to provide health-related information, services, and data collection capabilities.

Current Applications: Current applications include a vast array of wellness and fitness apps, medication reminder apps, symptom checkers, remote data

collection from connected devices, and mobile access to patient portals for viewing health records and scheduling appointments (Deniz-Garcia et al., 2023). mHealth is also used in public health campaigns and data collection for disease surveillance.

Future Potential: Future mHealth will be characterized by highly personalized health management through advanced apps that integrate data from multiple sources, including wearables, EHRs, and even genomic information. AI-powered mHealth apps could provide tailored health coaching, predict health risks based on user data, and offer just-in-time interventions. The role of mHealth in managing chronic diseases and promoting preventative care is expected to expand significantly.

Quantitative Data: The global mHealth market is a substantial segment of digital health, with market size estimates varying but generally in the tens of billions of US dollars in 2024 and strong projected growth, exhibiting a CAGR of 11.8% by 2032 (Fortune Business Insights, 2024). The socio-economic impact includes empowering individuals to take a more active role in managing their health, potentially leading to improved health outcomes and reduced healthcare utilization for preventable conditions.

Open Challenges: Key challenges include ensuring the accuracy and reliability of health information provided by apps, addressing data privacy and security concerns related to sensitive personal health data collected by mobile devices, regulatory oversight of medical-grade mHealth applications, and ensuring usability and accessibility across diverse user populations.

A1.1.3. Internet of Medical Things (IoMT)

IoMT refers to the connected infrastructure of medical devices, software applications, and health systems and services. It involves the use of internet-connected devices to collect and transmit health data, enabling remote monitoring, tracking, and management of patients and medical assets.

Current Applications: Current applications include remote patient monitoring devices for conditions like diabetes (connected glucose meters), cardiovascular disease (wearable ECG monitors), and respiratory disorders (smart inhalers). IoMT is also used to track medical equipment within hospitals, manage inventory, and monitor environmental conditions in healthcare facilities (Huang, Wang et al., 2023).

Future Potential: The future of IoMT involves real-time, continuous, and passive monitoring of a wide range of physiological parameters through advanced sensors and wearables. This will enable early detection of health deterioration, predictive alerts for critical events, and personalized adjustments to treatment plans based on continuous data streams. IoMT will also play a crucial role in connected hospitals, optimizing workflows and patient care through interconnected devices and systems.

Quantitative Data: The IoMT market is experiencing rapid growth, with market size estimates in the tens of billions of US dollars and high projected CAGRs (38.5%) (Fortune Business Insights, 2025a). The socio-economic impact includes improved management of chronic diseases, reduced hospital readmissions, increased efficiency in healthcare operations, and the potential for proactive health interventions based on continuous data.

Open Challenges: Significant challenges include ensuring the security of connected medical devices against cyber threats, managing the massive vol-

ume of data generated by IoMT devices, ensuring interoperability between different devices and platforms, addressing regulatory hurdles for connected medical devices, and establishing clear protocols for responding to data-driven alerts and insights.

A1.2. Data & Analytics

This category focuses on the collection, storage, processing, analysis, and interpretation of healthcare data to generate insights and support decision-making.

A1.2.1. Electronic Health Records (EHRs)

EHRs are digital versions of patients' paper charts containing medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory and test results. They are designed to be shared across different healthcare settings.

Current Applications: EHRs are fundamental to modern healthcare administration and delivery. They are used for storing and accessing patient information, streamlining clinical workflows, improving communication and coordination among healthcare providers, and supporting basic data analytics for reporting and quality improvement (Shen et al., 2025). Patient portals linked to EHRs allow patients to access their health information and communicate with providers.

Future Potential: The future of EHRs lies in achieving true interoperability,

allowing seamless and secure exchange of patient data across all healthcare providers and even between different countries. EHRs will be integrated with advanced AI and machine learning algorithms to provide real-time clinical decision support, identify patients at risk, and personalize treatment recommendations. They will also serve as a rich data source for research and public health initiatives.

Quantitative Data: The global EHR market is substantial, valued at about $30 billion in 2024, with steady growth expected (CAGR of about 5% from 2025 to 2033) as adoption rates increase and systems become more sophisticated (Business Research Insights, 2024). The socio-economic impact includes improved care coordination, reduced medical errors due to better access to patient information, increased efficiency in administrative tasks, and the potential to leverage aggregated data for research and public health.

Open Challenges: Major challenges include achieving true interoperability between disparate EHR systems, addressing data privacy and security concerns related to the centralization of sensitive patient information, the high cost of implementation and maintenance, usability issues that can lead to clinician burnout, and ensuring data quality and standardization.

A1.2.2. Big Data Analytics

Big Data Analytics involves the examination of large and complex datasets to uncover hidden patterns, correlations, trends, and other insights. In healthcare, these datasets can come from various sources, including EHRs, genomic data, medical imaging, wearable devices, and social media.

Current Applications: Currently, big data analytics is used to identify trends in patient populations, analyze the effectiveness of different treatments, manage hospital operations and resource allocation, predict patient demand, and support public health surveillance and outbreak prediction (Khan et al., 2022).

Future Potential: Future applications will include more sophisticated predictive modeling for individual patient outcomes, identifying specific patient cohorts for highly personalized medicine approaches, optimizing clinical trial design and recruitment, and gaining deeper insights into the social and environmental determinants of health by integrating diverse data sources. Real-time analytics will enable proactive interventions.

Quantitative Data: The global healthcare analytics market is valued at tens of billions of US dollars and is projected to reach more than 120 billion by 2033, growing at a CAGR of 24.3% from 2024 to 2033, driven by the increasing availability of health data and the need for data-driven decision-making (Allied Market Research, 2024). The socio-economic impact includes the potential for improved patient outcomes through personalized interventions, cost savings through optimized operations and resource allocation, and advancements in medical research and public health strategies.

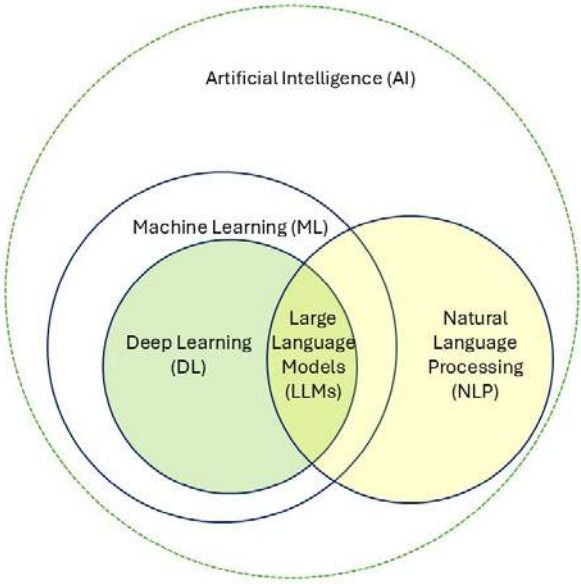
Open Challenges: Challenges include managing and processing the sheer volume, velocity, and variety of healthcare data, ensuring data quality and standardization across disparate sources, addressing data privacy and security concerns when working with large datasets, the need for skilled data scientists and analysts in healthcare settings, and the ethical considerations related to using patient data for analytics.

A1.2.3. Artificial Intelligence (AI)

AI refers to the ability of machines to perform tasks autonomously, mimicking human cognitive functions, namely, learning and problem-solving (Jiang et al., 2017; Topol, 2019a,b).

Within the healthcare domain, subfields such as machine learning and deep learning are particularly relevant. Machine learning (ML), a subset of AI, leverages vast datasets to discern patterns and progressively enhance their predictive accuracy. Deep learning (DL), a further subset of ML characterized by its intricate, multi-layered neural networks, has demonstrated a remarkable capacity for understanding complex language structures and contextual nuances. Natural Language Processing (NLP) refers to AI techniques that enable machines to understand and generate human language. At the intersection of DL and NLP lie Large Language Models (LLMs), which leverage deep learning architectures to process and produce human-like language. The Venn diagram in Figure A.1 illustrates the hierarchical and overlapping relationships between major areas within AI. The figure highlights how LLMs draw on advances in both deep learning and language understanding. LLMs are an example of Generative AI (GenAI). However, not all Generative AIs are LLMs, including also, among others, Generative Adversarial Networks (GANs), mainly for images/videos, and generative models specifically designed to create novel chemical structures.

Figure A.1 **Conceptual relationships among key subfields of Artificial Intelligence.**



Source: Our elaboration.

Current Applications: AI is increasingly central to the evolution of modern medicine (OECD, 2023). AI is currently being applied in medical image analysis (e.g., detecting anomalies in X-rays, CT scans, and MRIs), speeding up drug discovery and development by analyzing vast biological datasets, identifying potential diagnoses based on patient symptoms and history, and automating administrative tasks like scheduling and billing (Yu et al., 2018; Mak & Pichika, 2019; Kanakia et al., 2025; Morone et al., 2025). AI-powered chatbots are also used for initial patient interaction and information provision (Bajwa et al., 2021).

Future Potential: The future of AI in healthcare holds immense promise, including highly accurate and rapid diagnostic tools, personalized treatment plan generation based on individual patient profiles (including genomics), predictive analytics for identifying patients at high risk of developing certain conditions or experiencing adverse events, and AI-powered virtual assistants that can provide comprehensive patient support and even perform initial triage. AI could also revolutionize robotic surgery with increased precision and autonomy.

Quantitative Data: The global AI in the healthcare market is a rapidly expanding sector, valued in the billions of US dollars, and projected to grow at a very high CAGR of 38.62% from 2025 to 2030 (Grand View Research, 2024). The socio-economic impact includes the potential for earlier and more accurate diagnoses, the development of more effective and personalized treatments, increased efficiency for healthcare professionals by automating routine tasks, and potentially reducing healthcare costs in the long run.

A recent Deloitte research (Deloitte, 2024) reveals that applying AI, particularly GenAI, in pharmaceutical R&D can generate $5–7 billion in value over five years for a top 10 biopharma company. R&D holds the greatest potential, contributing 30–45% of this value. This is achieved through the acceleration of drug development processes and substantial cost reductions. GenAI can significantly improve the modeling of proteins and other biomolecules, which is crucial in identifying and validating new drug candidates at a much faster pace. By analyzing vast repositories of scientific data, GenAI supports the discovery of novel drug targets and illuminates previously unknown connections between diseases. These insights are then tested and validated through laboratory experiments, demonstrating a highly productive synergy

between AI-generated analysis and the insights of human researchers.

Open Challenges: Significant challenges include ensuring the explainability and transparency of AI decision-making processes (the "black box" problem), addressing potential biases in AI algorithms that could lead to health disparities, regulatory approval and validation of AI-based medical devices and diagnostics, ensuring data privacy and security when using large datasets for AI training, and the ethical considerations surrounding the use of AI in critical healthcare decisions. Despite significant advances in AI research, the deployment and adoption of AI technologies in clinical practice remain limited, pending the development and implementation of trustworthy AI tools (Lekadir et al., 2025).

A1.2.4. Machine Learning (ML) and Deep Learning (DL)

Machine Learning, a subset of AI, focuses on developing algorithms that allow computer systems to learn from data without being explicitly programmed. Deep learning is itself a subset of machine learning that uses multi-layered neural networks to learn representations from large amounts of data automatically. In healthcare, this involves training models on medical datasets to identify patterns, make predictions, and improve performance over time (Esteva et al., 2019; Topol, 2019a,b).

Current Applications: ML is currently used to develop algorithms for predicting patient risk factors (e.g., for developing chronic diseases or readmission), analyzing genomic data to identify genetic predispositions, personalizing

treatment protocols based on patient characteristics and historical data, and improving the accuracy of diagnostic tools through pattern recognition (Deo, 2015; Rajkomar et al., 2019; Zeleke et al., 2023). DL models, in particular, have shown strong performance in medical imaging, avoiding delayed diagnosis or misdiagnosis of acute myocardial infarction (AMI), enabling radiologists to identify anomalies such as tumors or fractures with near-human or even superior accuracy (Litjens et al., 2017; Liu et al., 2021; Huang, Yang et al., 2023).

Future Potential: Future ML applications will involve more sophisticated predictive models that can anticipate health events with greater accuracy, continuous learning from real-world patient data to refine diagnoses and optimize treatments in real-time, identifying subtle and complex patterns in large biological and clinical datasets that are imperceptible to humans, and developing adaptive therapeutic interventions that adjust based on patient response. Deep learning, in particular, holds promise for revolutionizing image-based diagnostics, enabling nuanced analysis of radiological, pathological, and genomic images.

Quantitative Data: As a core component of AI, ML—including DL—represents a significant and expanding area within the healthcare market, contributing substantially to the overall AI market size and growth. The socio-economic impact reflects AI's broader potential: improved predictive accuracy, personalized interventions, and the ability to extract valuable knowledge from increasingly complex and heterogeneous healthcare data.

Open Challenges: Key challenges include the need for large, high-quality, and

unbiased datasets to train ML models, ensuring interpretability and transparency—particularly for DL architectures, which are often considered "black boxes"—addressing overfitting and generalization limits, managing the intensive computational demands of deep neural networks, and confronting the ethical and legal implications of using predictive models in clinical decision-making, especially in terms of bias, equity, and accountability (Obermeyer et al., 2019). Moreover, disparities in the datasets used to train AI systems may inadvertently perpetuate existing inequities in healthcare delivery (Wiens et al., 2019). To mitigate these concerns, it is essential to adopt robust strategies for data collection, validation, and continuous model updating. This includes curating diverse and representative datasets and ensuring that algorithms are periodically retrained to reflect evolving clinical knowledge and patient populations (Chen et al., 2020). Post-deployment monitoring and algorithm auditing are critical not only for performance optimization but also for addressing ethical concerns, such as accountability and transparency (Morley, Floridi et al., 2020).

A1.2.5. Natural Language Processing (NLP)

NLP is a field of AI that focuses on enabling computers to understand, interpret, and generate human language. In healthcare, this is particularly relevant for processing and analyzing unstructured text data found in clinical notes, reports, and medical literature.

Current Applications: NLP plays a pivotal role in unlocking insights from unstructured data—such as clinical notes, patient conversations, and EHR en-

tries—comprising up to 80% of healthcare information (Chen et al., 2020). It enables extraction of relevant data points, improves predictive modeling, and automates administrative tasks like documentation and coding, which reduces clinician workload and enhances workflow efficiency. Natural Language Generation (NLG), a subset of NLP, is increasingly used for generating patient summaries, clinical reports, and tailored health communications, further advancing the usability of complex healthcare data (Croxford et al., 2025). NLP and ML algorithms are being integrated into real-time feedback systems, offering dynamic performance assessment and personalized coaching to accelerate competency development (Wartman & Combs, 2018). These innovations not only optimize the training pipeline but also ensure that clinical education keeps pace with the rapidly evolving demands of modern healthcare.

Future Potential: Future NLP applications will include automated summarization of vast amounts of medical literature to assist clinicians and researchers, improved and more sophisticated medical conversational agents that can provide personalized health information and support, automated generation of clinical documentation, and the ability to analyze patient narratives and feedback to gain insights into their experiences and preferences.

Quantitative Data: According to Cogent Infotech (2025), the adoption of NLP solutions in the healthcare and life sciences market is expected to increase from USD 2.2 billion in 2022 to USD 7.2 billion by 2027 at a CAGR of 27.1%. The contributors to this market growth include the increasing demand for predictive analytics to address significant health issues, the need to make electronic health record (EHR) data more usable, and the necessity to analyze and extract insights from narrative text. The socio-economic impact

includes improved efficiency in processing clinical documentation, enhanced access to medical information, and potentially improved patient engagement through natural language interfaces.

Open Challenges: Challenges include the complexity and variability of medical language, the presence of jargon, abbreviations, and inconsistencies in clinical notes, ensuring the accuracy and reliability of information extracted by NLP systems, addressing privacy concerns when processing sensitive patient narratives, and the need for domain expertise to train and validate NLP models for healthcare applications (Meskó & Topol, 2023). Over-dependence on these tools could potentially hinder the development of fundamental clinical skills and the ability to reason through complex cases autonomously (García-Torres et al., 2024).

A1.3. Devices & Wearables

This category includes physical devices used by patients and healthcare providers, often with connectivity features to collect and transmit data.

A1.3.1. Wearable Devices

Wearable devices are electronic technologies worn on the body that collect and transmit data about the user's health and activity. These range from fitness trackers and smartwatches to more sophisticated medical-grade sensors.

Current Applications: Currently, wearable devices are widely used for tracking physical activity levels, monitoring heart rate, analyzing sleep patterns, and providing general wellness insights (Albites-Sanabria et al., 2024; Di Rienzo & Mukkamala, 2021; Lu et al., 2020). Some medical-grade wearables are used for remote monitoring of specific conditions like atrial fibrillation or to support self-management of chronic conditions, e.g., for continuous glucose monitoring in diabetes management.

Future Potential: Future wearable devices will offer continuous and passive monitoring of a much wider range of physiological parameters, including blood pressure, oxygen saturation, hydration levels, and even early indicators of infectious diseases. They will be seamlessly integrated with healthcare platforms, providing real-time data streams that enable proactive health interventions and personalized feedback. Advanced wearables could also incorporate diagnostic capabilities.

Quantitative Data: The global wearable healthcare devices market size was valued at USD 39.9 billion in 2023 and is expected to reach USD 114.8 billion by 2033, according to a research report published by Spherical Insights & Consulting (2024). The socio-economic impact includes empowering individuals to monitor their health and make informed lifestyle choices, facilitating early detection of potential health issues, and supporting remote patient monitoring programs, potentially reducing the need for frequent clinic visits.

Open Challenges: Challenges include ensuring the accuracy and reliability of data collected by consumer-grade wearables, addressing data privacy and security concerns related to the continuous collection of sensitive personal

health data, the need for regulatory frameworks for medical-grade wearables, ensuring usability and comfort for long-term wear, and integrating wearable data effectively into clinical workflows.

A1.3.2. Connected Medical Devices

Connected medical devices are medical devices that are equipped with connectivity features, allowing them to transmit data to other devices, systems, or healthcare providers. This category overlaps with IoMT but focuses specifically on the medical devices themselves.

Current Applications: Current applications include connected glucose meters that transmit readings to a smartphone or cloud platform, smart blood pressure cuffs, connected infusion pumps that can be remotely monitored, and smart inhalers that track medication usage. These devices facilitate remote monitoring and improve data collection for both patients and clinicians.

Future Potential: Future connected medical devices will offer more advanced functionalities, including real-time adjustment of device settings based on patient data and AI analysis, predictive alerts for potential device malfunctions or patient deterioration, enhanced data sharing and interoperability between different devices and healthcare systems, and the development of closed-loop systems (e.g., automated insulin delivery systems).

Quantitative Data: Connected Healthcare Devices Market was valued at over USD 55 billion in 2023 and is estimated to register a CAGR of over 17.5%

between 2024 and 2032, driven by the increasing demand for remote monitoring and data-driven healthcare (Global Market Insights, 2024b). The socio-economic impact includes improved management of chronic conditions, reduced hospitalizations and emergency room visits, and enhanced efficiency in data collection and analysis for healthcare providers.

Open Challenges: Key challenges include ensuring the cybersecurity of connected medical devices, which are vulnerable to hacking and data breaches, addressing regulatory complexities for connected devices, ensuring interoperability between devices from different manufacturers, managing the lifecycle and updates of connected devices, and establishing clear protocols for data ownership and access.

A1.4. Advanced Technologies

This category encompasses emerging technologies with transformative potential across various sectors, including healthcare.

A1.4.1. Blockchain

Blockchain is a decentralized, distributed ledger technology that records transactions across many computers. This makes the data immutable, transparent, and secure, as the network must validate any changes.

Current Applications: In healthcare, blockchain is being explored and pilot-

ed for securely storing and sharing patient data, managing supply chains for pharmaceuticals and medical devices to prevent counterfeiting, verifying the credentials of healthcare professionals, and facilitating secure and transparent clinical trial data management (Agbo et al., 2019; Engelhardt, 2017; Kuo et al., 2017).

Future Potential: The future of blockchain in healthcare could involve truly interoperable and patient-controlled health records, where individuals have ownership and control over who can access their data. It could revolutionize healthcare data marketplaces, enabling secure and transparent sharing of aggregated data for research while preserving patient privacy. Blockchain could also streamline claims processing and billing.

Quantitative Data: The blockchain in the healthcare market is still relatively nascent but is projected for significant growth as pilot projects demonstrate its value. The socio-economic impact could include enhanced data security and patient privacy, improved efficiency and transparency in healthcare operations, reduced fraud and errors in billing and supply chains, and accelerated medical research through secure data sharing.

Open Challenges: Challenges include the scalability of blockchain networks to handle the massive volume of healthcare data, the energy consumption of some blockchain protocols, regulatory uncertainty surrounding the use of blockchain in healthcare, the need for standardization and interoperability between different blockchain platforms, and the technical complexity of implementing and managing blockchain solutions (Haque et al., 2021; McGhin et al., 2019).

A1.4.2. Augmented Reality (AR)

AR is a technology that overlays digital information, images, or models onto the real world, typically viewed through a device like a smartphone, tablet, or AR glasses.

Current Applications: In healthcare, AR is currently used for surgical planning and visualization, allowing surgeons to overlay patient imaging data onto the patient's body during procedures (Longo et al., 2024). It is also used in medical training and education, providing interactive anatomical models and simulations (Tang et al., 2020). AR can assist nurses in finding veins for injections.

Future Potential: Future AR applications in healthcare include image-guided surgery with real-time, highly accurate overlays of critical anatomical structures and patient data, immersive and interactive anatomy learning experiences for medical students, remote expert guidance for complex procedures where a remote surgeon can provide real-time visual instructions, and AR-based rehabilitation programs that provide interactive exercises and feedback.

Quantitative Data: AR in the healthcare market is a growing niche with increasing investment and development. The socio-economic impact includes improved surgical accuracy and outcomes, enhanced medical training and education, and potentially more engaging and effective rehabilitation programs.

Open Challenges: Challenges include the cost of AR hardware and software, the need for high-precision tracking and registration to ensure accurate over-

lays during procedures, developing user-friendly interfaces for medical professionals, addressing potential distractions or cognitive load caused by AR overlays, and regulatory approval for AR applications used in clinical settings.

A1.4.3. Virtual Reality (VR)

VR is a technology that creates immersive, interactive simulated environments that users can experience through a VR headset.

Current Applications: VR is currently used in healthcare for medical training simulations, allowing trainees to practice procedures in a realistic and risk-free environment. It is also used for pain management and therapy, providing distracting and immersive experiences that can reduce the perception of pain (Alvarado-Omenat et al., 2025; Giannelli et al., 2024). VR is used in exposure therapy for treating phobias, anxiety, and post-traumatic stress disorders (PTSD) and for patient education (Donnelly et al., 2021).

Future Potential: Future VR applications will include highly realistic and haptic-feedback-enabled surgical training simulations, immersive rehabilitation programs that make exercises more engaging and effective, VR-based telemedicine consultations that provide a more immersive and personal interaction, and advanced VR environments for pain management and psychological therapies that are tailored to individual patient needs.

Quantitative Data: A comprehensive market research report by Grand View Research (2024b) estimates the global VR in healthcare market size at USD

5.62 billion in 2024, with a projected growth at a CAGR) of 30.3% from 2025 to 2030. The report highlights the increasing adoption of VR technologies in medical training, surgical simulation, patient care, rehabilitation, and therapy procedures. The growing demand for minimally invasive treatments and enhanced diagnostic tools has accelerated the use of virtual environments to improve procedural accuracy and patient outcomes. The socio-economic impact includes improved medical training outcomes, non-pharmacological approaches to pain management, and potentially more effective psychological therapies.

Open Challenges: Challenges include the cost of VR hardware and software, potential side effects like motion cybersickness, the need for content tailored to specific medical applications, ensuring the realism and accuracy of simulations for training purposes, and integrating VR therapy effectively into clinical workflows.

A1.4.4. Robotics

Robotics in healthcare involves the use of robots to perform various tasks, ranging from surgical procedures to logistics and patient care assistance.

Current Applications: Surgical robots are widely used for minimally invasive procedures, offering increased precision, dexterity, and control for surgeons (Picozzi et al., 2024). Robots are also used for automated dispensing of medications in pharmacies, laboratory automation for handling samples and running tests, and for transporting materials and equipment within hospitals.

Future Potential: Future healthcare robotics will see the development of more advanced and autonomous surgical robots capable of performing increasingly complex procedures. Robots will play a larger role in direct patient care, assisting with tasks like lifting and transferring patients, providing physical therapy guidance, and even offering companionship. Automated logistics and inventory management within hospitals will become more sophisticated.

Quantitative Data: The global medical robotics market was valued at approximately USD 12.8 billion in 2024 and is projected to grow at a CAGR of 16.6% from 2025 to 2034 (Global Market Insights, 2024a). Key market segments are surgical robots, currently market lead, and rehabilitation robots, which are expected to be the fastest-growing segment. The socio-economic impact includes improved surgical outcomes, reduced recovery times for patients undergoing robotic surgery, increased efficiency in laboratory and pharmacy operations, and potentially reduced physical strain on healthcare workers.

Open Challenges: Challenges include the high cost of purchasing and maintaining medical robots, the need for specialized training for healthcare professionals to operate and interact with robots, addressing safety concerns related to human-robot interaction in clinical settings, regulatory approval for new robotic applications, and the ethical considerations surrounding the increasing role of automation in patient care.

A1.4.5. 3D Printing

3D printing, or additive manufacturing, is a process of creating three-dimensional solid objects from a digital model by adding material layer by layer.

Current Applications: In healthcare, 3D printing is currently used to create patient-specific prosthetics and implants that are customized for a perfect fit. It is also used to produce anatomical models from patient scan data for surgical planning and training. 3D printing is used to create customized medical devices and surgical guides (McAnena, McClennen & Zheng, 2025).

Future Potential: The future of 3D printing in healthcare includes the bioprinting of tissues and potentially even organs using living cells, revolutionizing transplantation and regenerative medicine. It will enable the on-demand printing of personalized medications with precise dosages and release profiles. 3D printing will also facilitate the creation of highly complex and customized medical devices and surgical tools at the point of care.

Quantitative Data: The global healthcare 3D printing market was valued at USD 8.52 billion in 2023 and is projected to reach USD 27.29 billion by 2030, growing at a CAGR of 18.5% from 2024 to 2030 (Grand View Research, 2023). The socio-economic impact includes the availability of highly customized medical devices and implants, potentially lower costs for certain medical products compared to traditional manufacturing, and accelerating research in regenerative medicine and drug development.

Open Challenges: Challenges include the regulatory approval process for

3D-printed medical devices and bio-printed tissues, ensuring the quality and safety of 3D-printed materials for medical use, the cost and accessibility of 3D printing technology in healthcare settings, the need for specialized skills to design and print medical products, and the ethical considerations surrounding bioprinting.

A1.4.6. Digital Twins

A digital twin is a virtual replica of a physical object, process, or system that is continuously updated with real-time data from its physical counterpart. This allows for simulation, analysis, and optimization.

Current Applications: In healthcare, digital twins are being explored to create virtual replicas of organs or physiological systems to simulate disease progression and treatment responses (Viceconti et al., 2024). They are also used for optimizing hospital workflows, managing resources, and simulating the impact of changes to the healthcare system.

Future Potential: Future applications of digital twins in healthcare include creating patient-specific digital twins that integrate data from various sources (EHRs, wearables, genomics) to simulate the potential outcomes of different treatment options, enabling highly personalized medicine. Digital twins of hospitals and healthcare networks could optimize operations, predict bottlenecks, and improve disaster preparedness. They could also revolutionize clinical trial design by simulating patient responses.

Quantitative Data: The digital twin market in healthcare is still in its early stages but is expected to grow significantly as the technology matures and its benefits are demonstrated. The socio-economic impact could include more personalized and effective treatments, improved efficiency and cost savings in healthcare operations, and accelerated medical research and drug development through simulation.

Open Challenges: Challenges include the complexity of creating accurate and realistic digital twins of biological systems, the need for massive amounts of real-time data to keep digital twins updated, ensuring the interoperability of data sources, the computational resources required for running complex simulations, and addressing data privacy and security concerns related to creating and using detailed digital replicas of individuals.

A1.5. Advanced Computing

This category highlights the role of high-performance computing and the emerging field of quantum computing in addressing complex healthcare challenges.

A1.5.1. High-Performance Computing (HPC)

HPC refers to the use of supercomputers and parallel processing techniques to solve complex computational problems that are too large or require too much time for standard computers.

Current Applications: In healthcare, HPC is currently essential for processing and analyzing large genomic datasets to identify genetic variations and understand disease mechanisms. It is used for molecular simulations in drug discovery and development to predict how potential drug candidates will interact with biological targets. HPC is also used for complex medical imaging processing and analysis (Li et al., 2024).

Future Potential: Future applications of HPC in healthcare will involve even more sophisticated genomic analysis for personalized medicine and disease prediction, accelerating the drug discovery and development process through large-scale simulations and virtual screening, enabling more advanced medical imaging analysis and reconstruction, and supporting large-scale epidemiological studies and public health modeling.

Quantitative Data: The use of HPC in healthcare and life sciences is a growing area driven by the increasing volume and complexity of biological and medical data. The socio-economic impact includes accelerating breakthroughs in genomics and personalized medicine, speeding up the development of new drugs and therapies, and improving our understanding of complex diseases.

Open Challenges: Challenges include the high cost of acquiring and maintaining HPC infrastructure, the need for specialized expertise to utilize HPC effectively for healthcare applications, managing and transferring large datasets to and from HPC systems, and ensuring the security and privacy of sensitive data processed on these platforms.

A1.5.2. Quantum Computing

Quantum computing is a new paradigm of computing that uses the principles of quantum mechanics to perform calculations. Quantum computers have the potential to solve certain types of problems that are intractable for even the most powerful classical supercomputers.

Current Applications: Quantum computing in healthcare is currently in the research and development phase. Researchers are exploring its potential for drug discovery by simulating molecular interactions with unprecedented accuracy, optimizing complex treatment plans, and advancing medical imaging techniques (Flöther, 2023).

Future Potential: Future quantum computing applications in healthcare could revolutionize drug discovery by enabling the simulation of highly complex biological systems and the design of entirely new molecules. It could lead to the development of highly personalized treatment plans that account for an individual's unique genetic makeup and disease characteristics. Quantum computing could also enhance the capabilities of AI in healthcare by enabling more complex and powerful algorithms.

Quantitative Data: The quantum computing market in healthcare is currently very small, representing primarily research and development investments. However, it has the potential for significant future growth as the technology matures. The socio-economic impact is potentially revolutionary, leading to the discovery of new cures and therapies, highly personalized medicine, and unprecedented advancements in our understanding of biological systems.

Open Challenges: Significant challenges include the immaturity of quantum computing hardware and software, the difficulty in building and maintaining stable quantum systems, the need for specialized algorithms tailored for quantum computers, the high cost of quantum computing resources, and the need to train a workforce with the necessary skills in quantum mechanics and computer science.

A1.6. Digital Therapeutics & Interventions

This category focuses on software-based interventions and programs designed to treat or manage medical conditions and support patient care.

A1.6.1. Digital Therapeutics (DTx)

DTx are software programs that deliver evidence-based therapeutic interventions to prevent, manage, or treat a medical disorder or disease. Unlike general health and wellness apps, DTx are clinically validated, often prescribed by healthcare professionals, and are regulated as medical devices in many regions.

Current Applications: Current DTx applications include programs for managing chronic conditions like diabetes (e.g., providing behavioral support and glucose monitoring insights), treating mental health disorders such as anxiety and depression (e.g., delivering cognitive behavioral therapy), and managing substance abuse disorders (Chengyu, Xueyan & Ying, 2024; Fassbender et al., 2024).

Future Potential: Future DTx will be more integrated into clinical workflows, with seamless data exchange between the DTx program, patient, and healthcare provider. They will offer more personalized and adaptive therapeutic interventions based on real-time patient data and AI analysis. The range of medical conditions addressed by DTx is expected to expand significantly, including neurological disorders, cardiovascular diseases, and chronic pain.

Quantitative Data: Fortune Business Insights (2025b) projects the market of DTx to expand from USD 8.28 billion in 2024 to USD 43.88 billion by 2032, reflecting a CAGR of 23.2% during the forecast period, as regulatory frameworks mature and adoption increases. The socio-economic impact includes providing accessible and scalable therapeutic options, potentially reducing the need for traditional treatments and hospitalizations, and empowering patients to manage their conditions actively.

Open Challenges: Challenges include the need for rigorous clinical validation and regulatory approval for DTx products, establishing clear reimbursement pathways, ensuring equitable access to DTx for all patients, integrating DTx effectively into existing healthcare workflows, and addressing concerns about patient engagement and adherence to digital interventions.

A1.6.2. Digital Care Programs

Digital care programs are comprehensive digital platforms and services designed to support patient care and management, often for specific conditions or patient populations. They can integrate various digital technologies to pro-

vide a holistic care experience.

Current Applications: Current digital care programs include remote patient monitoring programs for chronic diseases that integrate data from connected devices and provide educational content and support. They also include virtual rehabilitation programs, digital platforms for care coordination among multiple providers, and patient engagement platforms that provide personalized information and communication tools (Jansen et al., 2025).

Future Potential: Future digital care programs will represent highly integrated and personalized care pathways that leverage the full spectrum of digital technologies. They will be powered by AI for personalized care coordination, predictive risk assessment, and automated patient support. These programs will enable remote management of increasingly complex conditions and provide a more seamless and patient-centric healthcare experience.

Quantitative Data: The market for digital care programs is expanding as healthcare providers and payers seek innovative ways to manage patient populations and improve outcomes. The socio-economic impact includes improved care coordination, better management of chronic conditions, reduced healthcare costs through preventative care and reduced hospitalizations, and enhanced patient engagement and satisfaction.

Open Challenges: Challenges include ensuring the interoperability of different digital tools and platforms within a program, integrating digital care programs effectively into existing clinical workflows, addressing data privacy and security concerns when aggregating data from multiple sources, ensuring

equitable access to these programs, and demonstrating their long-term effectiveness and cost-effectiveness.

A.2 - Application Areas

A.2.1. Telemedicine: Expanding Access to Care and Remote Monitoring.

Telemedicine utilizes telecommunications and information technology to provide clinical healthcare from a distance, and it emerged as an essential tool during the COVID-19 pandemic (Omboni et al., 2022). New technologies are significantly expanding the capabilities and reach of telemedicine, whose use is comparable to in-person care across a variety of outcomes and clinical areas (Ezeamii et al., 2024). LLMs can enhance doctor-patient interactions during virtual consultations, offering real-time translation and summarizing key information. AI-powered remote patient monitoring systems, often integrated with wearable devices, allow for continuous tracking of physiological data, enabling early detection of health issues and personalized interventions. VR and AR can further augment telemedicine by enabling doctors to conduct sensory tests on patients with motor impairments during virtual visits and by projecting medical images onto a patient's body during video consultations, enhancing visual communication and remote diagnosis. Predictive analytics can identify patients who would benefit most from remote monitoring and predict potential health risks, allowing for proactive care delivery. HPC and big data infrastructure support the large-scale data transmission and analysis required for effective remote monitoring and telehealth services, ensuring se-

cure and timely communication. Robotics also plays a role, with the development of telerobotics enabling remote surgeries and consultations, potentially increasing access to specialized treatments in underserved areas (Evans, Medina & Dwyer, 2018).

Telemedicine, empowered by these technologies, directly impacts the social dimension of the biopsychosocial model by breaking down geographical barriers and increasing access to healthcare services, especially for individuals in remote or underserved communities. Remote monitoring can also improve psychological well-being by providing patients with a sense of security and continuous support while also enabling early intervention for biological issues (Tan et al., 2024). Furthermore, telemedicine can enhance activity and participation for individuals with mobility limitations by allowing them to receive care and monitoring from the comfort of their homes. Commercial solutions in this area include platforms like Teladoc Health and Amwell, which offer virtual consultations, and companies like Biofourmis and Current Health (acquired by Best Buy Health), which provide AI-powered remote monitoring solutions.

A.2.2. Self-Assessment and Self-Management Tools: Empowering Patient Agency.

New technologies are providing patients with increasingly sophisticated tools for self-assessment and self-management of their health (Deniz-Garcia et al., 2023; Fassbender et al., 2024). LLMs can power chatbots that answer patient questions about symptoms, medications, and health conditions, improving health literacy and empowering individuals to take a more active

role in their care. AI-driven mobile apps can analyze user-inputted symptoms and provide preliminary assessments, guiding individuals on when to seek professional help. VR and AR applications can educate patients about their conditions and treatment plans through immersive and interactive experiences, improving understanding and adherence. Predictive analytics can identify individuals at high risk for certain conditions, prompting them to adopt preventive behaviors and engage in self-management strategies. Wearable devices, integrated with big data analytics platforms, continuously collect health data, providing individuals with personalized insights and feedback to support self-management of chronic conditions like diabetes and hypertension.

These tools primarily impact the psychological dimension by increasing patients' knowledge, confidence, and sense of control over their health. Improved health literacy, facilitated by LLM-powered explanations and VR/AR-based education, can reduce anxiety and empower patients to make informed decisions about their care. By providing tools for remote monitoring and self-tracking, technology can also enhance activity and participation by enabling individuals to manage their conditions while maintaining their daily routines. Commercial examples include health and wellness apps like MyFitnessPal and Headspace, AI-powered symptom checkers like Ada Health, and wearable devices from companies like Fitbit and Apple.

A.2.3. Preventive Medicine: Utilizing Technology for Early Detection and Risk Reduction.

Technology is playing an increasingly vital role in preventive medicine, enabling early detection of diseases and reduction of health risks. AI algorithms

can analyze vast datasets, including medical images, genetic information, and lifestyle factors, to identify individuals at high risk for developing certain conditions like cancer, diabetes, and cardiovascular diseases, allowing for timely interventions (Hao et al., 2024). Predictive analytics models can forecast disease outbreaks and identify populations at risk, enabling public health organizations to implement targeted prevention strategies (Golinelli et al., 2025). Digital biomarkers, derived from data collected through wearable sensors and other digital health tools, can provide continuous monitoring of physiological parameters, detecting subtle changes that may indicate early stages of disease (Jabara et al., 2024). Quantum computing holds future potential for accelerating the analysis of complex biological data to identify novel biomarkers for early disease detection.

Preventive medicine strategies leveraging these technologies primarily impact the biological dimension by enabling early detection and intervention, potentially preventing or delaying the onset of chronic diseases. By providing individuals with risk assessments and personalized recommendations, technology can also influence psychological well-being by empowering them to make proactive lifestyle changes. Public health initiatives informed by predictive analytics and digital surveillance systems can improve the overall health of communities, addressing the social determinants of health and promoting health equity. Commercial solutions include AI-powered diagnostic tools for medical imaging from companies like Enlitic and Viz.ai, as well as predictive analytics platforms for healthcare organizations from companies like Optum and Cerner (now Oracle Health).

A.2.4. Clinical Decision Support Systems: Enhancing Diagnostic Accuracy and Treatment Guidance.

Clinical Decision Support Systems (CDSS) utilize new technologies to assist healthcare professionals in making more informed and accurate decisions regarding vaccination, diagnosis and treatment (Grechuta et al., 2024; Specchia et al., 2024). LLMs can analyze patient records and medical literature to provide clinicians with relevant information, diagnostic suggestions, and treatment options, enhancing their decision-making capabilities. AI algorithms can analyze medical images, laboratory results, and patient data to identify patterns and anomalies that may be missed by human review, improving diagnostic accuracy and speed. NLP can extract key information from unstructured clinical notes and present it in a structured format, making it easier for clinicians to review patient histories and identify relevant factors for decision-making. Predictive analytics can forecast patient outcomes and treatment responses, helping clinicians choose the most effective interventions for individual patients.

CDSS primarily impact the biological dimension by improving the accuracy and efficiency of diagnoses and treatment plans, leading to better patient outcomes. By providing clinicians with comprehensive and timely information, CDSS can also reduce stress and improve their confidence in making critical decisions, indirectly benefiting their psychological well-being. Furthermore, by standardizing care pathways and reducing diagnostic errors, CDSS can contribute to more equitable healthcare delivery, impacting the social dimension. Commercial examples include IBM Watson Health, Epic's integrated decision support tools, and numerous AI-powered diagnostic platforms for various specialties.

A.2.5. Point-of-Care (PoC) Diagnostics: Enabling Rapid and Convenient Testing.

Point-of-Care (PoC) diagnostics involve medical testing performed near or at the site of patient care rather than in a centralized laboratory. New technologies are enhancing the speed, accuracy, and accessibility of PoC diagnostics. AI algorithms can be integrated into portable diagnostic devices to analyze results in real-time, providing immediate feedback to healthcare providers (Pillay, Khan & Yenice, 2025). Digital biomarkers, collected through wearable sensors and analyzed using AI, can function as continuous PoC diagnostics, monitoring patient health status outside of traditional clinical settings. Microfluidics and nanotechnology are enabling the development of miniaturized and highly sensitive PoC testing devices for a wide range of analytes. Telemedicine platforms can facilitate specialists' remote interpretation of PoC test results, expanding access to diagnostic expertise.

PoC diagnostics primarily impact the biological dimension by enabling rapid and convenient testing, leading to quicker diagnoses and faster initiation of treatment. The accessibility of PoC testing can also improve psychological well-being by reducing anxiety associated with waiting for lab results and by allowing for immediate clinical decisions. Furthermore, by bringing diagnostic capabilities to the patient's location, PoC diagnostics can significantly improve access to healthcare for individuals in remote areas or with limited mobility, addressing the social dimension of health. Commercial examples include rapid antigen tests for infectious diseases, portable blood glucose monitors, and handheld ultrasound devices.

A.2.6. Digital Biomarkers: Continuous Health Monitoring and Personalized Insights.

Digital biomarkers are defined as physiological and behavioral data that are collected and measured by digital devices, such as wearables, portables, implantables, or digitals, and are used to explain, influence, and/or predict health-related outcomes (Goldhahn, 2017; Rochester et al., 2020). New technologies are crucial for the development and application of digital biomarkers. AI and machine learning algorithms are essential for analyzing the large volumes of data generated by these devices to identify meaningful patterns and insights. Wearable sensors can continuously monitor a wide range of physiological parameters, including heart rate, activity levels, sleep patterns, and glucose levels. NLP can be used to analyze patient-generated text data from journals or social media to identify behavioral biomarkers related to mental health or disease progression. Predictive analytics can leverage digital biomarker data to forecast health risks and predict disease exacerbations, enabling proactive interventions(Albites-Sanabria et al., 2024).

Digital biomarkers provide continuous insights into a patient's biological state, allowing for personalized monitoring and early detection of health changes. The Mobilise-D consortium, for example, has developed and validated digital mobility outcomes (DMOs) for remotely monitoring physical mobility, which can be crucial for managing various health conditions (Rochester et al., 2020). The ability to track and understand their health data can also improve patients' psychological well-being by increasing their awareness and motivation to engage in healthy behaviors. Remote monitoring through digital biomarkers can enhance social health by allowing individuals to manage their conditions from home and maintain their independence. Activity and participation can be directly measured and encouraged through wearable

devices that track movement and provide feedback. Commercial examples include wearable devices like the Apple Watch and Fitbit, continuous glucose monitoring systems from Dexcom and Abbott, and various AI-powered platforms for analyzing digital biomarker data.

A.2.7. In Silico Medicine: a Critical Enabler of Precision Medicine.

In Silico Medicine (ISM) represents a transformative approach in healthcare, where sophisticated computational models simulate biological processes at organ, tissue, and even cellular levels. Closely related to the concept of digital twins, ISM differs in scope: while digital twins are dynamic, continuously updated virtual replicas of specific patients or systems, ISM provides the scientific and technological foundation for their creation, validation, and use in predictive, personalized, and preventive medicine (Katsoulakis et al., 2024; Viceconti et al., 2024). Regulatory agencies like the FDA and EMA are increasingly recognizing ISM-based evidence in regulatory decisions, especially for medical devices and pharmacological modeling.

The development and deployment of ISM rely heavily on a convergence of advanced technologies. Artificial Intelligence (AI) and machine learning algorithms enable the construction and calibration of complex models capable of simulating physiology and forecasting treatment outcomes. Big data analytics is essential for integrating diverse data sources, including electronic health records (EHRs), medical imaging, genomics, and wearable sensors, into computational frameworks (Viceconti et al., 2024). These simulations often require high-performance computing (HPC) infrastructure to perform real-time, multiscale analyses, while virtual reality (VR) and augmented re-

ality (AR) platforms enhance user interaction with the models, supporting decision-making and communication between clinicians and patients.

ISM has the potential to profoundly influence healthcare by supporting individualized treatment planning, testing interventions virtually before implementation, and improving outcomes through enhanced physiological insight. Moreover, immersive visualization of complex data can reduce patient anxiety and improve clinician confidence, contributing to psychological well-being (Katsoulakis et al., 2024).

Pioneering research in ISM is being conducted at several leading institutions. The Insigneo Institute at the University of Sheffield is a global reference in the modeling of musculoskeletal systems and predictive simulations. The Auckland Bioengineering Institute in New Zealand excels in integrated modeling of organ-level physiology, while Johns Hopkins University's Computational Cardiology Lab has made major advances in in silico simulation of cardiac function and electrophysiology.

Commercial applications are also emerging. For instance, Atlas Meditech has developed tools that allow brain surgeons to rehearse operations using AI-enhanced 3D platforms and VR environments. Their systems generate realistic, patient-specific brain models based on CT and MRI data, enabling precise surgical planning and training.

However, the widespread adoption of ISM and related technologies is currently limited by high implementation costs. Establishing these platforms requires investment in a wide range of enabling technologies—including smart automation, CAD, product lifecycle management (PLM), model-based systems engineering (MBSE), and extended reality (XR)—as well as the IT infrastructure to support real-time processing and secure data integration. While these costs are substantial, they are increasingly seen as a necessary investment

for advancing precision medicine and clinical innovation.

A.2.8. Digital Therapeutics: Delivering Software-Based Interventions for Various Conditions.

Digital therapeutics (DTx) are evidence-based software programs designed to prevent, manage, or treat a medical disease or disorder (Chengyu, Xueyan & Ying, 2024; Fassbender et al., 2024). New technologies are central to the development and delivery of DTx. AI algorithms can personalize treatment plans and adapt interventions based on individual patient progress and data. Mobile apps and web-based platforms provide convenient and accessible delivery mechanisms for DTx. VR and AR can enhance the engagement and effectiveness of DTx by creating immersive therapeutic experiences for conditions like phobias, PTSD, and chronic pain. Digital biomarkers, collected through wearable devices, can provide objective measures of treatment adherence and outcomes for DTx.

Digital therapeutics can directly address psychological health by providing accessible and personalized interventions for mental health conditions like anxiety, depression, and insomnia. They can also impact biological health by supporting the management of chronic conditions such as diabetes, hypertension, and obesity through lifestyle modifications and behavioral changes. By providing remote access to therapy and support, DTx can improve social health by reducing barriers to care and increasing patient engagement. Activity and participation can be promoted through DTx that incorporate gamification and tracking of physical activity. Commercial examples include FDA-approved DTx like Pear Therapeutics' reSET for substance use disorder

and Somryst for chronic insomnia, as well as numerous other DTx in development for a wide range of conditions.

A.2.9. Pain Management: Innovative Technological Solutions for Chronic and Acute Pain.

New technologies are offering innovative solutions for managing both chronic and acute pain (Tan et al., 2024). VR therapy has shown promise in reducing pain perception by distracting patients and creating immersive experiences that can alter pain pathways in the brain (Giannelli et al., 2024). AR can be used to overlay information and guidance during physical therapy exercises for pain rehabilitation. Digital therapeutics can deliver cognitive behavioral therapy and other psychological interventions for chronic pain management through mobile apps and web-based platforms. Wearable devices can provide neuromodulation or electrical stimulation to alleviate pain. AI algorithms can analyze patient data to personalize pain management plans and predict treatment responses.

These technologies primarily impact the biological dimension by providing non-pharmacological approaches to pain relief and management. VR and digital therapeutics can also significantly improve psychological well-being by reducing the emotional distress and anxiety associated with chronic pain. By enabling more effective pain management, technology can enhance activity and participation by allowing individuals to engage more fully in their daily lives. Commercial examples include VR pain management programs from companies like AppliedVR and Firsthand Technology and wearable pain relief devices from companies like NeuroMetrix and TENS units.

A.2.10. Health Literacy: Leveraging Technology to Improve Patient Understanding.

Technology plays a crucial role in enhancing health literacy, which is the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions (Deniz-Garcia et al., 2023; Pierce at al., 2025). LLMs can generate patient education materials in plain language, answer patient questions in an accessible manner, and translate complex medical information into various languages. VR and AR can provide immersive and interactive educational experiences, allowing patients to visualize their conditions and treatment plans in a way that is easier to understand than traditional text-based materials. Multimedia resources, including videos and animations, delivered through digital platforms can cater to different learning styles and improve comprehension. AI-powered chatbots can provide personalized health information and guidance based on individual patient needs and questions.

Improving health literacy through technology primarily impacts the psychological dimension by increasing patients' understanding of their health conditions and treatment options, reducing anxiety, and empowering them to make informed decisions. Better understanding can also lead to increased adherence to treatment plans, positively impacting biological health. By making health information more accessible and understandable, technology can also improve social health by enabling individuals to navigate the healthcare system more effectively and advocate for their own needs. Commercial examples include patient education platforms like Krames and Healthwise, as well as various health information websites and apps.

A.2.11. Digital Consent: Streamlining and Securing the Informed Consent Process.

New technologies are transforming the process of obtaining informed consent from patients. Digital platforms can present consent forms in a clear and interactive manner, incorporating multimedia elements like videos and animations to explain procedures and risks more effectively than traditional paper-based forms (Cohen et al., 2023). LLMs can simplify the language of consent forms, making them easier for patients to understand. Electronic signatures and secure digital records streamline the consent process and ensure proper documentation. Telemedicine platforms with integrated digital consent features allow for remote consent, improving accessibility for patients in remote locations. Blockchain technology can provide a secure and auditable record of the consent process, enhancing trust and transparency.

Digital consent processes primarily impact the psychological dimension by improving patients' understanding of the information they are consenting to, leading to more informed decisions and potentially reducing anxiety. The streamlined and convenient nature of digital consent can also improve social health by making the process more accessible and less burdensome for patients. Secure digital records also contribute to the ethical and legal aspects of healthcare. Commercial solutions include electronic health record systems with integrated e-consent functionalities from vendors like Epic and Cerner (now Oracle Health), as well as dedicated digital consent platforms like DocuSign and Formstack.

A.2.12. Digital Clinical Trials: Enhancing Efficiency and Accessibility in Research.

Technology is revolutionizing the design, conduct, and analysis of clinical trials. Digital platforms can facilitate remote patient recruitment and enrollment, expanding the reach and diversity of study participants. Wearable devices and mobile apps enable remote and real-world data collection outside traditional clinical settings, reducing the need for frequent in-person visits and improving patient convenience (Mittermaier, Venkatesh & Kvedar, 2023). AI and machine learning algorithms can assist in identifying suitable candidates for trials based on complex inclusion and exclusion criteria, speeding up the recruitment process. NLP can analyze unstructured data from patient records to identify potential trial participants and extract relevant information for analysis. Predictive analytics can forecast patient dropout rates and identify factors influencing trial outcomes. Digital platforms also enhance data management, monitoring, and communication between researchers and participants.

Digital clinical trials primarily impact the social dimension by increasing accessibility to research participation for a wider range of individuals, including those in remote areas or with mobility limitations. The convenience of remote participation and data collection can also improve the psychological well-being of participants. By accelerating the pace of research and improving the efficiency of trial processes, technology ultimately contributes to advancements in biological health through the development of new treatments and therapies. Commercial solutions include platforms like Medable and Science 37, which offer end-to-end solutions for conducting decentralized clinical trials.

A.2.13. Digital Surveillance Systems: Monitoring and Managing Public Health.

New technologies are crucial for enhancing public health surveillance and management. AI algorithms can analyze large datasets from various sources, including social media, news reports, and healthcare records, to detect and predict disease outbreaks in real-time. NLP can analyze text data for early signals of public health threats and monitor public sentiment and information related to health issues. Predictive analytics can forecast the spread of infectious diseases and identify high-risk populations, enabling timely public health interventions (Shakeri Hossein Abad et al., 2021). Geographic information systems (GIS) and mobile technologies can be used to track disease spread and coordinate response efforts.

Digital surveillance systems directly impact the biological dimension by enabling early detection and control of disease outbreaks, protecting public health. By providing timely and accurate information to the public, these systems can also improve psychological well-being by reducing anxiety and uncertainty during public health emergencies. Effective public health surveillance contributes to social well-being by ensuring the health and safety of communities. Commercial examples include platforms developed by public health agencies like the CDC and WHO, as well as private sector solutions for disease surveillance and outbreak prediction.

A.2.14. Virtual and Physical Assistants: Supporting Patients and Healthcare Professionals.

Technology is enabling the development of both virtual and physical assistants to support patients and healthcare professionals. Virtual assistants, often

powered by AI and NLP, can answer patient questions, schedule appointments, provide medication reminders, and offer emotional support (Cuthbert et al., 2024). Physical assistants, such as soft wearable exoskeletons, can aid in rehabilitation, provide support for individuals with mobility impairments, and reduce the physical strain on healthcare workers (Abery, Canetti & Hing, 2025). Robots are also being used to automate logistical tasks within hospitals, such as transporting supplies and medications, freeing up nurses and other staff to focus on direct patient care.

Virtual assistants can improve psychological well-being by providing patients with readily available information and support, reducing feelings of isolation and anxiety. Physical assistants like exoskeletons can enhance biological health by improving mobility and reducing physical strain. By automating tasks and providing support, both virtual and physical assistants can improve social health by increasing efficiency and allowing healthcare professionals more time for direct patient interaction and personalized care. Activity and participation can be directly supported by physical assistants that aid mobility and rehabilitation. Commercial examples include AI-powered chatbots from various healthcare providers and technology companies, as well as wearable exoskeletons like the ones developed by ABLE Human Motion and ReWalk Robotics.

A.2.15. Age-Friendly Solutions: Tailoring Technology to the Needs of Older Adults.

Technology is playing an increasingly important role in creating age-friendly environments and healthcare solutions that cater to the specific

needs and challenges faced by older adults (Sülz et al., 2021; Dogra et al., 2022). AI-powered virtual assistants can provide reminders for medications and appointments, offer companionship, and assist with daily tasks. Wearable sensors can monitor vital signs and activity levels, alerting caregivers or healthcare providers to potential health issues. Telemedicine platforms with user-friendly interfaces can facilitate remote consultations and monitoring, reducing the need for travel. VR and AR applications can provide engaging cognitive training and social interaction for older adults. Robotics, including social robots and assistive robots, can provide companionship, assist with mobility, and support daily living activities.

Age-friendly technologies can significantly improve the psychological well-being of older adults by reducing feelings of loneliness and isolation, providing cognitive stimulation, and increasing their sense of independence and control. By enabling remote monitoring and early detection of health issues, these solutions can also positively impact biological health. Improved access to care through telemedicine and assistance with daily living activities can enhance social health by allowing older adults to maintain their independence and social connections. Assistive robots and wearable devices can directly support activity and participation by improving mobility and enabling engagement in daily tasks. Commercial examples include social robots like Pepper and Paro, telehealth platforms designed for seniors, and various wearable health monitoring devices.

A.2.16. Innovative Health Data Representations: Visualizing Complex Information for Better Understanding.

New technologies are enabling innovative ways to represent complex health data, making it easier for both patients and healthcare professionals to understand and interpret (Cuthbert et al., 2024). Interactive dashboards and visualizations can present large datasets in a user-friendly format, allowing for easy identification of trends and patterns. VR and AR can transform traditional 2D medical images into interactive 3D models, providing a more intuitive understanding of anatomical structures and medical conditions. Digital twins offer a dynamic and personalized way to visualize an individual's health status and potential treatment outcomes. AI-powered platforms can generate summaries and highlight key insights from complex medical reports, making it easier for clinicians to grasp the most important information quickly (Croxford et al., 2025).

Innovative health data representations primarily impact the psychological dimension by improving understanding and reducing the cognitive burden associated with complex medical information for both patients and clinicians. Better visualization can lead to more informed decision-making and increased confidence in treatment plans, positively impacting biological health [10]. By making health data more accessible and understandable, technology can also improve social health by empowering patients to engage more actively in discussions about their care. Commercial examples include data visualization tools from companies like Tableau and Qlik, as well as specialized medical imaging software and platforms for creating digital twins.

Finanziamento e Spesa Sanitaria in Italia

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Sintesi

Il presente articolo analizza l'evoluzione delle dinamiche di finanziamento e spesa del Servizio Sanitario Nazionale (SSN) italiano, mettendo in luce criticità strutturali e rischi per la sua sostenibilità futura. Dopo aver descritto l'assetto multilivello di finanziamento – centrale, regionale e locale – il lavoro evidenzia come il sottofinanziamento cronico, le persistenti disparità territoriali e l'allocazione inefficiente delle risorse compromettano la capacità del SSN di garantire equità e qualità nell'erogazione dei servizi. Attraverso un confronto con altri Paesi OCSE ed europei, si evidenzia come l'Italia si collochi sotto la media in termini di spesa sanitaria pubblica, mentre cresce la quota di spesa privata a carico delle famiglie. Il progressivo invecchiamento demografico, la diffusione delle malattie croniche e l'impatto dell'innovazione tecnologica pongono ulteriori pressioni sul sistema. Il contributo propone

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infine alcune direttrici di riforma necessarie per assicurare la sostenibilità del SSN, incentrate sul rafforzamento della governance, sull'efficientamento della spesa, sull'incremento degli investimenti e sull'adeguamento dei modelli di finanziamento alle esigenze emergenti della popolazione.

Abstract - Health Expenditure and the Italian NHS Funding

This article analyses the evolution of the Italian health expenditure and the National Health Service (NHS) funding, highlighting structural issues and risks to its future sustainability. After describing the multilevel financing structure - central, regional and local - the essay highlights how chronic underfunding, persistent territorial disparities and inefficient allocation of resources compromise the ability of the NHS to guarantee equity and quality in the delivery of services.

A comparison with other OECD and European countries shows how Italy is below average in terms of public health expenditure, while the share of private expenditure borne by households is growing. The progressive ageing of the population, the spread of chronic diseases and the impact of technological innovation put further pressure on the system.

The article concludes by outlining a set of reform guidelines deemed essential for ensuring the long-term sustainability of the National Health Service (NHS). These guidelines focus on enhancing governance structures, improving the efficiency of public expenditure, increasing investment levels, and adapting financing criteria to better reflect both the evolving needs of the population and the imperative to promote equity and efficiency within the system.

JEL Classification: I1; H51; H61.

Parole chiave: Finanziamento sanitario; Spesa sanitaria; Confronti internazionali; Servizio Sanitario Nazionale (SSN); Sostenibilità del sistema sanitario; Italia.

Keywords: *Health expenditure; National Health Service (NHS); NHS Funding; International comparisons; Sustainability of the health system; Italy.*

1. Introduzione [1]

Il finanziamento della spesa sanitaria in Italia rappresenta una questione cruciale per la sostenibilità del Servizio Sanitario Nazionale (SSN). Istituito per garantire universalismo, uguaglianza e accesso gratuito ai servizi sanitari, il SSN si fonda sul principio secondo cui le cure devono essere erogate sulla base dei bisogni di salute e non della capacità di pagamento. Tuttavia, fin dagli anni Novanta – e in modo più intenso dopo l'introduzione del federalismo fiscale – persistono criticità strutturali, quali il sottofinanziamento cronico rispetto alla media dell'Unione Europea, l'inefficienza nella distribuzione delle risorse e una consistente disuguaglianza territoriale nei livelli essenziali di assistenza.

Le tendenze demografiche e tecnologiche complicano ulteriormente il quadro. L'invecchiamento demografico - con una quota di popolazione oltre i 65 anni passata dal 16 % nel 2000 a oltre il 21 % nel 2023 nei Paesi UE - ha determinato un aumento della prevalenza delle malattie croniche e della domanda di assistenza a lungo termine, con significative implicazioni sui volumi e i costi del servizio sanitario (OECD/EU, 2024). Allo stesso tempo, l'innovazione in campo medico ha introdotto tecnologie sempre più complesse e costose, che pur migliorando gli esiti clinici, gravano ulteriormente sul bilancio del SSN.

I dati più recenti segnalano come l'Italia rimanga sotto la media europea in termini di spesa sanitaria complessiva e pubblica, mentre la componente privata ha raggiunto una quota pari al 24,8 %, tra le più elevate nell'UE. La

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spesa sanitaria nazionale è inferiore dell'11,3 % rispetto a quanto ci si attenderebbe in relazione al PIL al netto degli interessi passivi, e anche una sua completa integrazione non raggiungerebbe i livelli medi comunitari. A ciò si aggiunge una persistente disparità regionale, dovuta a un sistema di riparto del Fabbisogno Sanitario Nazionale che non considera appieno la complementarità tra spesa pubblica e privata né le diverse capacità economiche delle famiglie (Neri, Vainieri & Vola, 2020).

In tale scenario, il Servizio Sanitario Nazionale rischia di non riuscire a mantenere le sue promesse di universalità e equità. La crescente quota di spesa privata – inclusa la diffusione di fondi sanitari aziendali – solleva interrogativi sul ruolo del SSN e la sua capacità di integrare in modo regolato le forme di protezione emergenti. È pertanto urgente ripensare meccanismi di finanziamento e allocazione, favorendo un approccio sussidiario basato su regolamentazione e trasparenza.

Sebbene un aumento delle risorse pubbliche rimanga l'opzione più auspicabile, i vincoli di bilancio attuali rendono questo obiettivo complesso nel breve termine. Ne consegue l'esigenza di una strategia basata su due filoni paralleli: da un lato, riequilibrare la spesa privata, integrandola nel sistema pubblico; dall'altro, definire criteri di prioritizzazione delle prestazioni e riallocare le risorse disponibili in modo più equo, tenendo conto di principi distributivi e delle condizioni di fragilità economica e sanitaria dei cittadini.

Alla luce di queste evidenze, l'obiettivo del presente lavoro è quello di offrire una riflessione sistematica sui temi del finanziamento e della spesa sanitaria in Italia, pubblica e privata, anche in comparazione con quanto accade a livello internazionale. Il lavoro si propone di fornire un inquadramento delle principali criticità emerse negli ultimi trent'anni, con particolare attenzione alle dinamiche di sostenibilità economica, equità territoriale e complementa-

rità tra pubblico e privato, al fine di orientare eventuali interventi di policy.

A tal fine, l'articolo è articolato in sei sezioni. La Sezione 2 ricostruisce l'evoluzione storica del finanziamento sanitario in Italia, con particolare riferimento all'impatto del federalismo fiscale e al confronto con i modelli sanitari europei. La Sezione 3 quantifica la composizione pubblica e privata della spesa sanitaria, analizzandone l'andamento nel tempo e le sue implicazioni in termini di equità. La Sezione 4 esplora le disuguaglianze regionali e il meccanismo di riparto del fabbisogno, evidenziando le inefficienze e le criticità strutturali. La Sezione 5 presenta scenari di policy per fronteggiare le sfide emergenti, attraverso interventi regolatori e redistributivi, nonché opzioni di riforma finanziaria. Infine, la Sezione 6 propone una sintesi delle evidenze, formula raccomandazioni operative e traccia le principali direzioni per ulteriori approfondimenti di ricerca.

2. Il finanziamento del SSN

Il processo di finanziamento del SSN riveste un duplice e fondamentale ruolo nella *governance* della Sanità. In primo luogo, perché le regole di finanziamento sono funzionali a realizzare i principi di equità che sono fondanti del SSN italiano; in secondo luogo, perché, distribuendo le risorse sulle Aziende sanitarie deputate all'erogazione dei servizi, impatta sulla loro efficienza.

In tema di equità va osservato che essa si estrinseca sia sul lato del prelievo che su quello dell'erogazione; il prelievo dovrebbe essere, infatti, deputato a realizzare una redistribuzione solidaristica: nella realtà, come segnalato da Itinerari Previdenziali (XI Osservatorio sulle entrate fiscali e sul finanziamento

del *welfare*, 2024) solo il 24,2% degli italiani dichiara redditi tali da corrispondere un'imposta sufficiente a coprire la spesa per il *welfare* (sanità e assistenza), confermando così i limiti del sistema fiscale nazionale e la conseguente difficoltà nel mantenere i livelli di *welfare* attuali. Sul versante dell'equità di accesso ai servizi, una corretta allocazione delle risorse è condizione necessaria, ancorché non sufficiente, per garantirne l'universalità e, quindi, la realizzazione del principio costituzionale della tutela della salute.

In tema di efficienza, infine, va aggiunto che il processo di determinazione delle risorse necessarie per mantenere le "promesse" del SSN, e la conseguente allocazione delle stesse a livello regionale e locale, in assenza di prezzi di mercato, va a costituire i ricavi delle Aziende sanitarie pubbliche, la cui determinazione impatta a sua volta sugli indici di bilancio, in primis sui risultati di esercizio: pertanto, le analisi sulle efficienza delle Aziende condotta sui loro bilanci è condizionata dalla corretta attribuzione dei finanziamenti, in assenza della quale i risultati di esercizio restituiscono una valutazione distorta dell'efficienza delle Aziende stesse.

Per comprendere le complessità del sistema di finanziamento della Sanità, appare opportuno seguirne il processo dal livello Centrale a quello locale (Aziende sanitarie), passando per il cosiddetto riparto regionale. Nelle pagine che seguono tale processo viene dettagliato con lo scopo di far capire meglio se e dove possono sorgere problemi legati all'equità e all'efficienza.

2.1 Il processo del finanziamento a livello centrale

A livello Centrale, il processo inizia con la determinazione delle risorse pubbliche da assegnare alla Sanità. Sebbene il flusso che ne segue non si sia

modificato in modo significativo negli ultimi 20 anni, alcune soluzioni di continuità meritano segnalazione. La prima è quella legata alla modifica delle fonti di finanziamento; dopo la fiscalizzazione degli oneri sociali avvenuta nella prima metà degli anni '90, con l'introduzione dell'IRAP (Imposta Regionale sulle Attività Produttive), la principale modifica è quella derivante dalla modifica del Titolo V della Costituzione in senso federalista e dal conseguente perseguimento dell'autonomia finanziaria regionale.

Quest'ultima, realizzata con il D.Lgs. n. 56/2000, ha cancellato il trasferimento statale alle Regioni, con il fine ultimo di responsabilizzarle sul versante economico-finanziario, oltre che su quello organizzativo: una scelta maturata a fronte del perdurare di ingenti disavanzi di gestione della Sanità, che rimane la prima voce per dimensione nei bilanci regionali. Tralasciando l'incremento delle addizionali regionali IRPEF e delle accise sulla benzina, quantitativamente di minore importanza, la compensazione dell'abolizione dei trasferimenti statali è stata effettuata istituendo una compartecipazione regionale al gettito IVA (Imposta sul Valore Aggiunto), per le Regioni a statuto ordinario.

L'abolizione dei trasferimenti statali, seguita poi dalla pratica dei Piani di Rientro e dei commissariamenti delle Regioni in disavanzo, si è dimostrata "vincente" in termini di responsabilizzazione finanziaria delle Regioni, come dimostrato dal rapido rientro dei disavanzi regionali. Non di meno, l'utilizzo della compartecipazione all'IVA per il finanziamento della Sanità (la cui aliquota è, almeno sulla carta, oggetto di pattuizione fra lo Stato e le Regioni sulla base della stima dei fabbisogni sanitari) ha però legato indissolubilmente le risorse disponibili per la Sanità all'andamento dei consumi e quindi alle variazioni congiunturali dell'economia, dalle quali l'IRAP, in teoria, avrebbe dovuto tenere sostanzialmente al riparo. Di fatto, gli anni della pandemia hanno evidenziato una estrema "volatilità" del gettito IVA e IRAP (il secondo

persino maggiore), per cui la copertura della crescita del finanziamento è stata necessariamente ottenuta sterilizzando la "volatilità" del gettito, modificando (di fatto ex post) l'aliquota di compartecipazione all'IVA (vedere Tabella A.5.1 nell'appendice online).

Un secondo aspetto di discontinuità meritevole di segnalazione è quello legato alle modalità di determinazione delle risorse da assegnare alla Sanità (in teoria, a fondamento dell'accordo Stato-Regioni sull'aliquota di compartecipazione all'IVA). Con l'approvazione del D.Lgs. n. 68/2011, emanato ai sensi della L. n. 42/2009, è stato, infatti, introdotto il concetto di Fabbisogno Sanitario *Standard* (FSN), ovvero la stima delle risorse necessarie al SSN per mantenere le sue "promesse" (ovvero i Livelli Essenziali di Assistenza o LEA) in condizioni di appropriatezza ed efficienza. Nello specifico, il D.Lgs. n. 68/2011 recita: « … *(il FSN) è determinato tramite intesa con le Regioni, in coerenza con il quadro macroeconomico complessivo e nel rispetto dei vincoli di finanza pubblica e degli obblighi assunti dall'Italia in sede comunitaria, coerentemente con il fabbisogno derivante dalla determinazione dei livelli essenziali di assistenza (LEA) erogati in condizioni di efficienza ed appropriatezza* …». Quindi, pur nel rispetto delle compatibilità macroeconomiche, il FSN dovrebbe essere frutto di una quantificazione "oggettiva", basata sui bisogni della popolazione.

Una lettura logica del dispositivo normativo implica, quindi, una non predominanza di un criterio sull'altro e che, per garantire la "composizione" dei due criteri, si debba addivenire ad una programmazione capace di aumentare le risorse assegnate in caso di aumento dei bisogni, ma anche di ridurre le "promesse" ove le compatibilità macroeconomiche non permettessero di garantire al settore le risorse necessarie per l'erogazione dei LEA vigenti. Riduzione delle promesse realizzabile con una delimitazione dei servizi forniti, ovvero aumentando le compartecipazioni dei cittadini alla spesa per i servizi

del SSN. Tralasciando gli aspetti operativi che, secondo la norma, dovrebbero portare alla determinazione dei costi *standard* dei LEA e quindi del FSN, peraltro rimasti in sostanza sulla carta, è lecito chiedersi se la citata "composizione" si sia effettivamente realizzata.

Nel decennio 2014-2024, l'andamento del FSN mostra tre fasi distinte (vedere Figura A.4.1 nell'appendice online). Nel periodo pre-pandemico (2014-2019), è cresciuto con un incremento medio annuo dello 0,8% in termini nominali, che corrisponde a una crescita reale modesta dello 0,3% annuo, tenuto conto dell'inflazione. Durante la fase pandemica (2019-2021), il ritmo di crescita si è intensificato, raggiungendo un incremento nominale medio annuo del 3,3%, pari al 2,4% in termini reali, grazie all'introduzione di risorse straordinarie per fronteggiare l'emergenza sanitaria. Nel triennio successivo (2021-2024), pur con l'incorporazione strutturale di tali risorse nel finanziamento ordinario, la crescita nominale si è attestata al 3,2% medio annuo, mentre in termini reali si è registrata una contrazione media dell'1,5% annuo. Qualora si escludessero dal computo i finanziamenti aggiuntivi destinati specificamente al contrasto del Covid-19, considerando quindi il FSN al netto della componente emergenziale, il tasso di crescita nel periodo 2019-2023 si ridurrebbe all'1,9% medio annuo in termini nominali e si collocherebbe al -1,9% in termini reali, evidenziando una significativa erosione del potere d'acquisto delle risorse sanitarie disponibili.

Le considerazioni quantitative che precedono segnalano la concreta difficoltà di "comporre" efficacemente il *trade-off* fra i vincoli di finanza pubblica e i bisogni di salute, e anche una discrasia fra risorse e programmazione. Infatti, a fronte di una decrescita (o per lo meno una "non crescita") in termini reali del finanziamento, l'equilibrio ai sensi del D.Lgs. n. 68/2011 avrebbe richiesto una riduzione/congelamento dei LEA, realizzabile o con una loro

"contrazione fisica", o grazie ad una maggiore efficienza "produttiva", o per effetto di una diminuzione dei loro costi unitari.

Per quanto concerne la prima opzione, appare evidente come la politica sanitaria non si sia indirizzata verso una riduzione dei LEA anzi, semmai, ad una loro espansione: sebbene non si sia ancora trovato l'accordo definitivo fra Stato e Regioni, sono stati, infatti, approvati i "nuovi LEA", in contraddizione "programmatoria" con la limitatezza delle risorse. La "possibilità" di perseguire guadagni significativi di efficienza produttiva (seconda opzione) appare anch'essa di difficile sostenibilità, a fronte della duplice constatazione di una spesa pubblica italiana per la Sanità che è ormai (si veda Polistena, 2023) inferiore di oltre il 40% a quella dei Paesi europei di confronto (ovvero quelli membri già prima del trattato di Corfù del 1995), e con un *trend* di crescita anch'esso costantemente inferiore: nel periodo 2019-2022 al 3,6% medio annuo in Italia, contro il 5% dei Paesi EU-Ante 1995 e il 5,3% dell'intera Unione.

Per quanto concerne la terza opzione, infine, va propedeuticamente osservato che l'invecchiamento farebbe sottintendere un aumento dei costi unitari, come confermato dal fatto che il solo effetto demografico, assumendo come validi i pesi adottati per il riparto regionale, negli anni considerato avrebbe comportato un aumento atteso della spesa sanitaria dello 0,54% per l'ospedaliera e del 0,48% per la specialistica ambulatoriale. A questo andrebbe aggiunta la considerazione degli incrementi attesi per effetto dell'innovazione terapeutica e delle aspettative della popolazione.

Il "congelamento" dei costi è, con tutta probabilità, alla base della mantenuta "sostenibilità" del SSN ed è stato comunque perseguito bloccando amministrativamente (ove possibile) i costi unitari dei servizi acquistati. In primo luogo, quelli relativi al personale, ma anche quelli degli acquisti di

tecnologie sanitarie (per farmaci e dispositivi medici). Che questa politica sia sostenibile nel tempo è discutibile, come appare evidente sul lato del personale, vista la mancanza di vocazioni in campo infermieristico, per la medicina generale e per le specializzazioni mediche più "disagiate". Sul lato delle tecnologie, la continua crescita del *payback* dovuto dalle Aziende, malgrado il progressivo aumento dei tetti, mette sempre più a rischio l'approvvigionamento dei farmaci innovativi. Senza poi considerare che la necessaria crescita dei tetti citati implica un corrispondete (e implicito) razionamento per altre voci, quali l'assistenza territoriale, che pure è dichiarata essere in cima all'agenda delle priorità del SSN. Il rischio, in definitiva, è che la mancata capacità di compensazione del *trade off* implicito nelle indicazioni del D.Lgs. n. 68/2011 in tema di determinazione del FSN, si trasformi in un razionamento implicito che, in assenza di governo del processo di "redistribuzione" dei diritti di accesso alle tutele, risulta foriero di crescita delle iniquità.

Se il primo *step* del processo di finanziamento, come sopra argomentato, è stato segnato da importanti discontinuità rispetto al passato, gli *step* successivi, paradossalmente, sono invece caratterizzati da una prolungata "immutabilità".

Sempre a livello centrale, una volta determinato l'importo da distribuire per la Sanità, questo viene ripartito in quattro diverse poste in funzione delle priorità del Legislatore[2]:

1. Fondo Indistinto (di cui una parte finalizzato)
2. Accantonamenti
3. Fondo vincolato per Regioni
4. Fondo vincolato per altri Enti.

2 Nel triennio 2020 – 2022 è stata aggiunta una quinta voce rappresentata dagli importi per finalità relative all'emergenza Covid–19.

Il fondo indistinto (comprendente una parte finalizzata a obiettivi specificamente determinati) è la quota che va alle Regioni per l'erogazione dei LEA. Non tutto il fondo indistinto viene reso immediatamente disponibile per le Regioni. Ai sensi della L.191/2009 una parte (inizialmente lo 0,30%, poi portato allo 0,50% dalla L.197/2022) viene accantonata per essere distribuita successivamente. Il meccanismo originariamente era stato introdotto per incentivare comportamenti regionali virtuosi (ovvero l'adempimento agli obblighi descritti nell'accordo Stato-Regioni dell'8.8.2001), ma ha man mano perso questa sua finalizzazione, e viene ormai allocato su base pattizia concordata nell'ambito del Comitato permanente per i rapporti tra lo Stato, le Regioni e le Provincie Autonome per la verifica dell'erogazione dei LEA e dal Tavolo tecnico per la verifica degli adempimenti regionali.

A conferma di ciò, nella Figura A.4.2 nell'appendice online si vede come negli ultimi anni Liguria, Basilicata, Molise e Campania abbiano beneficiato di una maggiore quota delle risorse accantonate a "scapito" di quelle settentrionali. In altri termini, sembra siano state utilizzate per "compensare" le diseconomie di scala delle Regioni di minori dimensioni, e l'insufficienza del sistema di riparto regionale nel tenere conto delle demografie "estreme" delle Regioni più vecchia e più giovane.[3] Per completezza, va poi ricordato che la L. 232/2016 ha introdotto i cosiddetti Fondi per i farmaci innovativi (oncologici e non oncologici, ora riuniti), le cui risorse, nei limiti dello stanziamento previsto, sono stornate dall'indistinto e dalle quote vincolate per essere assegnate alla Regioni ex post (a rimborso) in base ai consumi di farmaci innovativi sostenuti.

Il fondo vincolato destinato alle Regioni è destinato a finanziare la realizzazione di specifici obiettivi, di cui la componente principale è rappresentata

3 Nella sezione 2.2 si chiarisce meglio la modalità di riparto regionale del fondo indistinto.

dagli obiettivi di Piano ai sensi della L. n. 662/1996, sebbene il Piano sia scaduto e mai più rinnovato. Si segnala anche che gli eventuali residui della quota finalizzata del fondo indistinto, sebbene anch'essi destinati a finanziare la realizzazione di obiettivi prefissati, a differenza delle quote vincolate, diventano liberamente disponibili per le Regioni. In tal modo rappresentano dei "gradi di libertà" per le Regioni nell'allocazione delle risorse, sebbene rischino di evidenziare limiti nella corretta valutazione dei costi *standard* per il raggiungimento degli obiettivi a cui le risorse sono destinate. Infine, il fondo vincolato per gli Enti del settore sanitario (Croce Rossa italiana, Istituti zooprofilattici sperimentali, Centro nazionale trapianti, etc.) è funzionale al loro funzionamento.

2.2 Il processo del finanziamento regionale (riparto)

Passando al cosiddetto riparto regionale, iniziamo osservando che esso avviene sul fondo indistinto, che rappresenta oltre il 96% del FSN, e che viene attribuito ai 3 macro-livelli di assistenza (LEA) vigenti:

1. Assistenza sanitaria preventiva (ambiente di vita e di lavoro)
2. Assistenza ospedaliera
3. Assistenza distrettuale.

L'assistenza distrettuale è a sua volta ripartita in quattro "sub-livelli":

4. Medicina di base
5. Farmaceutica
6. Specialistica
7. Territoriale.

Il riparto avviene separatamente per ogni singolo LEA (e sub-LEA), adottando dei pesi applicati alla popolazione, ritenuti rappresentativi dei diversi bisogni sanitari dei cittadini (vedere Tabella 2 nell'appendice online). Appare immediatamente evidente come le quote di allocazione sui LEA risultino invariate (peraltro da oltre un decennio), a meno della variazione del tetto della farmaceutica: la quale ha l'effetto di ridurre la quota per l'assistenza territoriale ad un mero residuo, essendo tutte le altre voci determinate "ex ante". La sostanziale invarianza del fabbisogno attribuibile ai LEA sembra di difficile "giustificazione" a fronte del già richiamato invecchiamento demografico e delle variazioni organizzative indotte dall'evoluzione tecnologica, ma anche delle scelte strategiche del SSN: si pensi all'epocale riduzione dei posti letto ospedalieri (oltre il 30% nell'ultimo decennio) e il potenziamento dei *setting* assistenziali cosiddetti "territoriali".

Inoltre, appare paradossale che, in presenza di un imponente investimento per lo sviluppo dell'assistenza territoriale (obiettivo primario della missione 6 del PNRR), la voce destinata al suo finanziamento corrente sia quella determinata a residuo, e oltretutto in competizione con l'assistenza farmaceutica che è una delle voci di spesa più dinamiche. A livello regionale, peraltro, si riscontrano notevoli divergenze rispetto ai criteri nazionali, dimostrando che le allocazioni sui LEA non rappresentano vincoli di destinazione: ad esempio la Valle d'Aosta aumenta la quota destinata alla prevenzione di un punto percentuale (p.p.) sottraendolo equamente agli altri livelli. Di contro, l'Emilia-Romagna la riduce per aggiungere mezzo p.p. di finanziamento alla distrettuale e all'ospedaliera.

Per tenere conto dei diversi livelli di bisogno sanitario delle popolazioni, la ripartizione fra le Regioni delle risorse assegnate ai LEA avviene commisurandola alla loro popolazione "pesata", ovvero rideterminata in base ai diversi bi-

sogni sanitari dei cittadini, assunti "proporzionali" all'età e al genere, con pesi stimati dai dati di consumo rilevati dal Nuovo Sistema Informativo Sanitario (NSIS), quali le SDO e il Flusso Tessera Sanitaria (nel caso della specialistica ambulatoriale), e dalle tariffe nazionali delle prestazioni sanitarie. La stima dei pesi presenta due criticità rilevanti: la prima è rappresentata dalla dipendenza dalle tariffe, che non vengono aggiornate significativamente da circa 20 anni e hanno presumibilmente ormai accumulato uno differenziale significativo rispetto ai costi reali; la seconda dal fatto che i pesi sono frutto di un calcolo "ragionieristico" effettuato sui consumi, ovvero senza tenere conto tanto (in negativo) dei consumi inappropriati e (in positivo) degli *unmet needs,* quanto della interazione con i consumi in altri *setting* assistenziali, il cui impatto è ben dimostrato in letteratura (Brenna, Polistena, Spandonaro, 2023). A parte le questioni metodologiche, anche per i pesi si registra una loro prolungata costanza nel tempo, ignorando l'impatto dell'avvento continuo di innovazioni terapeutiche e organizzative.

Nel complesso, indipendentemente dai problemi metodologici di stima dei pesi e di costanza nel tempo degli stessi, come si può vedere dalla Tabella A.5.2 nell'appendice online, l'attuale processo di allocazione delle risorse alle Regioni sposta poco rispetto ad un semplice criterio di riparto basato sulla popolazione residente. Fatta 100 la media Italia, le quote capitarie regionali variano, relativamente al 2023, in un *range* che va da 96,73 a 104,12, con una differenza assoluta di 7,39 p.p..

Le uniche modifiche intervenute nei criteri di riparto, lungi dall'avere affrontato le tematiche segnalate, sembrano piuttosto da ascriversi a logiche pattizie fra le Regioni. Fino al 2023, sono state tese a ridurre gli effetti della composizione demografica, aumentando le quote ripartite sulla base della popolazione residente non pesata. Nel 2023, con l'approvazione del DM n.

61/2023, il riparto si è, invece, arricchito del criterio della "deprivazione". Gli effetti di tali manovre, quantitativamente limitati, sull'allocazione delle risorse alle varie Regioni è visibile nella Figura A.4.3 nell'appendice online, dalla quale risulta che la Liguria ha subito la "perdita" maggiore in termini di quota capitaria assegnata (-2,31%) e la Campania il vantaggio maggiore (+2,24%).

Va inoltre notato che il *gap* tra le Regioni agli estremi del *range* si è ridotto negli anni, per poi stabilizzarsi fra il 2022 e il 2023 (vedere Figura A.4.4). In definitiva la differenza di quota capitaria fra le Regioni agli estremi (Campania e Liguria), che era pari a € -154,61 nel 2019, si è ridotto di € 13,22 (€ 141,39) nel 2023. Peraltro, va considerato che sulla spesa che le Regioni devono sostenere con la quota capitaria loro assegnata incide la quota di spesa privata che va a ridurre l'onere regionale per l'erogazione dei LEA (compartecipazioni alla spesa, farmaci di classe A acquistati privatamente, prestazioni specialistiche effettuate a pagamento a causa delle liste di attesa, etc.).

La spesa sostenuta privatamente dalle famiglie varia nel *range* € 453,90 per la Puglia e € 1.029,89 per la Valle D'Aosta, con un differenziale di € 575,99. Anche senza considerare questa ultima Regione, che è a statuto speciale, il *range* risulta compreso fra € 453,90 della Puglia e € 868,10 della Lombardia, con un differenziale di € 414,19. Quindi, le differenze di finanziamento generate dal riparto rappresentano circa un terzo delle differenze indotte dai comportamenti di spesa dei cittadini che esitano in spese private.

Da quanto descritto si evince, quindi, un implicito incentivo per le Regioni a trasferire oneri sulla popolazione, nella misura in cui queste esitano in un risparmio per il bilancio regionale non compensato in fase di allocazione (riparto) delle risorse. In conclusione, gli algoritmi del riparto dimostrano la necessità di una "manutenzione", sia sul versante dei metodi di stima, che dovrebbero essere statisticamente più corretti, ma anche introducendo fattori

di correzione, in primis quelli legati alla diversa incidenza della spesa privata.

2.3 Il processo di finanziamento a livello locale

L'ultima fase del processo di finanziamento è quello con cui le Regioni accertano le risorse assegnate e le distribuiscono fra le Aziende sanitarie (territoriali e ospedaliere), nonché agli altri Enti dei Servizi Sanitari Regionali (SSR). Un'analisi esaustiva del processo di riparto effettuato dalle Regioni esula dallo scopo del presente contributo, per cui ci si limita ad asservarne solo alcuni elementi rilevanti.

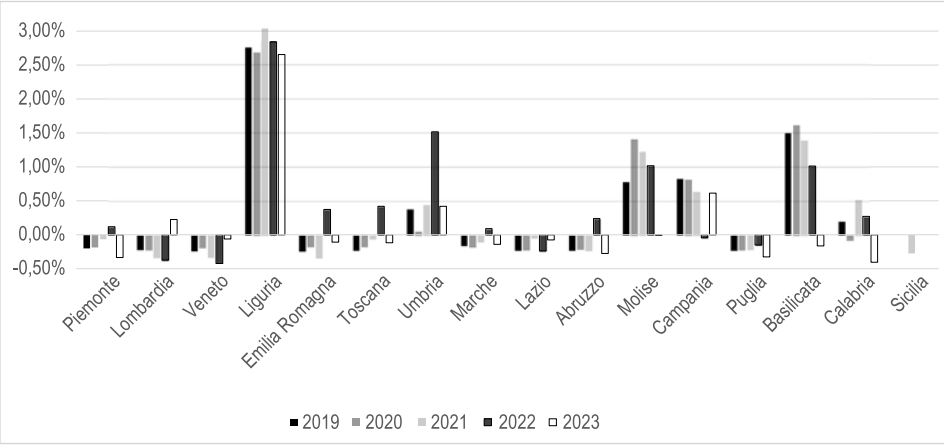
In varie realtà regionali si registra un sistema di allocazione delle risorse basato su criteri molto più dettagliati di quelli nazionali: a titolo di esempio, a fronte delle sei quote di allocazione nazionali delle risorse, il Piemonte ne adotta 11 per la Prevenzione, 5 per l'Ospedaliera, 11 per la Distrettuale, mentre l'Emilia-Romagna ne adotta 3 per la Prevenzione, 1 per l'Ospedaliera, 9 per la Distrettuale. Analogamente, in Piemonte per l'applicazione dei pesi, per tenere conto del bisogno si utilizzano 16 criteri aggiuntivi oltre quelli adottati a livello nazionale, in Emilia-Romagna 14, in Campania 5 e in Basilicata 4 in più.

Un secondo aspetto degno di nota è quello relativo agli effetti dell'introduzione della Gestione Sanitaria Accentrata (GSA) prevista dal D.Lgs. 118/2011. Tale norma è finalizzata a razionalizzare la gestione contabile delle somme che le Regioni mantengono accentrate. Parallelamente, si è osservata l'istituzione di Aziende regionali di "supporto", cosiddette "Aziende Zero" (con diverse denominazioni, A.Li.Sa, ARCS, etc.), deputate a funzioni centralizzate di coordinamento (con varie "sfumature"), che in alcune Regioni

hanno anche preso in carico la GSA. La Tabella A.5.4 nell'appendice online evidenzia come, in tutte le Regioni a statuto ordinario per cui è stato possibile reperire informazioni sufficienti, la GSA è stata attivata. Quattro Regioni hanno anche istituito una "Azienda Zero", a cui, in tre casi è stata attribuita la gestione della GSA. La quota di risorse mantenute accentrate risulta fortemente variabile sia fra le Regioni, sia nel tempo (Figura 1).

Anche in considerazione del fatto che alcune Regioni (Veneto, Marche, Emilia-Romagna, etc.) dichiarano di fare accantonamenti per il ripiano di disavanzi programmati, si può sostenere che le quote accentrate siano funzionali anche alla necessità di ripianare eventuali disavanzi locali. Di fatto il sistema di finanziamento, pur basato nelle fasi centrali e regionali su stime del bisogno, "atterra" a livello locale mantenendo un approccio che in larga misura rappresenta un "rimborso a piè di lista" delle spese sostenute.

Figura 1 **Quota di finanziamento accentrata**



Fonte: elaborazione C.R.E.A. Sanità© su dati Delibere regionali

Un ultimo punto che merita segnalazione riguarda il definitivo allontana-

mento dal disegno originario del D. Lgs.502/1992 ove prevedeva l'attribuzione del finanziamento alle Aziende territoriali, a loro volta chiamate ad acquistare prestazioni tariffate presso le strutture di erogazione, ivi comprese le Aziende Ospedaliere. Nei fatti, le AO sono in larga misura finanziate direttamente dalla Regione, configurando un sistema "ibrido", in parte legato ai DRG e alle prestazioni ambulatoriali "prodotte", e in parte legato alla copertura dei costi per funzione e/o a un *budget* regionale preassegnato. Questa attitudine, ormai generalizzata, conferma che le tariffe dei DRG e delle prestazioni di specialistica ambulatoriale, non sono rappresentative dei costi (pieni) sostenuti. A indiretta dimostrazione di quanto affermato, ed in contraddizione con gli atti di programmazione del SSN che indicano la volontà di potenziare l'assistenza territoriale, nel periodo considerato, nella maggioranza delle Regioni, si osserva un progressivo spostamento di risorse sulle Aziende Ospedaliere a scapito di quelle territoriali (vedere la Tabella A.5.5 nell'appendice online).[4]

3. La previsione di spesa sanitaria pubblica nel 2024-2027

Il rifinanziamento del SSN è il provvedimento più rilevante per il settore sanitario contenuto nella Legge di Bilancio 2025 (L. 207/2024), approvata lo scorso dicembre, che individua anche le aree di destinazione delle risorse aggiuntive. Secondo la nostra ricostruzione (Tabella 1), l'incremento del finanziamento ordinario o *standard*, rispetto a quello vigente, è pari a 1,3 miliardi di euro nel 2025, 5 e 5,7 miliardi nei due anni seguenti (per il biennio

4 Il risultato del processo di finanziamento qui sopra descritto è più facilmente valutabile se si effettua una comparazione con i livelli di finanziamento della Sanità degli altri Paesi EU. A tal proposito si rimanda il lettore interessato alla sezione "A.1 Confronti internazionali" nell'Appendice online.

2028-2029 l'incremento annuale è pari a 6,6 e di 7,7 miliardi di euro, mentre è di 8,8 miliardi a decorrere dal 2030). In particolare, nelle nostre stime oltre alle maggiori risorse indicate nell'art. 1, c. 273, specificatamente dedicato al rifinanziamento del SSN, abbiamo considerato anche quelle previste per la fornitura di ausili e protesi per i disabili impegnati in attività sportive (1 milione di euro all'anno) e per gli specializzandi non medici (30 milioni di euro per il 2025).[5] Abbiamo inoltre considerato il taglio di 50 milioni di euro annui dal 2025 del "fondo" finalizzato al contrasto delle patologie derivanti dalla pratica del gioco d'azzardo compulsivo, in concomitanza con la revisione più generale della disciplina della cura e riabilitazione delle patologie da dipendenze.[6] Va peraltro detto al riguardo che nel nuovo assetto le Regioni "rientrano" delle risorse perdute, attingendole dal neoistituito Fondo per le dipendenze patologiche (FDP).

Tabella 1 **Il finanziamento statale ordinario del SSN 2024-2030** ***(milioni di euro)***

	2024	2025	2026	2027	2028	2029	2030
Finanziamento a legis. vigente	134.015	135.231	135.517	135.518	135.518	135.518	135.518
Incremento LB 2025	-	1.283	4.966	5.685	6.557	7.619	8.792
- Personale		1.070	2.857	3.859	4.742	5.804	6.977
- Adeguamento tariffe DRG		77	1.000	1.000	1.000	1.000	1.000
- Obiettivi di carattere prioritario		0	774	341	379	379	379
- Piano pandemico		50	150	300	300	300	300
- Altre misure		86	186	186	136	136	136
Finanziamento programmato	134.015	136.514	140.483	141.203	142.075	143.137	144.310
Finanziamento programmato in % PIL	6,1	6,1	6,0	5,9			

Fonte: elaborazioni su dati UPB (2024) e A.S. 1330 (LB 2025)

5 Cfr. L. 207/2024, art. 1 commi 305 e 340.
6 Cfr. L. 207/2024, art. 1 commi 367-375.

La gran parte del finanziamento aggiuntivo è destinato a sostenere le maggiori spese per il personale: in particolare, rientrano nella nostra stima oltre agli effetti del rinnovo dei contratti del triennio 2025-2027 e di quello successivo, l'erogazione di nuove e specifiche indennità, l'incremento dei trattamenti accessori e le nuove risorse previste per gli specializzandi.[7] Tra le altre misure, le più significative almeno dal punto di vista del costo a carico del bilancio pubblico sono l'aggiornamento delle tariffe delle prestazioni ospedaliere, i cosiddetti DRG (77 milioni di euro nel 2025 e 1 miliardo a decorrere dal 2026), la "riserva" a favore degli obiettivi sanitari di carattere prioritario e di rilievo nazionale, ossia specifiche aree di intervento individuati dal governo e condivisi dalle Regioni (774 milioni di euro nel 2026 e importi inferiori di circa la metà negli anni successivi) e l'attuazione del Piano pandemico nazionale 2025-2029, ossia il rinnovato sistema di linee guida per la gestione delle eventuali nuove emergenze sanitarie dovute a virus respiratori, al momento non ancora definitivamente approvato.[8] Infine, tra le altre misure sono ricompresi diversi interventi specifici di modesta entità e la minore spesa riconducibile al riordino del sistema di cura delle dipendenze tossicologiche, di cui si è detto in precedenza.

A seguito di tali interventi il finanziamento del SSN salirebbe nell'anno in corso a 136,5 miliardi di euro e a 140,5 nel 2026, mentre negli anni successivi le stime risentono sia del fatto che il finanziamento tendenziale (o a legislazione vigente) dal 2027 in poi è tenuto fermo al livello del 2026 e che gli incrementi previsti annui (in media meno di 1 miliardo all'anno) sono inferiori a quelli dei due anni precedenti.[9] In percentuale del PIL, il finanziamento

7 Il costo dei rinnovi contrattuali non è esplicitamente indicato nei documenti ufficiali ed è stato stimato sulla base delle informazioni ricavabili dal prospetto riepilogativo degli effetti economici della Legge di bilancio.

8 Cfr. L. 207/2024, art. 1 commi 300-301, 275 e 308.

9 Per la stima del finanziamento tendenziale, vedere Ufficio Parlamentare di Bilancio (2024), p. 114.

rimarrebbe quest'anno allo stesso livello del 2024 (6,1%) per poi ridursi di un decimo di punto percentuale all'anno nei due anni seguenti e attestarsi nel 2027 sul 5,9%.[10] Nella Tabella 2 abbiamo riportato le stime ufficiali più aggiornate sull'evoluzione nel prossimo triennio della spesa sanitaria pubblica e della sua incidenza sulle principali variabili macroeconomiche.

Tabella 2 **La spesa sanitaria nel quadro tendenziale dei conti pubblici (2024-2027)**

	2024	2025	2026	2027
Spesa sanitaria (mld. euro)	138,3	143,4	149,8	151,6
Quota su PIL (in %)	6,3	6,4	6,4	6,4
Quota sulla spesa primaria corrente (in %)	15,3	15,4	15,7	15,7
Spesa sanitaria (variazione in %)	4,9	3,6	4,5	1,2

Fonte: elaborazioni su dati MEF (2025)

Secondo questa ricostruzione, la spesa aumenterebbe del 3,6% quest'anno, del 4,5% nel 2026 e dell'1,2% nel 2027.[11] In percentuale del PIL la spesa sanitaria è prevista crescere di un altro decimo di punto e raggiungere il 6,4%, valore sui cui rimarrebbe anche nei due anni successivi. Aumenta, infine, anche l'incidenza sulla spesa corrente primaria che passa dal 15,4% atteso per quest'anno (un decimo di punto percentuale in più del 2024) al 15,7% annuo nel biennio 2026-2027.

10 La revisione al ribasso della dinamica del PIL per il 2025-2027 rispetto alle analoghe stime ufficiali precedenti non ha effetti di rilievo sull'incidenza del finanziamento, se non per il 2025 che risulta un decimo di punto percentuale più alto di quello che sarebbe stato con il precedente profilo di crescita.

11 Oltre alle misure introdotte dalla Legge di bilancio 2025 e agli interventi previsti a legislazione vigente, tale dinamica sconta anche i maggiori costi pari a 1,3 miliardi di euro di alcuni interventi facenti parte del PNRR che vengono mantenuti a regime e che dal 2027 peseranno sul finanziamento ordinario del SSN. Cfr. MEF (2025), pp. 39-43.

4. La spesa sanitaria in Italia[12]

4.1 I *trend* nella spesa sanitaria pubblica italiana

Secondo i più recenti dati di contabilità nazionale riportati nella Figura 2, nel 2024 la spesa sanitaria complessiva della PA è stata pari a 138,3 miliardi di euro, in crescita del 4,9% rispetto all'anno prima, 1,2 punti percentuali in più del tasso di crescita medio dell'intero periodo. I dati considerati mostrano come la dinamica sia stata più sostenuta nel periodo iniziale fino al 2010 (quando la crescita media fu del 5,9% all'anno), a cui è seguita una riduzione dell'1% in media d'anno nel triennio seguente. Negli anni successivi, infine, la spesa è ritornata a crescere, anche se ad un tasso medio inferiore a quello del periodo iniziale e pari al 2,3%.

Scendendo più nel dettaglio, a spingere verso l'alto la spesa ha contribuito la dinamica della spesa sostenuta "direttamente" per l'erogazione delle prestazioni che è aumentata del 5,1%, praticamente il doppio di quella relativa alle altre "componenti" di spesa (servizi amministrativi, contribuzioni diverse e altre uscite), aumentate a loro volta del 2,6%. Tra le prestazioni, che raggiungono in tal modo il 94% della spesa totale (un decimo di punto percentuale in più dell'anno prima, ma inferiore della stessa misura alla media dell'intero periodo considerato), la componente più dinamica è quella erogata direttamente dalle strutture pubbliche ("produttori non *market*") che cresce del 7%, oltre quattro volte la crescita di quelle erogate dalle strutture private accreditate ("produttori *market*").

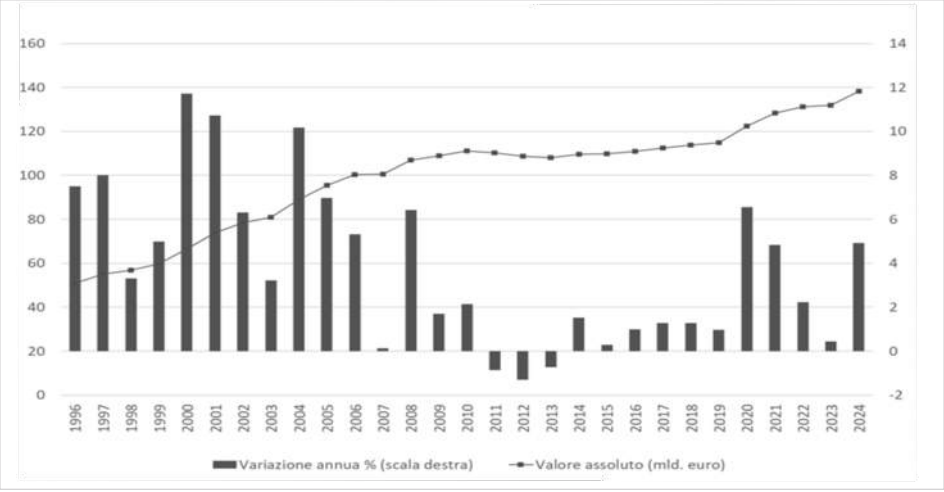
12 Nell'appendice online A.2 è riportato un confronto della spesa sanitaria italiana nel contesto dell'UE.

Nel complesso la componente pubblica della spesa è cresciuta nel 2024 del 6,6%, 2,6 punti percentuali in più del tasso di crescita medio del periodo considerato. In particolare, la spesa per redditi è cresciuta del 5,6%, sostenuta dagli oneri relativi al rinnovo dei contratti del triennio 2022-24, dal costo degli interventi messi in campo per per rispondere alla carenza di personale nelle strutture.[13] Gli acquisti di beni e servizi (i "consumi intermedi"), a loro volta, sono aumentati del 7,5%: in particolare, gli acquisti diretti di famaci da parte delle strutture sono cresciuti dell'8,4%, sostenuti anche dal previsto incremento del relativo tetto di spesa, mentre tra i restanti prodotti e servizi, cresciuti del 7,1%, spicca la maggiore spesa per dispositivi medici, anche per l'assenza nel 2024 di alcuna posta compensativa legata al relativo *pay-back*.[14]

La spesa per le prestazioni acquistate presso operatori *market*, è aumentata nel 2024 dell'1,6%, meno della metà del tasso di crescita medio annuo dell'intero periodo esaminato (3,4%). La riduzione della spesa ospedaliera accreditata e di quella dell'assistenza medico-generica (-0,8 e -0,3% rispettivamente) è più che compensata dall'incremento delle altre prestazioni. Tra queste, l'assistenza medico-specialistica aumenta sostanzialmente in linea con la spesa complessiva riconducibile agli operatori *market* (1,7%), mentre le prestazioni raggruppate nella cosiddetta "Altra assistenza", la farmaceutica territoriale e l'assistenza riabilitativa, integrativa e protesica crescono in maniera più sostenuta (rispettivamente 4,3, 2,8 e 2,2%).

13 Cfr. MEF (2025), pp. 31-33.
14 Cfr. MEF (2025), pp. 33-35.

Figura 2 **Dinamica della spesa sanitaria pubblica (1996-2024)**



Fonte: elaborazioni su dati Istat (2025a).
La spesa sanitaria rappresentata è elaborata dall'ISTAT, nell'abito della stima della spesa dell'intera PA, secondo i principi di contabilità economica nazionale (Sec 2010).

Valutata nel quadro più generale dei conti pubblici, la spesa sanitaria ha accresciuto la sua incidenza al 14% della spesa corrente, superiore di un decimo di punto percentuale a quella del 2023 e di tre decimi rispetto alla media dell'intero periodo esaminato, e al 15,3% della spesa primaria corrente, due decimi di punti percentuali in più dell'anno precedente, ma inferiore della spessa misura della media dell'intero periodo. Rispetto al PIL, infine, la spesa ha accresciuto la sua incidenza di un decimo di punto percentuale rispetto al 2023 e alla media dell'intero periodo considerato, raggiungendo il 6,3%.

4.2 Il peso e la composizione della spesa sanitaria pubblica italiana

Ulteriori indicazioni sull'adeguatezza della spesa sanitaria nel quadro della sostenibilità dei conti pubblici e del ruolo che tale settore ricopre nella più generale azione di governo possono essere ricavate dalla valutazione del peso della corrispondente spesa su quella complessiva e dal confronto con quello prevalente negli altri Paesi.[15] Secondo i dati disponibili, nel 2023 la spesa sanitaria pubblica, comprensiva anche della parte di spesa in conto capitale riconducibile al settore, è stata di 138,3 miliardi di euro, pari al 6,5% del PIL.[16] Il peso rispetto alla spesa pubblica complessiva si è attestato al 12,1%, quattro decimi di punti percentuali in meno dell'anno prima.[17] Il settore sanitario rappresenta il terzo settore di attività per ordine di importanza dopo la Protezione sociale (39,3%) e i Servizi generali delle amministrazioni pubbliche (13,8%).

Come si può vedere nella Figura 3, dove è riportato il peso della spesa sanitaria sulla spesa pubblica complessiva a partire dal 1995, il valore del 12,1% è il più basso registrato dal 2000. Più precisamente, il peso della spesa sanitaria cresce pressoché ininterrottamente dal 1995 al 2010 quando raggiunge il 14,8% della spesa complessiva. Si riduce nel decennio successivo quando si attesta in media sul 13,9% e in modo più significativo nel triennio finale

15 Utilizzeremo a tal fine la classificazione della spesa pubblica per funzioni comunemente adottata a livello internazionale (Classification Of the Functions Of Government – COFOG). La classificazione si articola su 3 livelli "gerarchici di aggregati contabili", di cui il primo è costituito dalle 10 Divisioni che rappresentano gli obiettivi generali della spesa pubblica (Servizi generali della Pubblica amministrazione, Difesa, Ordine pubblico e sicurezza, Affari economici, Protezione dell'ambiente, Abitazione e assetto territoriale, Sanità, Attività ricreative, culturali e di culto, Istruzione e Protezione sociale). Ciascuna Divisione è ripartita in Gruppi – relativi a specifiche aree di intervento - a lora volta ripartiti in Classi, che identificano specifici obiettivi delle aree di intervento.

16 Cfr. Istat (2024). Al momento l'Istat non ha ancora aggiornato la ripartizione della spesa pubblica complessiva per funzioni coerentemente con l'aggiornamento 2025 dei dati di contabilità nazionale.

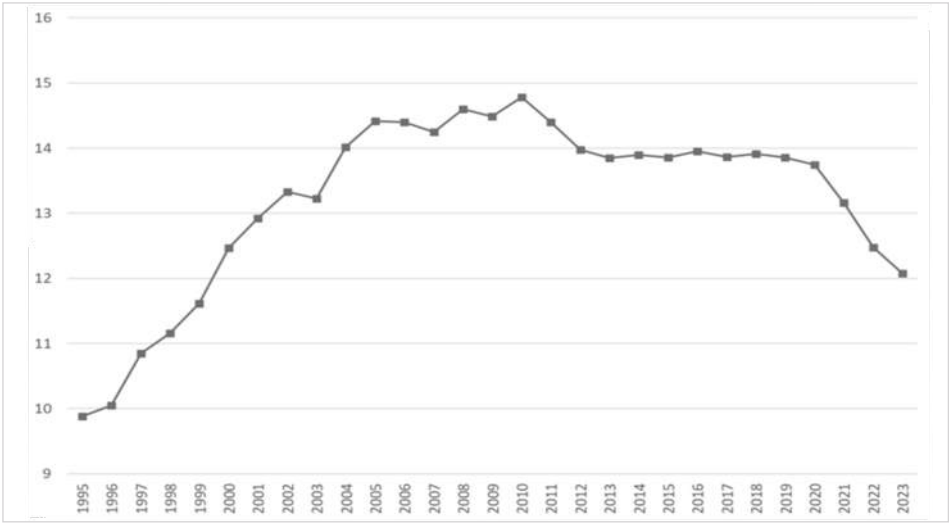
17 Al netto degli oneri per la sottoscrizione o l'emissione e il pagamento per interessi sul debito pubblico, il peso del settore sanitario nel 2013 è del 13%, mezzo punto percentuale in meno del 2022.

considerato (12,6% in media). Sulla riduzione registrata nell'ultimo triennio, oltre alle già viste specifiche decisioni prese per il settore sanitario, pesa la maggiore spesa pubblica sostenuta per le detrazioni di imposta concesse per i lavori di efficientamento energetico e ristrutturazione degli immobili, per ragioni contabili classificata tra le spese[18]: secondo alcune stime, il bonus 110% (cosiddetto "superbonus") e il bonus facciate hanno comportato nel triennio 2021-2023 una maggiore spesa di oltre 170 miliardi di euro. La funzione ("Abitazioni e assetto del territorio") in cui rientrano tali spese è passata da un'incidenza media dello 0,9% nel quinquennio 2016-2020 ad una del 6,2% nel triennio seguente, con il picco nel 2023 quando è stata dell'8,1%. Già a partire dal 2024, grazie anche alle modifiche normative varate che hanno posto un freno alla domanda di incentivi e comportato una modifica delle regole di contabilizzazione, il previsto esaurirsi di tale filone di spesa dovrebbe ricondurre l'incidenza della spesa sanitaria sui valori del recente passato.[19]

18 Considerate le caratteristiche degli incentivi edilizi, in particolare del bonus 110% (cosiddetto "superbonus") e del bonus facciate, e soprattutto la possibilità di cessione del credito d'imposta, le detrazioni di imposta relative agli anni 2021-2023 sono stati registrati nei conti della PA dal lato delle spese, nell'anno in cui la detrazione è maturata in relazione allo stato di avanzamento dei lavori per il suo intero ammontare, e non da quello delle entrate, quando i relativi crediti fiscali vengono effettivamente utilizzati (Istat, 2023a e 2023b).

19 La progressiva eliminazione della possibilità di cessione dei crediti realizzata dal governo (cfr. in particolare, Dl. 11/2023 e Dl. 39/2024) ha comportato a partire dal 2024 una revisione delle regole di contabilizzazione, per cui i crediti verranno registrati come una riduzione di entrate al momento della fruizione da parte dei contribuenti, mentre tra le spese continueranno a pesare solo quelli già ceduti e relativi ai lavori in corso di completamento (Eurostat, 2024).

Figura 3 **Il peso della spesa sanitaria pubblica in Italia in % della spesa pubblica (1995-2023)**



Fonte: elaborazioni su dati ISTAT (2024)

Nella Figura A.4.5 nell'appendice online abbiamo riportato la ripartizione della spesa pubblica per funzioni registrata nel 2023. In particolare, tale ripartizione è riportata secondo due modalità: nella prima (riquadro A) è riportata la composizione così come registrata dall'Istat, mentre nella seconda (Riquadro B) la composizione della spesa ottenuta depurando la stima "originaria" della maggiore spesa imputabile al superbonus.[20] Secondo i dati "originari", il settore sanitario rappresenta, come già detto, il 12,1% della spesa pubblica complessiva, inferiore all'incidenza della Protezione sociale (39,3%) e dei Servizi generali delle amministrazioni pubbliche (13,8%). Se si guarda invece alla composizione della spesa al netto degli esborsi per il superbonus, il peso del

20 Per la spesa relativa al superbonus nel 2023 (81,3 miliardi di euro) vedere Camera dei deputati - Osservatorio sulla finanza pubblica (2024), p. 5.

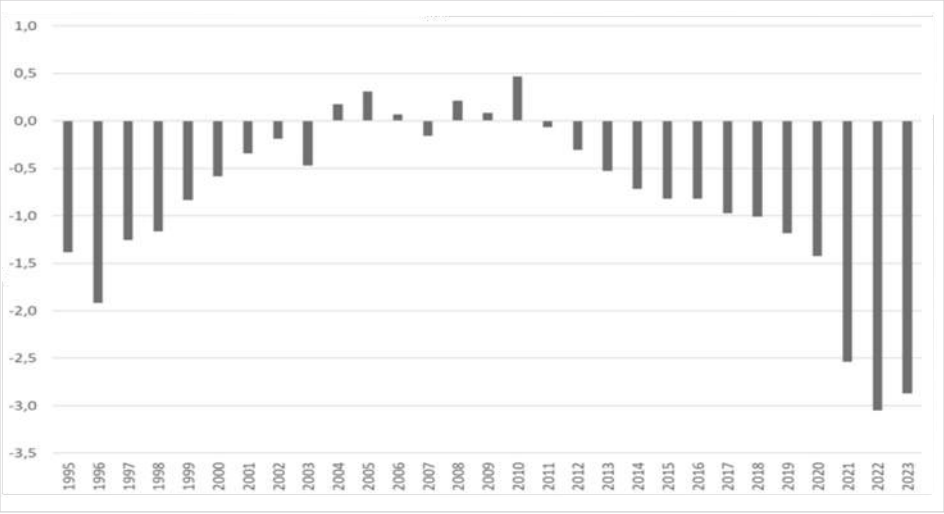
settore sanitario sale al 13% (nove decimi di punti percentuali in più del peso "originario"). In maniera analoga cresce il peso degli altri settori, ad eccezione di quello relativo alle "Abitazioni" (7 punti percentuali in meno del peso "originario"). Tra i settori che incrementano il loro peso, si segnalano quelli della "Protezione sociale" (3 punti percentuali in più) e dei "Servizi generali" (1 punto percentuale in più).

Il confronto con l'esperienza degli altri Paesi europei rivela come, in Italia, il peso della spesa sanitaria pubblica su quella complessiva sia stato negli ultimi trent'anni sostanzialmente più basso della media. Tale andamento lo si può vedere meglio nella Figura 4 dove si riporta la differenza tra l'incidenza della spesa sanitaria italiana rispetto a quella media dei 20 Paesi dell'area Euro (inclusa l'Italia). In particolare, nella seconda metà degli anni '90 sembra prevalente una tendenza a chiudere il divario rispetto all'Europa. Nel decennio successivo il peso della sanità pubblica si mantiene sostanzialmente in linea con quello europeo, per poi lasciare il campo a una tendenza opposta con un ampliamento del divario, che si accentua nel biennio 2021-2023.

In particolare, nel 2023 il minor peso del settore sanitario in Italia rispetto a quello medio dei Paesi dell'area Euro è di 2,9 punti percentuali. In modo analogo, ad eccezione dei "Servizi pubblici generali", in cui sono registrati anche gli oneri del debito pubblico, e delle "Abitazioni e assetto del territorio", per i quali il peso sulla spesa pubblica complessiva è in Italia superiore di 1,7 e 5,6 punti percentuali a quello medio dei paesi dell'area Euro, una differenza negativa si registra anche per i restanti settori e in particolare per l'"Istruzione" (2 punti percentuali in meno). Al netto della spesa riconducibile al superbonus, la differenza negativa dell'Italia nella "Sanità" e nell'"Istruzione" si riduce rispettivamente a 2,1 e 1,5 punti percentuali. Aumenta invece a 2,7 punti percentuali la differenza positiva relativa ai "Servizi generali", mentre per la

"Protezione sociale" la differenza muta di segno e da negativa (0,7 punti percentuali) diviene positiva (1,9 punti percentuali).

Figura 4 **Il peso della spesa sanitaria pubblica: un confronto internazionale (differenza tra Italia e media Area Euro)**



Fonte: elaborazioni su dati Eurostat (2025)

4.3. La dinamica della spesa sanitaria privata a livello nazionale

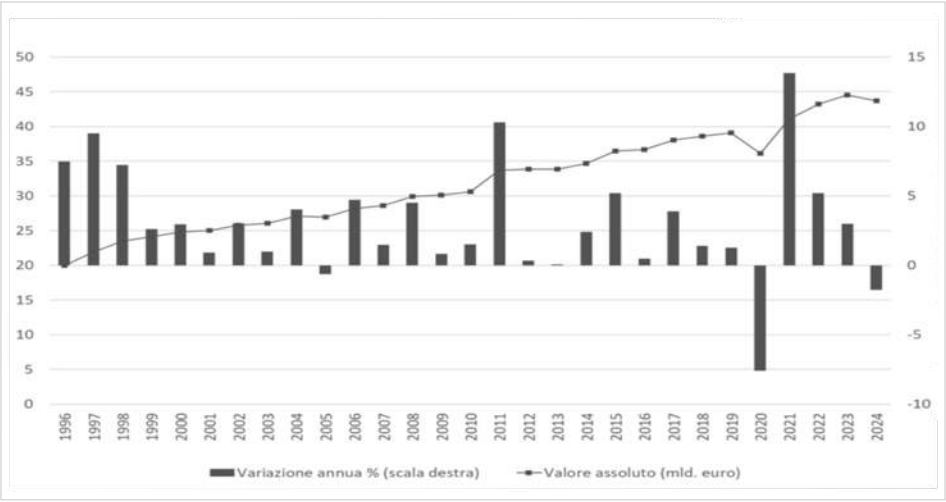
Nel 2024 la spesa sanitaria diretta delle famiglie si è ridotta dell'1,8%, attestandosi su un importo di 43,7 miliardi di euro (vedere Figura 5). È la terza volta che negli ultimi trent'anni si registra una riduzione della spesa sanitaria delle famiglie, dopo quella del 2005 (-0,7%) e del 2020 (-7,6%). Complessivamente dal 1995 la spesa sanitaria diretta delle famiglie si è più che raddoppiata, crescendo a un tasso medio annuo del 3%, più alto di quello della spesa

per consumi complessiva (2,7%).

In percentuale dei consumi finali interni complessivi (effettuati quindi sul territorio nazionale dalle famiglie residenti e non residenti), nel 2024 la spesa sanitaria è stata del 3,4%, un decimo di punto percentuale in meno del 2023, esattamente in linea con l'incidenza media registrata nell'intero periodo considerato. In modo analogo, si riduce l'incidenza rispetto al PIL che nel 2024 è stata pari al 2%, un decimo in meno dell'anno prima e in linea con la media dell'intero periodo considerato.

Scendendo più nel dettaglio, per il periodo 1995-2023, la ripartizione della spesa tra le principali tipologie che la compongono ("Prodotti sanitari" (medicinali e altri articoli sanitari), "Servizi ambulatoriali", "Servizi ospedalieri" e "Altri servizi sanitari") la più rilevante è quella dei "Servizi ambulatoriali" che, in media nell'intero periodo esaminato, ha assorbito il 41,7% della spesa totale. Seguono la spesa per "Prodotti sanitari" e per "Servizi ospedalieri", pari in media rispettivamente al 37,7 e al 16,4% della spesa totale, mentre i rimanenti servizi raggiungono un'incidenza media del 4,2%. Si segnala, infine, come nell'arco di tempo considerato si realizza una "ricomposizione" del paniere di consumo a vantaggio dei "Servizi ambulatoriali" e degli "Altri servizi" che hanno accresciuto la loro incidenza a scapito degli altri due tipi di spesa.

Figura 5 **Dinamica della spesa sanitaria privata (1996-2024)**



Fonte: elaborazioni su dati ISTAT (2025b)

5. I problemi nel finanziamento del SSN

Le analisi proposte segnalano la difficoltà che il SSN incontra nel coniugare i vincoli macroeconomici sulle risorse con le "promesse" fatte alla popolazione. Anche prescindendo dalle dichiarazioni relative all'aggiornamento (ovvero ampliamento) dei Livelli Essenziali di Assistenza (LEA), i Livelli Essenziali delle Prestazioni (LEP) definiti per la Sanità che dovrebbero essere garantiti a tutta la popolazione, la (pur significativa) crescita nominale delle risorse registrata dalla pandemia di Covid-19 in poi, nei fatti risulta negativa, o al più costante, in termini reali. Peraltro, è ragionevole attendersi una crescita dei costi del SSN, spinta dall'invecchiamento, dai crescenti costi per l'accesso

alle tecnologie (innovative), ma anche dall'espansione delle aspettative della popolazione.

5.1. L'impatto dell'invecchiamento della popolazione

L'Italia è uno dei paesi con la popolazione più anziana al mondo, con circa il 23% dei cittadini di età superiore ai 65 anni, una percentuale destinata a salire al 35% entro il 2050. Questa trasformazione demografica ha conseguenze significative sul sistema sanitario: malgrado si osservi una tendenza allo spostamento verso età più avanzate di alcuni eventi patologici (in particolare quelli acuti prevenibili, quali infarti e ictus), la "compressione della morbilità", in qualche modo registrata a livello aggregato dall'aumento dell'aspettativa di vita in buona salute, non sembra sufficiente a compensare l'aumento dei bisogni derivante dalla prevalenza delle cronicità. Tra queste ultime, particolarmente significativo risulta l'aumento della prevalenza delle cosiddette patologie non trasmissibili (cardiovascolari, metaboliche, neurodegenerative come demenze e Alzheimer), che spinge verso un incremento dei bisogni e quindi della spesa sanitaria.

L'invecchiamento implica anche un allargamento delle aspettative della popolazione, nel senso di una "integrazione" dei bisogni sanitari e sociali; questi ultimi derivano in primo luogo dalla progressiva degenerazione della cronicità in "non autosufficienza": ne segue che il confine fra bisogni sanitari e sociali diviene estremamente labile, spingendo ad un allargamento della domanda (ad esempio di assistenza domiciliare integrata) e quindi dei costi per il SSN.

Va aggiunto che l'invecchiamento evolve di pari passo con la trasformazione della struttura familiare, con nuclei sempre più piccoli e una maggiore

frequenza di anziani soli, i cui bisogni assistenziali (sociosanitari) si moltiplicano e non trovano ancora una credibile risposta formale nel SSN, rimanendo essa ad oggi confinata all'erogazione di provvidenze in denaro (ad esempio le indennità di accompagnamento) e/o alla presenza di un "esercito" di badanti, in larga misura "in nero".

Da ultimo, l'invecchiamento della popolazione genera anche una riduzione della forza lavoro, peggiorando il rapporto fra soggetti che contribuiscono al finanziamento del SSN e soggetti che usufruiscono dei relativi servizi: un elemento, quest'ultimo che rischia di compromettere ulteriormente la sostenibilità del sistema, ovvero le possibilità di mantenere una coerenza fra risorse disponibili e "promesse" di tutela sanitaria.

5.2. Il costo delle tecnologie mediche[21]

L'innovazione tecnologica ha portato a uno straordinario ampliamento delle opportunità terapeutiche: il numero di condizioni patologiche trattabili si è ampliato in modo molto significativo e l'efficacia delle cure è fortemente aumentata, permettendo di ridurne la mortalità, e in qualche caso di eradicare le patologie, e/o di rallentarne la progressione, aumentando anche i tassi di sopravvivenza per molte malattie dagli esiti infausti. L'innovazione tecnologica ha peraltro anche aumentato le capacità diagnostiche, facendo emergere condizioni patologiche sinora misconosciute (o diagnosticate in ritardo). Entrambi i fenomeni tendono a generare un aumento dei costi sanitari, amplificato dalla crescita dei costi "unitari" dei trattamenti. Senza pretesa di esaustività, quest'ultimi dipendono sia dall'allungamento della durata dei

21 Maggiori approfondimenti su questo tema sono disponibili in Atella e Chiari (2025) in questo *special issue*.

trattamenti (dovuto sia alla diagnosi precoce che all'allungamento della sopravvivenza), sia dall'aumento dei prezzi delle tecnologie.

Su questo ultimo aspetto rileva come l'introduzione delle biotecnologie, e in particolare delle cosiddette terapie avanzate (ad esempio quelle geniche), comporti incrementi nei costi di ricerca e sviluppo e anche di produzione. Inoltre, la "tendenza" allo sviluppo della medicina personalizzata, riducendo i mercati potenziali delle tecnologie (in campo farmaceutico, ad esempio, si assiste all'arrivo sul mercato di terapie con indicazioni sempre più specifiche per sottogruppi di popolazione), ovvero riducendo i volumi di vendita e quindi le possibilità di ritorno dall'investimento, rappresenta un'opportunità ma anche una sfida finanziaria per i sistemi sanitari.

Da ultimo ricordiamo che larga parte delle tecnologie delle *life sciences* hanno mercati globalizzati e quindi i prezzi si determinano con riferimento ad una *willingness to pay* che non è strettamente nazionale: nella misura in cui la crescita del finanziamento del SSN risulta da anni significativamente inferiore a quella media (ad esempio) europea, si evidenza un'ulteriore sfida per la sostenibilità del SSN, in termini di capacità di accesso a tecnologie il cui costo medio cresce più velocemente delle risorse disponibili.

5.3. Finanziamento, vincoli di bilancio, spesa ed equità

Malgrado il SSN rappresenti uno dei pilastri dello stato sociale italiano, e sia stato pensato con una impronta tipicamente "beveridgiana", ovvero perseguendo universalità e globalità delle tutele, alla prova dei fatti risulta che la quota di finanziamento pubblico della spesa sanitaria è significativamente al di sotto della media EU, risultando ormai persino inferiore a quella media dei

Paesi EU dell'Est (vedere Fig. 8). Ciò perché negli anni molte decisioni sono state prese più sulla base delle necessità imposte dai vincoli maro-economici che non da scelte di tutela dei fabbisogni dei cittadini.

Il risultato è che oggi, come visto in precedenza, anche se corretta per tenere conto della diversa incidenza degli oneri per gli interessi sul debito pubblico, la spesa sanitaria italiana in rapporto al PIL rimane sotto la "retta di regressione", ovvero la quota attesa sulla base delle regolarità statistiche rilevate nei dati (vedere Fig. 13). Non di meno, un rifinanziamento del servizio pubblico, che riportasse il dato italiano sulla "retta di regressione", anche qualora possibile, lascerebbe l'Italia su livelli di spesa (intorno al 7%) molto inferiori a quelli (ad esempio) di Germania e Francia, che destinano oltre il 10% del PIL alla sanità. Adottando una diversa ottica, il suddetto riallineamento implicherebbe il (difficile) reperimento di una somma che si aggira sui 10 mld. di €, cifra che rimane largamente insufficiente a garantire un riallineamento degli organici e delle relative retribuzioni (C.R.E.A. Sanità, 2022, 2023, 2024) agli standard europei: obiettivo che, come già argomentato, risulta esistenziale per il SSN, data la assoluta carenza di infermieri e anche di medici per le posizioni più disagiate.

In ogni caso, il reperimento di risorse aggiuntive per la Sanità appare operazione complessa, considerando che il confronto con gli altri Paesi EU in termini di allocazione delle risorse nei bilanci statali, restituisce una situazione che vede la Sanità in sofferenza (con una quota allocativa di 2,9 punti percentuali inferiore rispetto alla media EU) - ma l'Istruzione soffre ancor di più (-3,1 punti percentuali). In modo complementare, troviamo nel bilancio nazionale 3 p.p. allocati sostanzialmente per far fronte agli oneri del debito pubblico, e altri 3 p.p. sulla protezione sociale; quindi, su prestazioni in denaro che pur sempre hanno per destinataria la fascia anziana della popolazione.

L'arretramento della quota di intervento pubblico ha necessariamente effetti negativi sull'equità del sistema (si veda Atella, De Luca et Al., 2025 in questo *special issue*) ed è frutto di un evidente cambiamento di priorità nelle politiche economiche intervenuto a partire dagli anni 2008/2009. La progressiva riduzione della quota di finanziamento (pubblico), registratasi a partire dalla data citata, appare evocativa di un progressivo impegno verso le politiche di sostegno alla crescita (con effetti, se positivi, invero molto modesti) a scapito di quelli a sostegno della protezione sociale. La coerenza fra risorse e "promesse" è stata sinora perseguita con politiche di efficientamento che, per lo più, si sono estrinsecate in "blocchi amministrativi", come i tagli dei prezzi dei farmaci, i tetti di spesa per le tecnologie, l'incremento delle compartecipazioni dei cittadini alla spesa e, principalmente, i tetti imposto alle spese sul personale. Inoltre, negli ultimi anni si è assistito ad un crescente razionamento implicito (ad esempio generato dalle "liste di attesa"), concentrato sulle prestazioni "procrastinabili": in primis prevenzione, assistenza domiciliare, etc.. Quanto precede sintetizza l'elemento di maggiore criticità attuale del sistema, che rischia di implodere per manifesta incapacità di mantenere le "promesse" fatte ai cittadini, ma anche di mantenere "viva" la vocazione dei professionisti sanitari a lavorare per il SSN.

Tra gli effetti più evidenti di un tale processo di sottofinanziamento del SSN si riscontrano le difficoltà nel mantenere livelli di servizio adeguati, l'allungamento delle liste di attesa per le prestazioni mediche e il crescente ricorso alla sanità privata da parte dei cittadini per ottenere cure tempestive. Inoltre, la limitata disponibilità di risorse ha ostacolato gli investimenti in nuove tecnologie e infrastrutture, riducendo la capacità del SSN di rispondere alle nuove esigenze sanitarie. Inoltre, la carenza di risorse si riflette nella difficoltà nel reclutamento e nel mantenimento del personale sanitario, con medici e

infermieri che sempre più spesso emigrano verso altri Paesi per condizioni lavorative migliori.

5.4. Criteri di allocazione e disparità regionali

Se i livelli di finanziamento rappresentano un problema per la "tenuta" del SSN, anche per i processi di allocazione delle risorse si possono segnalare svariate contraddizioni. Le regole di allocazione appaiono sempre meno cogenti, e si assiste ad una deriva verso un riparto sempre più oggetto di negoziazione fra le Regioni e sempre meno legato a evidenze oggettive. Il processo appare molto "disordinato", quand'anche contraddittorio, in termini di incentivo per la promozione dell'equità ed efficienza di sistema. A livello regionale prevale il "fai da te", con scelte di finanziamento interne, variamente articolate, in termini tanto di processo, che di prioritizzazione degli interventi, nonché di algoritmi di riparto. In attesa che si creino le condizioni macroeconomiche per rifinanziare il sistema, sarebbe, quindi, almeno opportuno mettere mano ad un riordino complessivo della materia.

Appare evidente come il sistema attuale abbia fallito nell'obiettivo della rimozione delle disparità regionali (vedere Atella, De Luca et Al. (2025) in questo *special issue*). Da un lato osserviamo come le Regioni più ricche (e meglio amministrate), tipicamente del Nord, abbiano sviluppato sistemi sanitari più efficienti, mentre nelle Regioni meridionali si continuano a registrare carenze in termini di *understaffing*, obsolescenza delle strutture, etc.. Queste disuguaglianze si traducono anche in fenomeni di migrazione sanitaria, tipicamente dal Sud al Nord, che aumentano la pressione sugli ospedali del Nord, e aggravano il divario finanziario tra le Regioni, poiché parte delle risorse de-

stinate alle Regioni meridionali viene trasferita verso il Nord, attraverso i saldi finanziari della mobilità. Dall'altro va registrato che le Regioni più ricche sono avvantaggiate da uno sgravio di oneri derivante dai consumi sostenuti privatamente dai cittadini (anche per prestazioni teoricamente comprese nei LEA e quindi a carico del SSN): le differenze (fra Regioni agli estremi del *ranking*) di spesa privata sono di tre volte maggiori rispetto a quelle generate dagli algoritmi di riparto del Fabbisogno Sanitario Nazionale, che non le prende affatto in considerazione. Si genera nei fatti un incentivo "perverso" per le Regioni, potenzialmente spinte a "promuovere" la spesa privata (tipicamente mediante i già richiamati "razionamenti impliciti"), onde poter usare le risorse "liberate" per garantire prestazioni "extra LEA", aumentando la qualità relativa della propria risposta assistenziale.

6. Conclusioni

Il sistema sanitario italiano si trova di fronte a sfide significative. L'invecchiamento della popolazione, i costi delle tecnologie avanzate e le disparità regionali richiedono una riforma strutturale del modello di finanziamento. Fin dall'introduzione del federalismo fiscale – e, in realtà, anche nel periodo antecedente – il livello di finanziamento della spesa sanitaria in Italia si è mantenuto costantemente inferiore rispetto alla media dei Paesi dell'Unione Europea: ad oggi risulta essere risulta inferiore del 44,0% rispetto alla media dei Paesi dell'UE a 15 (ante 1995). Ciò ha ovviamente determinato un progressivo ampliamento del divario tra il sistema sanitario italiano e quelli degli altri Stati membri.

Nel confronto internazionale, la spesa sanitaria totale italiana risulta inferiore dell'11,3% rispetto a quanto atteso sulla base delle risorse economiche disponibili, misurate in termini di PIL depurato dagli interessi sul debito pubblico. Anche qualora questo divario fosse colmato, la spesa sanitaria in Italia continuerebbe a collocarsi ben al di sotto dei livelli medi dell'Unione Europea. Sebbene anche la spesa sanitaria privata rimanga, in termini assoluti, al di sotto delle medie europee, la sua incidenza sul PIL italiano è più elevata rispetto a quella osservata in altri contesti, indicando una maggiore propensione – o necessità – da parte delle famiglie italiane a sostenere spese sanitarie dirette.

A livello interno, persistono ampie disuguaglianze territoriali nella distribuzione della spesa sanitaria, ulteriormente acuite dalla componente privata sostenuta direttamente dalle famiglie e da un meccanismo di riparto del finanziamento pubblico che non considera adeguatamente la complementarità tra le due componenti. È in questo contesto che emerge un interrogativo cruciale: con una quota di spesa sanitaria a carico diretto delle famiglie pari al 24,8% della spesa complessiva – corrispondente a circa 41,4 miliardi di euro, al netto delle compartecipazioni al SSN – il Servizio Sanitario Nazionale è ancora in grado di garantire pienamente le proprie promesse di universalismo e uguaglianza nell'accesso alle cure?

A fronte di tali evidenze, la sostenibilità del SSN impone una riflessione strutturale sul rapporto tra i diritti garantiti e le risorse disponibili. Sebbene un incremento del finanziamento pubblico sarebbe auspicabile, l'attuale contesto di vincoli di bilancio rende tale obiettivo difficilmente realizzabile nel breve periodo. In questo scenario, appare urgente avviare una riflessione sistemica sulla spesa sanitaria privata, oggi crescente anche attraverso forme di intermediazione collettiva come i fondi sanitari aziendali. Un'integrazione

coerente e regolata tra la tutela pubblica e le iniziative private si renderebbe necessaria in un'ottica di Sussidiarietà, superando l'approccio storicamente egemonico del SSN, che ha spesso ostacolato la costruzione di un sistema integrato di protezione sanitaria.

Considerato che una soluzione fondata esclusivamente sul piano finanziario appare, allo stato attuale, irrealistica, si impone la necessità di procedere a una prioritizzazione esplicita delle tutele offerte e a una riallocazione delle risorse disponibili. Tale processo, inevitabilmente complesso sul piano politico e sociale, richiede una revisione delle aspettative e dei diritti di cittadinanza, ancorata a principi rigorosi di equità, con particolare attenzione alla protezione delle fasce più fragili della popolazione, tenendo conto non solo dello stato di salute, ma anche del reddito e del livello di competenza sanitaria (*health literacy*).

A livello macroeconomico, appare particolarmente urgente una revisione dei criteri di riparto del Fabbisogno Sanitario Nazionale (FSN), al fine di ridurre le disuguaglianze regionali, che permangono sostanzialmente invariate nonostante le riforme del SSN attuate dagli anni Novanta e l'introduzione del federalismo fiscale. In particolare, un sistema di allocazione più equo dovrebbe tener conto in misura maggiore della correlazione tra bisogni sanitari e condizioni socioeconomiche, comprese le diverse capacità delle famiglie di sostenere spese sanitarie private.

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Appendice

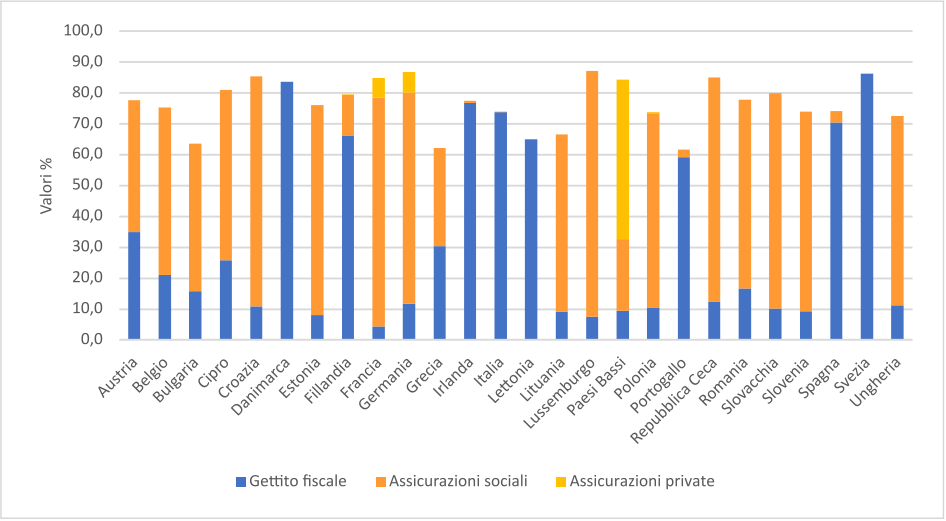
A.1 Confronti internazionali

In Europa la maggioranza dei sistemi sanitari è di stampo "bismarkiano", con un finanziamento prevalente attraverso contributi obbligatori versati a fondi che, tipicamente, sono di origine corporativa (Assicurazioni Sociali). Il SSN italiano è, di contro, classificabile fra i sistemi di stampo "beveridgiano", con un finanziamento esclusivamente di origine fiscale (Figura A.1.1).

Secondo i dati OCSE riportati nella Figura A.1.2, nel 2023, la quota media di copertura pubblica del finanziamento della Sanità in Europa risulta pari al 76,6%. I Paesi con la quota più bassa sono il Portogallo (61,7%), mentre quello con la quota più alta è la Lussemburgo (87,1%), con l'Italia al 74,0%, 2,7 p.p. in meno rispetto alla media Europea. Suddividendo i Paesi europei in due aree, quella dei Paesi membri dell'EU prima del 1995 (EU-Ante 1995) e quelli entrati nell'Unione successivamente (EU-Post 1995), si può osservare che per i primi la media di copertura del Finanziamento pubblico si attesta al 83,0%, risultando maggiore rispetto a quella italiana di 9,0 p.p.. Tuttavia, la quota di copertura pubblica italiana è ormai inferiore (di 2,2 p.p.) anche

rispetto alla media dei Paesi EU–post 1995 (Figura A.1.3), avendo "virato" la "traiettoria" dopo la crisi finanziaria dei mercati della fine del primo decennio del secolo.

Figura A.1.1 **Finanziamento pubblico della Spesa Sanitaria corrente (2023).**

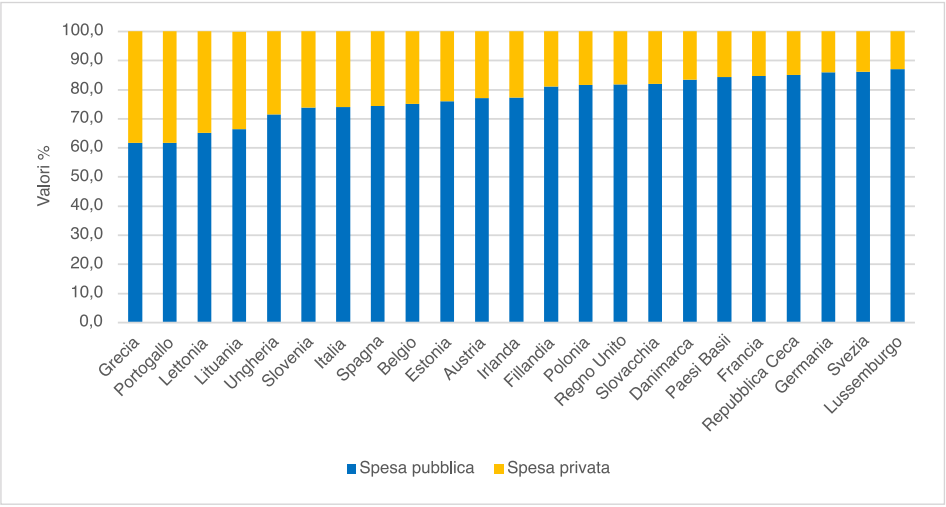


Fonte: elaborazione C.R.E.A. Sanità su dati EUROSTAT, 2024.

Nel periodo più recente (2020-2023), i Paesi EU–Ante 1995 hanno registrato una crescita del finanziamento pubblico in coincidenza con la pandemia da Covid-19, e la hanno poi mantenuta con una quota superiore all'82%. I Paesi EU–Post 1995 hanno invece visto aumentare con continuità la quota pubblica di finanziamento, essendo giunti a ridosso dell'80% nel 2023. Di contro, l'Italia è passata da una quota del 76% nel 2020 al 74,0% nel 2023. L'andamento descritto rispecchia un crescente impegno pubblico verso obiettivi di crescita, che si è realizzato a scapito del *welfare* sanitario. A fronte di una spesa privata in larghissima misura *out of pocket*, questo "disinvestimento" relativo appare evocativo di rischi di crescita delle iniquità, aumentando nei

fatti la correlazione fra opportunità di accesso ai servizi e condizioni socioeconomiche dei pazienti.[22]

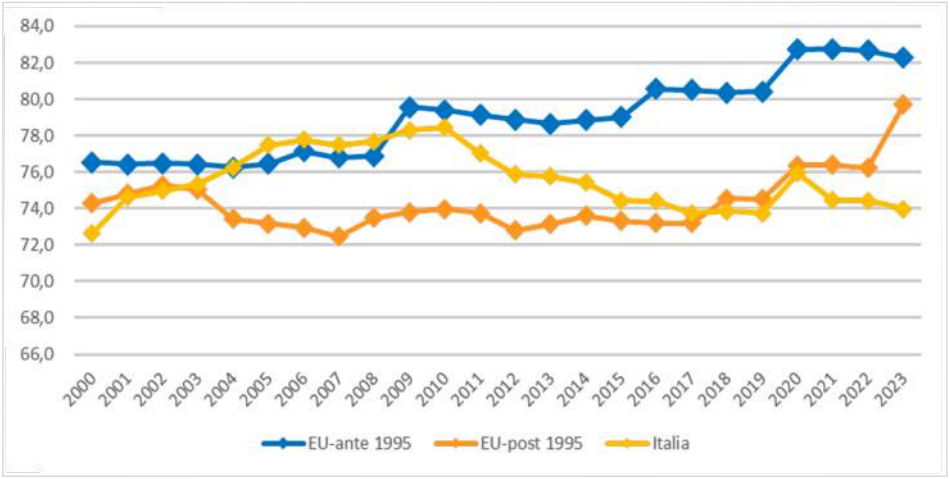
Figura A.1.2 - **Composizione del Finanziamento della Spesa Sanitaria (2023).**



Fonte: elaborazione C.R.E.A. Sanità su dati OCSE, 2024.

22 A tal proposito si veda il contributo di Atella, De Luca, et Al. (2025) in questo *special issue*.

Figura A.1.3 ***Trend* finanziamento pubblico della Spesa Sanitaria corrente**



Fonte: elaborazione C.R.E.A. Sanità su dati EUROSTAT, 2024.

A.2. L'evoluzione della spesa sanitaria in un confronto internazionale

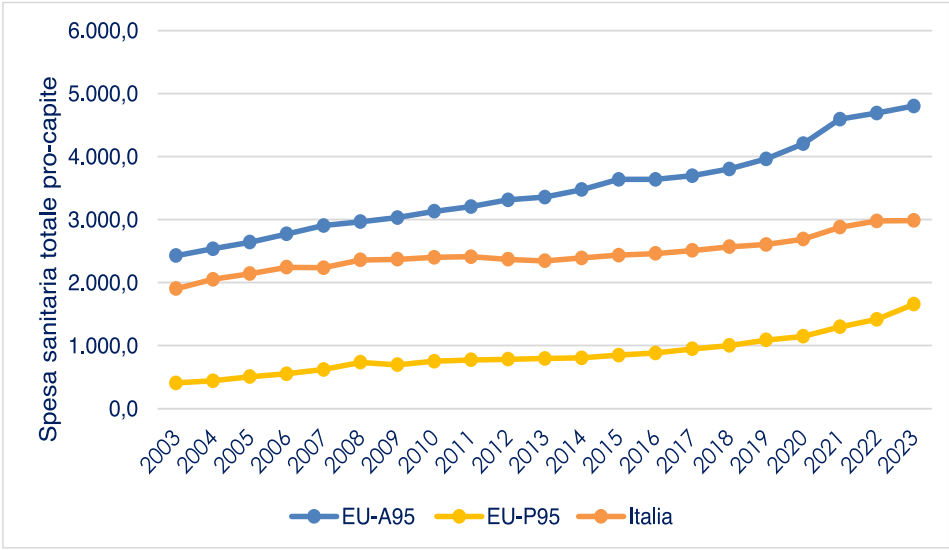
Nel 2023, la spesa sanitaria corrente italiana (pubblica e privata) è risultata pari a € 176,2 mld. (Figura A.2.1), pari a € 2.986,0 pro-capite. Secondo i dati diffusi dall'OCSE, e riportati nella Figura A.2.2, quest'ultimo valore è inferiore del 37,8% rispetto alla media (€ 4.802,4) dei (rimanenti) Paesi membri dell'Unione Europea (EU) da prima del 1995 (EU-Ante 1995), e superiore dell'80,3% rispetto alla media (€ 1.656,4) dei Paesi entrati nell'EU dopo il 1995 (EU-Post 1995) (Figura A.2.3).[23] Anche la crescita della spesa sanitaria italiana risulta inferiore a quella degli altri Paesi Europei; in particolare,

23 Per i Paesi presenti nell'UE prima del 1995 si fa riferimento a: Austria, Belgio, Danimarca, Finlandia, Francia, Germania, Grecia, Irlanda, Lussemburgo, Olanda, Portogallo, Regno Unito, Spagna e Svezia. Per i Paesi presenti nell'UE dopo il 1995 si fa riferimento a: Estonia, Lettonia, Lituania, Polonia, Repubblica Ceca, Slovacchia, Slovenia e Ungheria. Si tenga presente che nell'analisi non sono stati considerati i seguenti Paesi: Bulgaria, Cipro, Croazia, Malta e Romania in quanto non sono disponibili i dati relativi all'intero arco temporale analizzato.

nell'ultimo anno la spesa sanitaria italiana ha fatto registrare una crescita dello 0,3% inferiore di 2,0 p.p. rispetto a quella degli altri Paesi del blocco EU-Ante 1995. Nell'ultimo decennio la crescita della spesa in Italia è stata, invece, del 2,4% minore di 5,2 p.p. rispetto a quella verificatasi nei Paesi EU-Post 1995: nell'ultimo anno lo scarto ha raggiunto -16,6 p.p.. Di conseguenza, il *gap* (negativo) della spesa sanitaria pro-capite rispetto a "EU-Ante 1995" si è progressivamente allargato: di 1,3 p.p. nell'ultimo anno, di 7,7 p.p. nell'ultimo decennio, di 16,2 p.p. rispetto al 2003 (Figura A.2.2). Parallelamente, rispetto ai Paesi "EU-Post 1995" il *gap* (positivo) si è ridotto di 287,2 p.p. rispetto al 2003 e di 114,5 p.p. rispetto al 2013, di cui 30,0 p.p. nell'ultimo anno (Figura A.2.3).

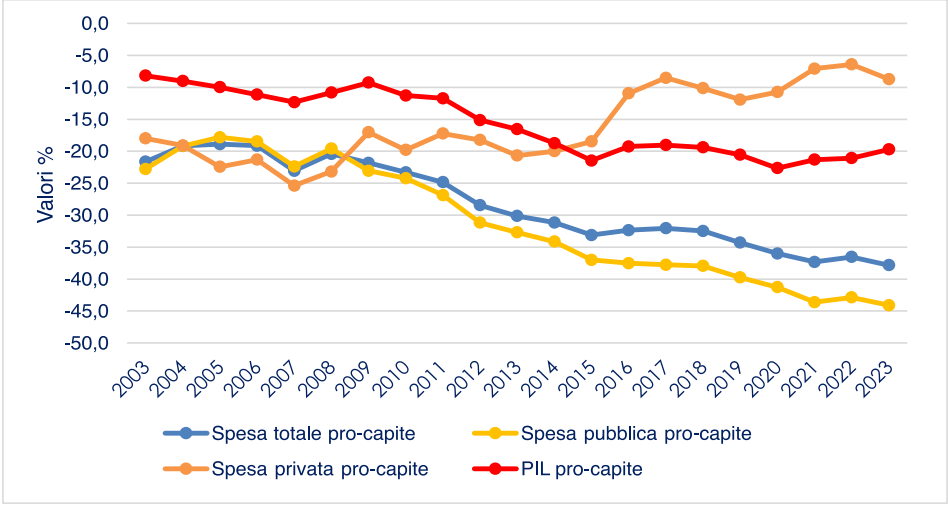
Analoghe osservazioni si possono fare utilizzando la spesa pro-capite a parità di potere di acquisto: il *gap* (negativo) tra l'Italia e i Paesi EU-Ante 1995 risulta pari al 28,8% nel 2023, ed è cresciuto di 10,8 p.p. rispetto al 2003, di 2,8 p.p. rispetto al 2013 e di 0,5 p.p. nell'ultimo anno; rispetto ai Paesi EU-Post 1995, il *gap* (positivo) risulta del +30,6% nel 2023, ed è diminuito di 9,6 p.p. nell'ultimo anno, di 35,3 p.p. rispetto al 2013 e di 103,0 p.p. rispetto al 2003. Inoltre, è degno di nota come il divario nella spesa sanitaria totale rispetto ai Paesi UE-15 si stia ampliando più rapidamente rispetto al divario in termini di PIL. In particolare, nell'ultimo decennio, il divario nella spesa sanitaria totale è aumentato di tre volte rispetto a quello del PIL, con una differenza media annua di -1,2 punti percentuali rispetto a -0,4 punti percentuali (+3,0% contro 3,4%). Questi andamenti sono in gran parte influenzati dalla componente pubblica.

Figura A.2.1 ***Trend* della spesa sanitaria totale pro-capite**



Fonte: elaborazione C.R.E.A. Sanità su dati OCSE, 2024.

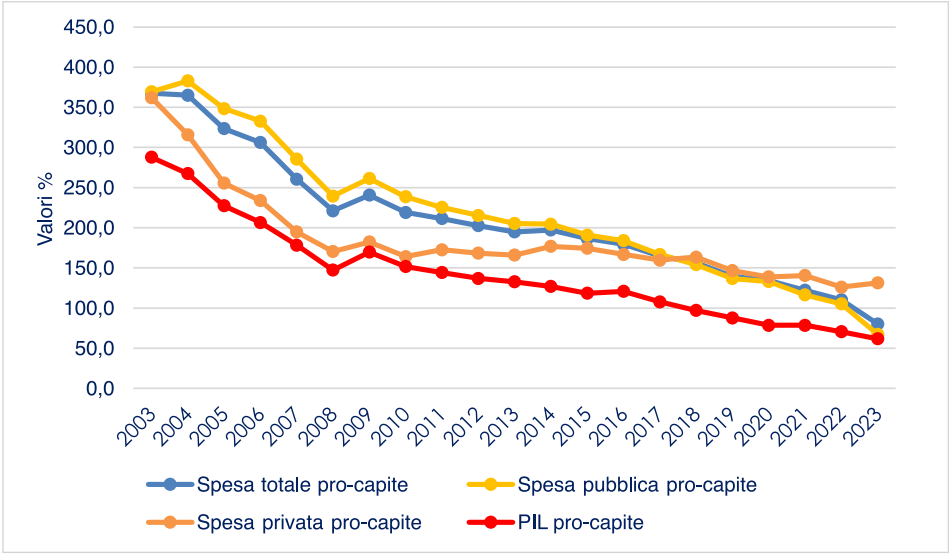
Figura A.2.2 ***Trend* del *gap* Italia vs. "EU-Ante 1995" in termini di spesa sanitaria (totale, pubblica e privata) e PIL pro-capite**



Fonte: elaborazione C.R.E.A. Sanità su dati OCSE, 2024.

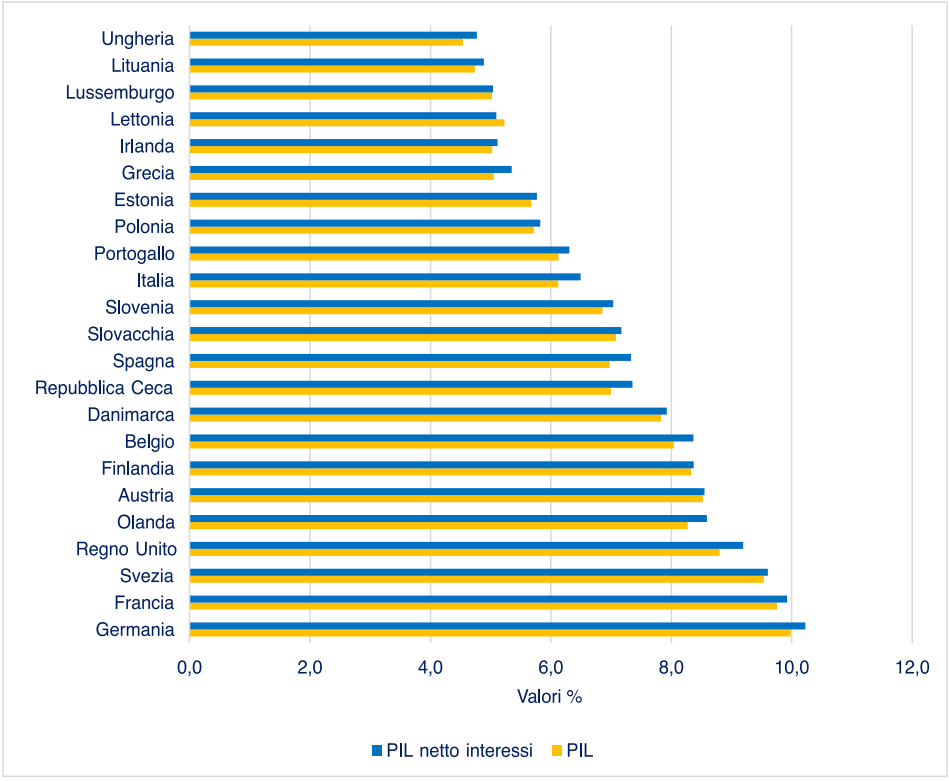
Il divario della spesa pubblica tra l'Italia e i Paesi EU-Ante 1995 nel 2023 risulta del -44,0%, in aumento di +1,2 p.p. sull'anno precedente, di +11,4 p.p. nell'ultimo decennio, di +21,3 p.p. tra il 2003 ed il 2023. Esprimendo la spesa in $-PPP, il divario risulta pari al -35,7%, con un incremento nell'ultimo anno (+0,4 p.p.), in aumento di +7,1 p.p. nell'ultimo decennio e +16,8 p.p. rispetto al 2003. Parallelamente, rispetto ai Paesi EU-Post 1995, la spesa pubblica, pur rimanendo maggiore (+67,3% nel 2023), vede ridursi il differenziale: di -302,0 p.p. rispetto al 2003 e di -138,1 p.p. nell'ultimo decennio. In $-PPP, lo scarto si è ridotto di quasi sei volte e mezzo rispetto al 2003 e di tre volte e mezzo dal 2013.

Figura A.2.3 ***Trend* del *gap* Italia vs. "EU-Post 1995" in termini di spesa sanitaria (totale, pubblica e privata) e PIL pro-capite**



Fonte: elaborazione su dati OCSE 2024 - © C.R.E.A. Sanità

Figura A.2.4 **Incidenza della spesa sanitaria pubblica sul PIL e sul PIL al netto degli interessi sul debito pubblico (2023)**



Fonte: elaborazione su dati OCSE 2024 - © C.R.E.A. Sanità

Infine, anche la componente privata della spesa sanitaria è inferiore dell'8,7% rispetto ai Paesi EU-Ante 1995. Il *gap* è stato "altalenante": è cresciuto nel periodo 2003-2007 (in larga misura per effetto dell'abolizione dei *ticket* nel 2001), ha quindi registrato un andamento altalenante fino al 2023, con un aumento di +2,3 p.p. nell'ultimo anno. La spesa privata espressa in $-PPP risulta superiore a quella degli altri Paesi EU-Ante 1995 del +2,0%, -2,4 p.p. rispetto all'anno prima. Fino al 2020, a parità di potere di acquisto,

l'onere sostenuto privatamente delle famiglie italiane è stata inferiore a quello medio delle famiglie residenti nei Paesi EU-Ante 1995, diventando successivamente maggiore.

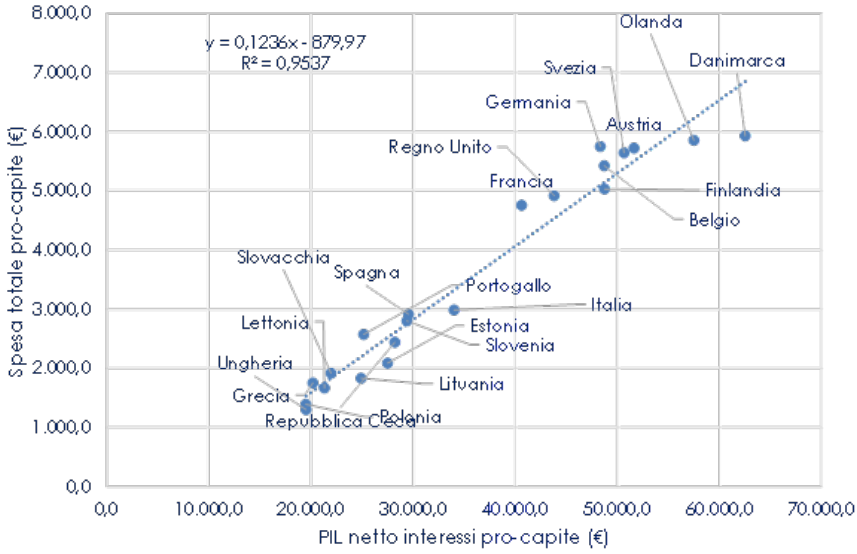
Come già anticipato prima, i *gap* di spesa sanitaria evidenziati sono, in larga misura, condizionati dagli andamenti della componente pubblica. Il divario della spesa pubblica tra l'Italia e i Paesi EU-Ante 1995 è, infatti, del -44,0% (in aumento di 1,2 p.p. sull'anno precedente); la crescita dello scarto, tra il 2003 ed il 2023, è stata di 21,3 p.p. e tra il 2013 e il 2023 di 11,4 p.p.. Il dato sul *gap* si conferma in $-PPP essendo passato dal -18,9% del 2003, al -28,6 del 2013, sino al -35,7% a fine 2023, con una lieve incremento nell'ultimo anno (+0,4 p.p.). Parallelamente il dato di spesa pubblica dei Paesi EU-Post 1995 si riavvicina a quello italiano: pur rimanendo ancora maggiore, il differenziale di spesa italiana si è ridotto di 302,0 p.p. nell'ultimo ventennio (dal +369,3% del 2003 al +67,3% nel 2023) e di 138,1 p.p. nell'ultimo decennio. In $-PPP, lo scarto tra Italia e Paesi EU-Post 1995 si è ridotto di quasi sei volte e mezzo rispetto al 2003 e di tre volte e mezzo dal 2013.

Nel 2023, la spesa sanitaria pubblica nell'UE, al netto degli interessi sul debito pubblico, ha rappresentato in media l'8,5% del PIL (8,3% "con interessi"). Nei Paesi EU-Ante 1995, arriva al 9,1% (8,8%) e nei Paesi EU-Post 1995 al 6,1% (5,9%). L'incidenza in Italia è del 6,5% del PIL (6,1% "con interessi"), quindi -2,0 p.p. rispetto all'EU, -2,6 p.p. agli altri Paesi EU-Ante 1995 (solamente Grecia, Irlanda, Lussemburgo e Portogallo hanno registrato quote inferiori) e +0,4 p.p. rispetto agli altri Paesi EU-post 1995. Le incidenze più alte in EU sono quelle della Germania (10,2%), della Francia (9,9%), della Svezia (9,6%) e del Regno Unito (9,2%) (Figura A.2.4). Infine, per quanto concerne l'incidenza della spesa privata sul PIL, in Italia essa è pari al 2,2%, pari +0,3 p.p. superiore a quella media dei Paesi EU-Ante 1995 e maggiore di

+0,6 p.p. a quella media dei Paesi EU-Post 1995.

Nel complesso, mettendo in relazione la spesa sanitaria totale pro-capite sul PIL (al netto degli oneri per gli interessi passivi sul debito pubblico), si osserva come essa risulti in Italia inferiore a quella statisticamente attesa dell'11,3%, ovvero di € 19,6 mld (Figura A.2.5).

Figura A.2.5 **Spesa sanitaria totale vs PIL netto interessi (valori pro-capite)**



Nota: sono stati considerati outliers ed esclusi nella regressione i dati di Irlanda e Lussemburgo.
Fonte: elaborazione su dati OCSE 2024 - © C.R.E.A. Sanità

A.3 Gli andamenti della spesa a livello regionale pre e post Covid-19

Per stimare i *trend* di spesa regionali sono stati considerati i dati pubblicati nel Rapporto "Il monitoraggio della spesa sanitaria" della Ragioneria Generale dello Stato e dall'Istat nell'ambito del sistema dei conti della sanità (*System of Health Accounts* – SHA), depurando quest'ultima statistica della voce inerente alla *governance* e all'amministrazione del sistema sanitario. Per quanto concerne la spesa sanitaria privata, alla componente *Out of Pocket* (OOP), è stata sottratta una stima della spesa rimborsata per effetto di copertura assicurative (in forma cosiddetta indiretta) ed aggiunto il valore della spesa privata intermediata (spesa per polizze collettive e individuali), secondo le informazioni ricavabili dalla banca dati dell'Associazione Nazionale fra le imprese assicuratrici (ANIA).

Le analisi sono state condotte con riferimento agli ultimi 3 bienni disponibili, dividendo il periodo nella fase pre-Covid-19 (2018-2019), Covid-19 (2020-2021) e Post Covid-19 (2022-2023). Sulla base delle stime ottenute, nel 2023 la spesa sanitaria complessiva a livello nazionale - comprendendo sia quella pubblica che privata – risulterebbe pari a € 171,5 mld. (€ 2.906,6 pro-capite). La spesa è risultata in aumento dello +0,2% (+€ 6,2 pro-capite) nell'ultimo biennio (2022-2023), del +7,1% (+€ 185,4 pro-capite) durante la pandemia da Covid-19 (anni 2020-2021) e del +2,2% (+€ 53,6 pro-capite) nel biennio precedente (2018-2019). In termini reali, nel periodo post-pandemico (2022-2023) la crescita della spesa totale pro-capite è risultata negativa del -4,9% (equivalente a -€ 126,4 pro-capite), mentre nei due bienni precedenti la crescita era rimasta positiva: del +3,4% nel periodo Covid-19 e del +1,6% in quello precedente.[24]

24 I valori nominali sono stati deflazionati impiegando il FOI (indice nazionale dei prezzi al consumo per le famiglie di operai e impiegati).

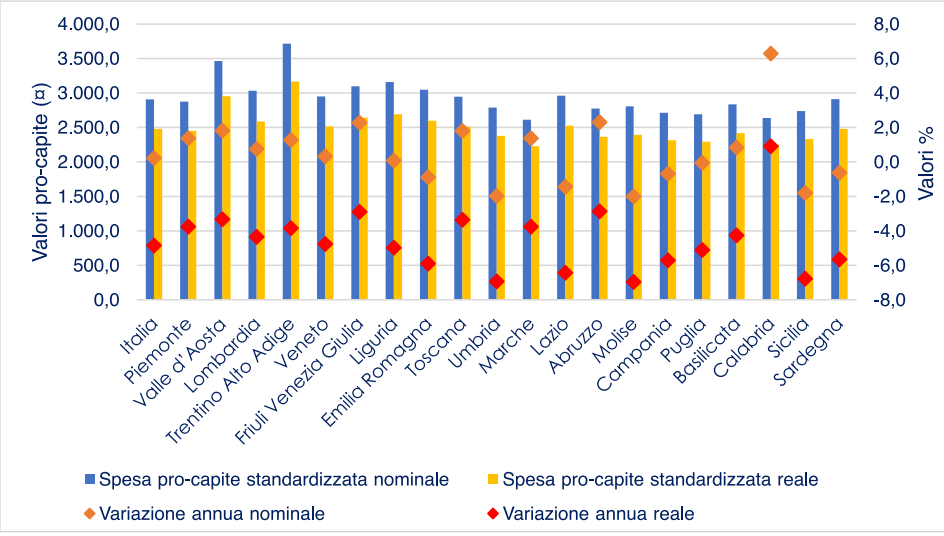
Gli andamenti descritti sono largamente legati a quelli della spesa sanitaria pubblica che nel 2023 si attesta a € 128,9 mld (71,2% della spesa, ovvero € 2.184,1 pro-capite), in diminuzione dello -0,4% rispetto al 2022; durante la pandemia era aumentata del +5,1%, e nel biennio precedente del +2,1%. In termini reali, nel post-pandemia si è registrata una contrazione del-5,4%, mentre la crescita dei due bienni precedenti era risultata rispettivamente pari al +1,4% e al +1,5%.

La spesa sanitaria privata ha raggiunto, nel 2023 € 42,6 mld., equivalenti a € 722,4 pro-capite. L'89,5% del totale della spesa privata risulta OOP (€ 38,1 mld.), in riduzione di 1,2 p.p. rispetto al 2018 e di 0,6 p.p. rispetto all'anno precedente; quella intermediata (€ 4,5 mld.) rappresenta il restante 10,5% (in aumento di 1,1 p.p. rispetto al 2018 e di 0,6 p.p. rispetto all'anno precedente); il peso della spesa intermediata è andato aumentando tra il 2018 e il 2023, ad eccezione di lievi flessioni nel 2020 e nel 2022. Nel complesso la spesa privata ha registrato un aumento del +2,0% nell'ultimo anno, mentre durante il periodo pandemico era aumentata del +13,8%, e nel biennio precedente del +2,2%. Anche per questa voce di spesa nel post-pandemia la crescita reale è risultata negativa (-3,2%), a fronte del +9,9% durante la pandemia e dell'+1,6% nel periodo immediatamente precedente.

A livello regionale, la spesa sanitaria pro-capite registra valori massimi in Trentino-Alto Adige e Valle d'Aosta (rispettivamente € 3.621,8 e € 3.502,9), mentre all'estremo opposto si collocano Campania (€ 2.643,5) e Calabria (€ 2.626,1). La differenza tra la Regione con spesa massima e quella con spesa minima è pari a 1,38 volte ovvero € 995,7; escludendo le Regioni a Statuto Speciale, la differenza risulta pari a € 662,1 (1,25 volte). Ad analoghe conclusioni si arriva anche standardizzando i dati di spesa mediante i pesi utilizzati per il riparto del finanziamento (desunti dalla delibere CIPE), che rappresen-

tano una stima dei diversi fabbisogni regionali in funzione delle caratteristiche della popolazione: i valori massimi di spesa si registrano ancora in Trentino Alto Adige (€ 3.715,2) e Valle d'Aosta (€ 3.465,1), con all'estremo opposto le Marche (€ 2.612,7) e la Calabria (€ 2.636,1); il differenziale tra la Regione con spesa massima e quella con spesa minima risulterebbe di 1,42 volte, ed escludendo le Regioni a statuto speciale di 1,21 volte (Figura A.3.1).

Figura A.3.1 **Spesa sanitaria totale pro-capite standardizzata nominale e reale**

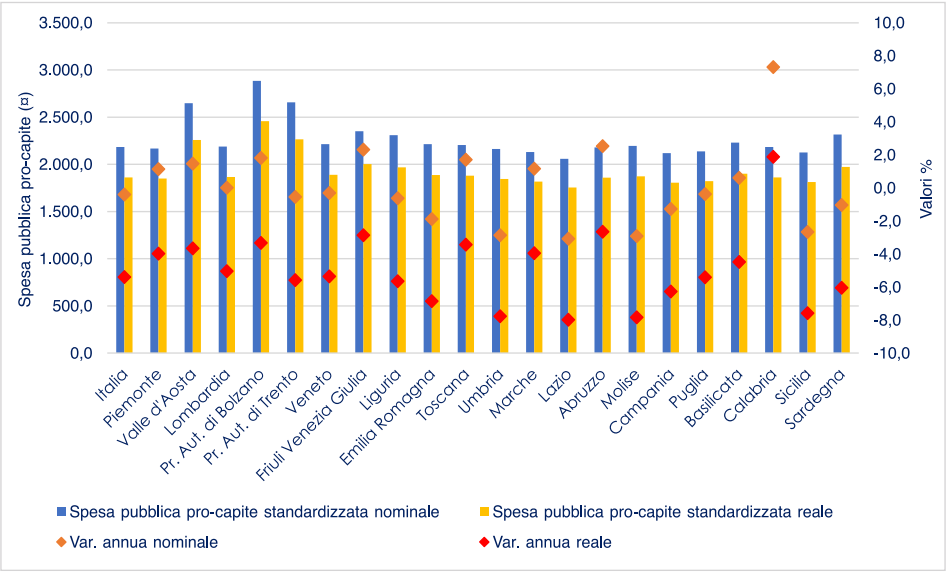


Fonte: elaborazione su dati Ragioneria Generale dello Stato e Istat, 2024 - © C.R.E.A. Sanità

La quota di spesa pubblica si attesta al 73,6% nelle Regioni del Nord, al 73,2% in quelle del Centro, mentre è pari al 78,8% in quelle del Sud. La spesa pubblica pro-capite risulta massima nella P.A. di Bolzano e in Valle d'Aosta (rispettivamente € 2.789,6 e € 2.676,7 pro-capite), seguite dalla P.A. di Trento (€ 2.610,5) e dalla Liguria (€ 2.403,8); all'estremo opposto si collocano Campania (€ 2.062,5) e Lazio (€ 2.038,8); la differenza tra la Regione con

spesa pubblica massima e minima è pari a 1,37 volte, ovvero € 750,8 pro-capite; escludendo le Regioni a statuto speciale, che non entrano nel riparto del Fabbisogno Standard, la differenza si riduce di 18,9 p.p. risultando pari al 1,18 volte (€ 365,8 pro-capite). Utilizzando nel confronto la spesa standardizzata[25], lo scarto tra la Regione con spesa pro-capite standardizzata massima (P.A. Bolzano € 2.883,6) e quella minima (Lazio € 2.058,7) sale al 1,40 volte (€ 824,9 pro-capite). Non considerando le Regioni a Statuto Speciale, si riduce a 1,14 volte ovvero a € 291,9 pro-capite (Figura A.3.2).

Figura A.3.2 **Spesa sanitaria pubblica pro-capite standardizzata nominale e reale**



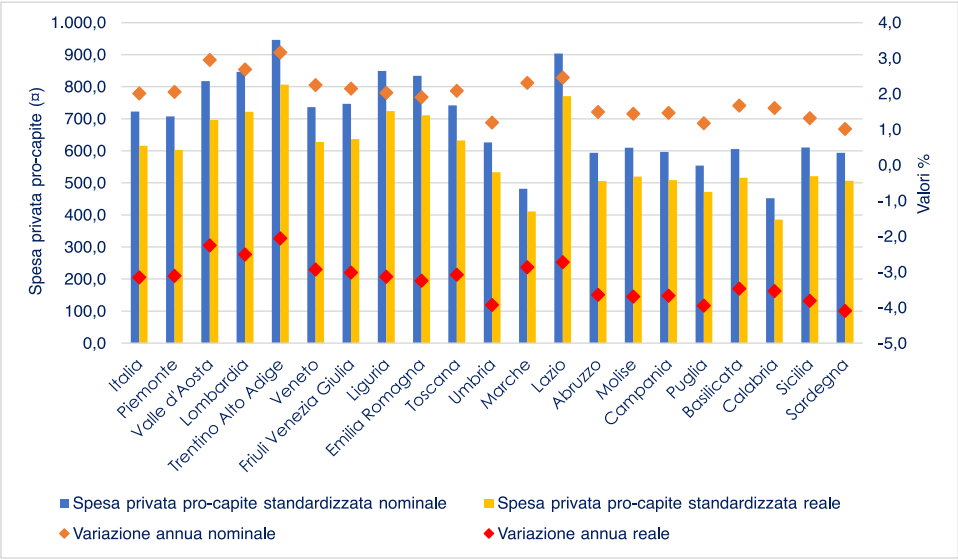
Fonte: stima su dati Ragioneria Generale dello Stato e Istat, 2024 - @ C.R.E.A. Sanità

La spesa sanitaria privata pro-capite registra i valori massimi in Trenti-

25 La spesa è stata standardizzata pesando la popolazione con i pesi impiegati per il riparto, come da relative delibere CIPE

no-Alto Adige (€ 822,5) e Lazio (€ 895,0), con all'estremo opposto la Calabria (€ 450,7). La differenza tra la Regione con spesa massima e quella con spesa minima supera le 2,0 volte (€ 471,8), valore in crescita rispetto all'anno precedente quando la differenza era pari a € 464,7. Utilizzando la stessa standardizzazione utilizzata per la spesa pubblica, si passa da € 946,3 pro-capite del Trentino-Alto Adige a € 452,4 delle Campania con una differenza pari a € 493,9 (2,09 volte) (Figura A.3.3). Escludendo dall'analisi le Regioni a Statuto Speciale la differenza si riduce a € 451,3 pro-capite (2,0 volte).

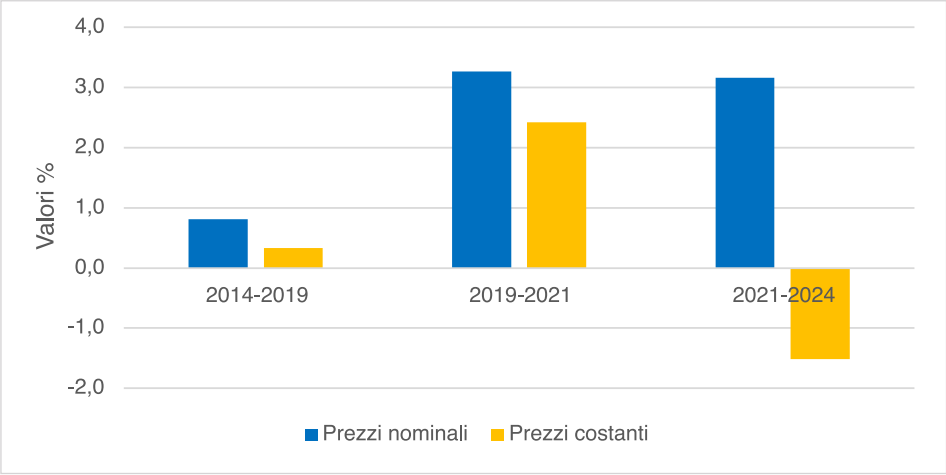
Figura A.3.3 **Spesa sanitaria privata pro-capite standardizzata nominale e reale**



Fonte: stima su dati Istat, 2024 - @ C.R.E.A. Sanità

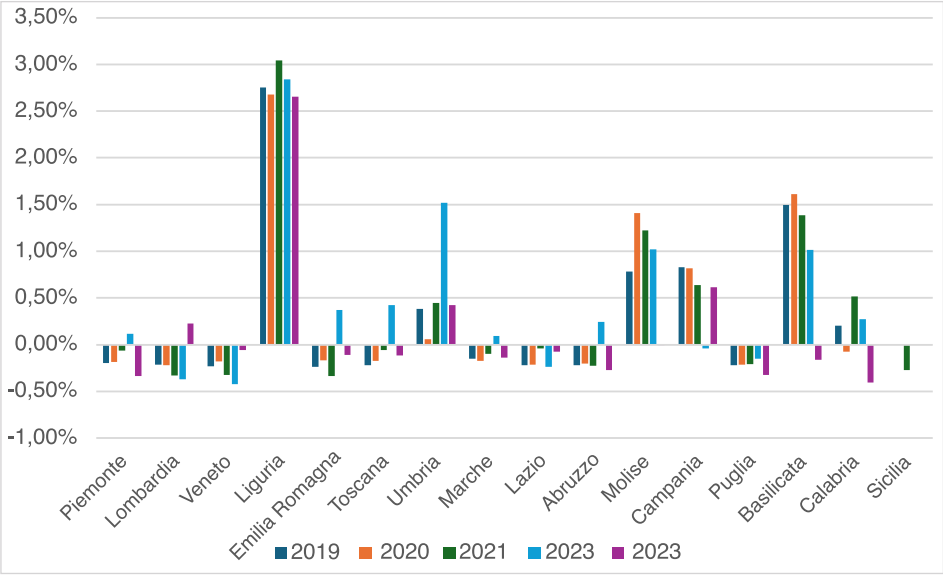
A.4 Figure

Figura A.4.1 **Fabbisogno *standard* nominale e reale**



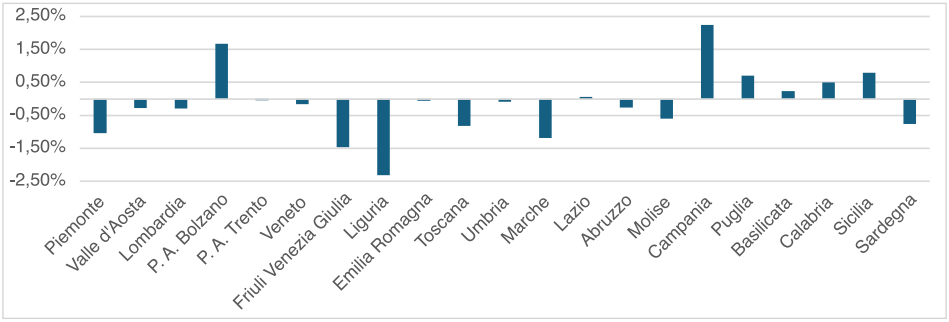
Fonte elaborazione © C.R.E.A. Sanità su Leggi di Bilancio e Istat, 2024

Figura A.4.2 **Variazioni della quota di riparto degli Accantonamenti**



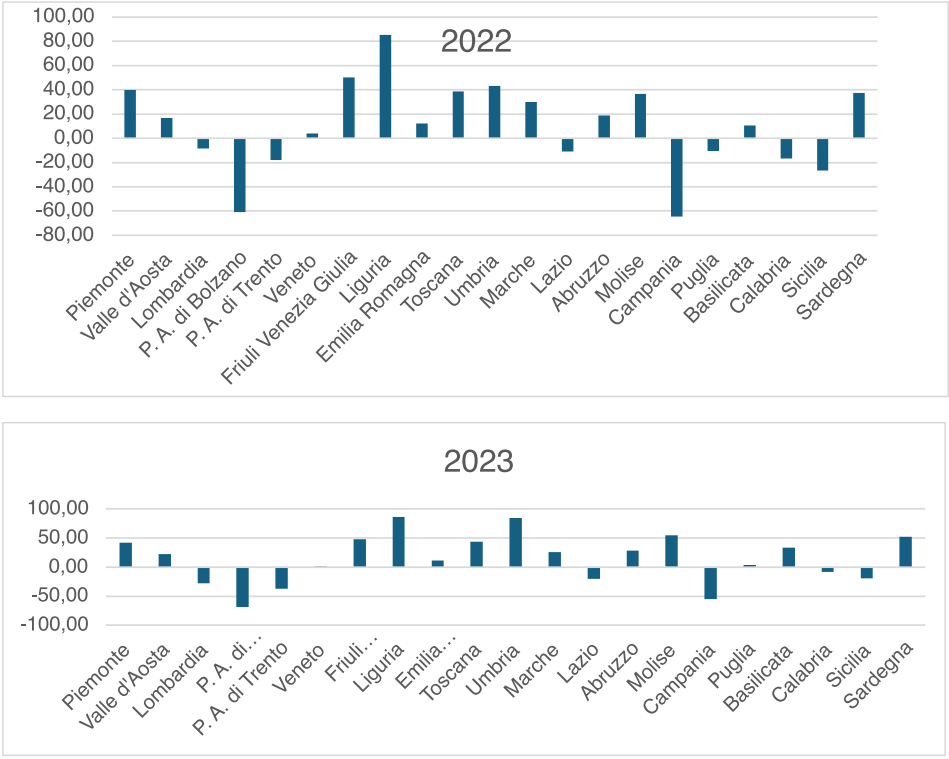
Fonte: elaborazione C.R.E.A. Sanità© su dati Delibere CIPE

Figura A.4.3 **Impatto DM n. 61/2023**



Fonte: elaborazione C.R.E.A. Sanità© su dati Delibere CIPE

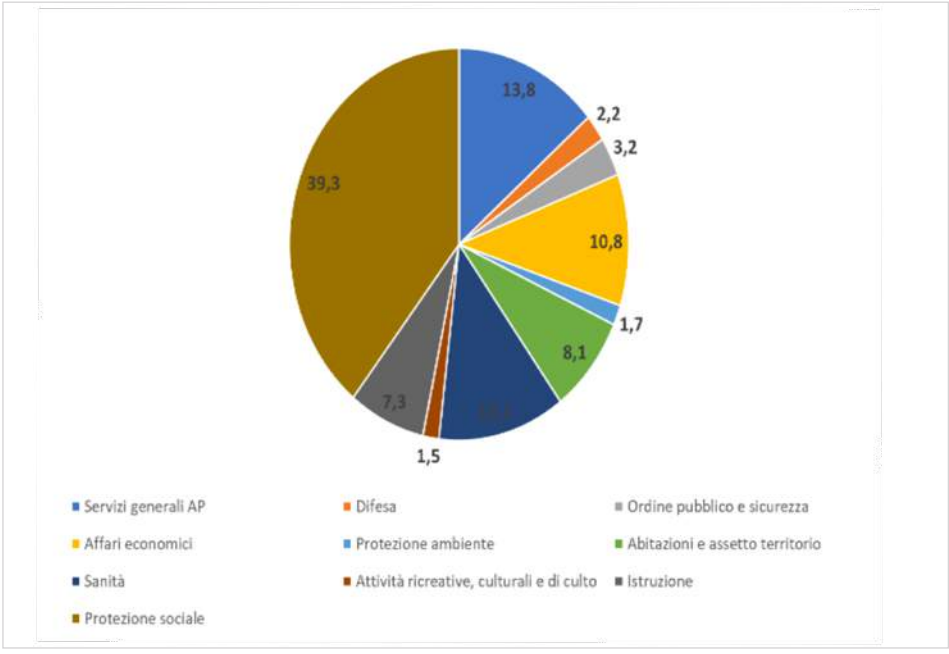
Figura A.4.4 **Differenze fra quota capitaria pura e pesata**



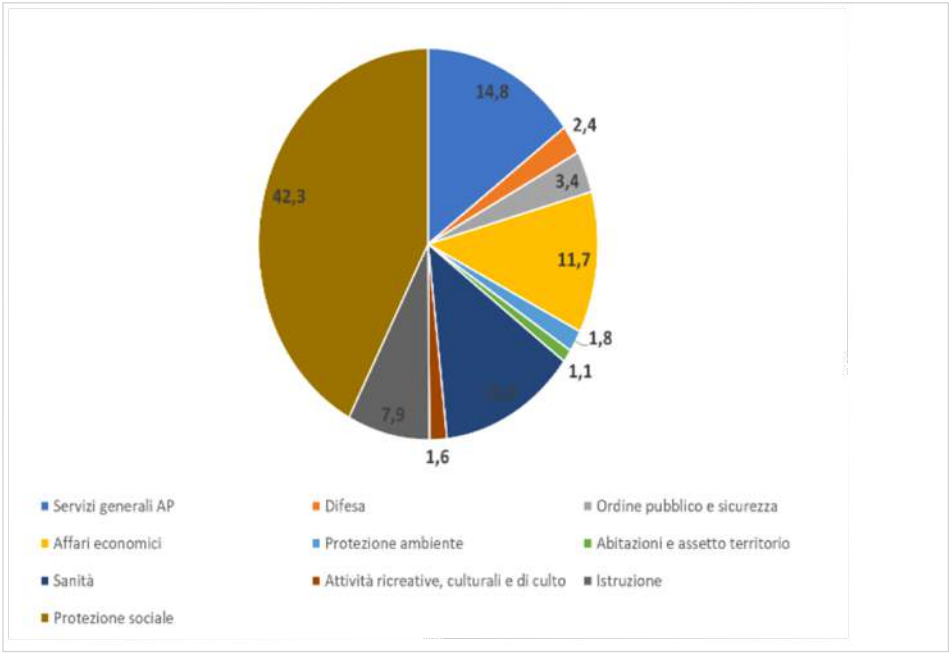
Fonte: elaborazione C.R.E.A. Sanità© su dati Delibere CIPE

Figura A.4.5 **La composizione della spesa pubblica italiana nel 2023**

A - Spesa effettiva



B - Spesa depurata



Fonte: elaborazioni su dati Istat (2024)

A.5 Tabelle

Tabella A.5.1 **Variazioni del finanziamento, dell'IVA e dell'IRAP**

	2023/2019	2020/2019	2021/2020	2022/2021	2023/2022
Finanziamento	11,46%	1,96%	2,68%	2,95%	3,41%
IVA (gettito)	27,79%	-9,36%	19,27%	15,98%	1,92%
IVA (ripartita)	14,51%	10,18%	-2,74%	3,08%	3,66%
IRAP (gettito)	19,41%	-20,79%	20,19%	19,90%	4,62%
IRAP (ripartita)	4,56%	-22,63%	29,28%	3,48%	1,02%

Fonte: elaborazione C.R.E.A. Sanità© su dati CIPE e MEF

Tabella A.5.2 **Percentuali e criteri di riparto dei Livelli Essenziali di Assistenza (LEA)**

LEA	2019	2020	2021	2022	2023	Criteri di riparto
Prevenzione	5,00%	5,00%	5,00%	5,00%	5,00%	Popolazione non pesata
Ospedaliera	44,00%	44,00%	44,00%	44,00%	44,00%	50% pop. pesata / 50% non pesata
Distrettuale	51,00%	51,00%	51,00%	51,00%	51,00%	
Medicina di base	7,00%	7,00%	7,00%	7,00%	7,00%	Popolazione non pesata
Farmaceutica	11,63%	11,76%	11,84%	11,84%	11,71%	Tetto imposto sul fabbisogno complessivo comprensiva delle somme vincolate
Specialistica	13,30%	13,30%	13,30%	13,30%	13,30%	Popolazione Pesata
Territoriale	19,07%	18,94%	18,86%	18,86%	18,99%	*Popolazione non pesata*

Fonte: CSR Atto 88/2019, CSR Atto 55/2020, CSR Atto 152/2021, CSR Atto 278/2022, CSR Atto 262/2023

Tabella A.5.3 **Quote capitarie (Numeri indice Italia = 100 e valori in euro)**

Regioni	2019 Italia = € 1857,00	2020 Italia = € 1898,97	2021 Italia = € 1963,25	2022 Italia = € 2028,19	2023 Italia = € 2098,75
Italia	100,00	100,00	100,00	100,00	100,00
Piemonte	102,21	102,16	102,03	101,95	102,02
Valle d'Aosta	100,89	100,95	100,83	100,82	101,08
Lombardia	99,89	99,79	99,58	99,58	98,69
P. A. di Bolzano	97,37	97,25	97,03	97,00	96,73
P. A. di Trento	99,24	99,21	99,03	99,13	98,21
Veneto	100,19	100,19	100,15	100,20	100,04
Friuli-Venezia Giulia	102,75	102,72	102,59	102,48	102,29
Liguria	104,74	104,60	104,36	104,20	104,12
Emilia-Romagna	101,07	100,90	100,68	100,61	100,56
Toscana	102,14	102,05	101,88	101,90	102,09
Umbria	102,12	102,11	102,13	102,13	104,02
Marche	101,56	101,56	101,53	101,48	101,24
Lazio	99,35	99,36	99,44	99,45	99,03
Abruzzo	100,82	100,86	100,94	100,93	101,34
Molise	101,40	101,64	101,82	101,81	102,62
Campania	96,42	96,54	96,76	96,81	97,38
Puglia	99,09	99,20	99,40	99,47	100,19
Basilicata	100,17	100,28	100,45	100,51	101,60
Calabria	98,76	98,92	99,17	99,17	99,61
Sicilia	98,36	98,44	98,70	98,68	99,07
Sardegna	101,01	101,26	101,66	101,83	102,49

Fonte: elaborazione C.R.E.A. Sanità© su dati Delibere CIPE

Tabella A.5.4 **Modalità accentramento regionale risorse**

Regioni	GSA	"Azienda Zero"	GSA gestita da Regione / Azienda Zero"
Piemonte	Si	Si*	Regione
Valle d'Aosta	No	No	No
Lombardia	Si	No	Regione
P. A. di Bolzano	No	No	No
P.A. di Trento	No	No	No
Veneto	SI	SI	Aziende Zero
Friuli-Venezia Giulia	No	SI (ARCS)	Azienda Zero
Liguria	Si	Si (A.Li.Sa)	Azienda Zero
Emilia-Romagna	SI	No	Regione
Toscana	SI	No	Regione
Umbria	Si	No	Regione
Marche	Si	No	Regione
Lazio	Si	No	Regione
Abruzzo	Si	No	Regione
Molise	SI	No	Regione
Campania	Sì	No	Regione
Puglia	Si	No	Regione
Basilicata	n.d.	n.d.	n.d.
Calabria	Si	No	Regione
Sicilia	Si	No	Regione
Sardegna	No	No	No

Fonte: elaborazione C.R.E.A. Sanità© su Normativa Regionale e Provinciale

Nota: * nel 2022

Tabella A.5.5 **Variazioni delle quote di riparto per ASL e AO**

Regioni	Δ2020/2019		Δ2021/2020		Δ2022/2021	
	ASL	AO	ASL	AO	ASL	AO
Piemonte	0,82%	17,36%	3,39%	9,05%	2,32%	15,30%
Valle d'Aosta	-	-	-	-	-	-
Lombardia	-8,35%	35,66%	8,81%	-0,64%	0,37%	-4,94%
P. A. di Bolzano	-	-	-	-	-	-
P.A. di Trento	-	-	-	-	-	-
Veneto	0,10%	0,97%	3,78%	-0,05%	6,45%	-1,85%
Friuli-Venezia Giulia	-1,93%	47,65%	-1,74%	-3,99%	1,22%	-6,21%
Liguria	1,55%	1.63%	1,445	2,30%	3,42%	3,20%
Emilia-Romagna	4,13%	13,25%	-0,25%	30,04%	4,44%	23,96%
Toscana	-0,73%	13,21%	4,89%	-1,48%	4,78%	27,98%
Umbria	0,31%	7,11%	0,43%	0,40%	2,07%	18,44%
Marche	-0,70%	2,09%	2,23%	2,18%	4,73%	5,89%
Lazio	1,49%	1,32%	0,53%	27,80%	4,09%	-14,53%
Abruzzo	0,89%	-	n.d.	-	n.d.	-
Molise	0,10%	-	0,57%	-	-3,67%	-
Campania	1,42%	27,26%	0,74%	2,89%	4,79%	-17,87%
Puglia	-0,39%	-9,93%	4,76%	8,29%	2,39%	2,83%
Basilicata	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Calabria	1,73%	0,09%	2,36%	6,25%	9,93%	3,18%
Sicilia	-1,53%	29,35%	2,35%	0,79%	6,78%	8,48%
Sardegna	-0,32%	25,15%	7,335	-13,25%	-0,75%	15,94%

Fonte: elaborazione C.R.E.A. Sanità© su Normativa Regionale e Provinciale

Note: AO include anche AOU e IRCCS.

Aziende ospedaliere (AO), Aziende ospedaliere universitarie (AOU) e Istituti di ricovero e cura a carattere scientifico (IRCCS)

L'evoluzione delle disuguaglianze di salute in Italia (1984-2023)

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Cecilia De Luca [*]
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Sintesi

Questo articolo analizza le disuguaglianze di salute in Italia dal 1984 al 2023, concentrandosi sulle disparità legate allo status socioeconomico e alla regione geografica. Nonostante l'impianto universalistico del Servizio Sanitario Nazionale (SSN), permangono disuguaglianze significative, in particolare tra il Nord più prospero e il Sud con minori risorse. Basandosi su dati provenienti da indagini sanitarie, lo studio mostra come le crisi economiche e la pandemia di COVID-19 abbiano ampliato tali divari, con le regioni meridionali che registrano tassi più elevati di mortalità evitabile e un accesso più limitato alle cure. Il crescente ricorso all'assistenza sanitaria privata e l'aumento dei costi a carico diretto dei cittadini hanno ulteriormente penalizzato

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i gruppi a basso reddito. Rispetto ai paesi dell'Europa settentrionale, caratterizzati da sistemi più equi, l'Italia si colloca nel quadro di una tendenza dell'Europa meridionale a mostrare disuguaglianze marcate a favore dei più abbienti. I risultati evidenziano la necessità di riforme politiche mirate a rafforzare l'investimento pubblico, promuovere l'equità territoriale e affrontare le determinanti sociali della salute, al fine di garantire la sostenibilità a lungo termine del sistema sanitario.

Abstract - The evolution of health inequalities in Italy (1984 2023)

This paper analyzes health inequalities in Italy from 1984 to 2023, focusing on access and outcomes disparities by socioeconomic status and geographic region. Despite the universalist design of Italy's National Health Service (SSN), substantial inequalities persist, particularly between the more affluent North and the under-resourced South. Drawing on data from health surveys, the study shows that economic crises and the COVID-19 pandemic have widened these gaps, with southern regions experiencing higher avoidable mortality and reduced access to care. Increased reliance on private healthcare and rising out-of-pocket costs have further disadvantaged low-income groups. Compared to Northern European countries with more equitable systems, Italy reflects a Southern European trend of pronounced pro-rich inequality. The findings highlight the need for policy reforms to strengthen public investment, enhance regional equity, and address the broader social determinants of health, ensuring long-term healthcare sustainability.

JEL Classification: H51; I1; I14.

Parole chiave: Disuguaglianze di salute; Accesso ai servizi sanitari; Analisi su microdati; Confronto europeo; Disparità socioeconomiche; Italia.

Keywords: *Health inequalities; Access to healthcare services; Microdata analysis; EU comparison; Socio-economic disparities; Italy.*

L'equità sanitaria non può riguardare solo la salute considerata isolatamente. Deve invece affrontare la questione più ampia dell'equità e della giustizia negli assetti sociali, comprese le allocazioni economiche, riconoscendo adeguatamente il ruolo fondamentale della salute nella vita e nella libertà umana. L'equità sanitaria non si limita alla distribuzione della salute, e ancor meno alla sola distribuzione dell'assistenza sanitaria. Al contrario, rappresenta un concetto di vasta portata e rilevanza, con implicazioni profonde per l'intera struttura sociale.

Sen, A. (2002)

1. Introduzione

La sostenibilità dei sistemi sanitari è diventata una delle sfide più critiche per i governi di tutto il mondo. L'incremento della spesa sanitaria, strutturalmente determinato dall'invecchiamento della popolazione, dall'aumento delle malattie croniche e dall'adozione di tecnologie mediche sempre più avanzate, ha esercitato una crescente pressione sui bilanci pubblici (OECD, 2021; WHO, 2021). Nei paesi dell'OCSE, la quota del PIL destinata alla sanità è passata dal 5% negli anni '70 a oltre il 9% nel 2020, con alcuni paesi come gli Stati Uniti che hanno superato il 17% (OECD, 2022). Questo incremento è dovuto a molteplici fattori, non ultimo l'aumento della speranza di vita, che ha portato a una maggiore incidenza di patologie croniche come diabete, ipertensione e malattie cardiovascolari (Marmot et al., 2015).

Per limitare le conseguenze di queste pressioni finanziarie sui bilanci, molti governi hanno implementato misure di contenimento della spesa, tra cui la riduzione del finanziamento pubblico, l'introduzione di ticket sanitari e, in ultima istanza, il razionamento delle cure (Stuckler et al., 2017) o misure di

efficientamento quali il decentramento amministrativo. Tali strategie hanno, però, avuto ripercussioni indesiderate sulle disuguaglianze sanitarie. Il calo della spesa pubblica ha determinato un aumento della quota di costi sanitari a carico dei cittadini, con una particolare crescita delle spese out-of-pocket, che a sua volta ha generato un accesso differenziato alle cure. Tutto ciò ha compromesso l'equità nell'accesso ai servizi sanitari, determinando un aumento delle disuguaglianze sia negli esiti di salute che nelle possibilità di usufruire delle cure. Le fasce economicamente più deboli hanno riscontrato maggiori difficoltà nell'ottenere trattamenti tempestivi e di qualità, aumentando così il rischio di peggioramento della loro condizione di salute (Ghislandi, Migheli, & Sanderson, 2021).

L'introduzione di barriere economiche all'accesso alla sanità ha anche determinato una riduzione del ricorso alla prevenzione e alla diagnosi precoce, con conseguenze negative sugli esiti di salute a lungo termine (WHO, 2021). Studi internazionali hanno evidenziato che i gruppi socio-economicamente svantaggiati tendono ad avere un'aspettativa di vita inferiore e una maggiore incidenza di malattie croniche rispetto ai gruppi più abbienti (Marmot et al., 2015). Inoltre, i paesi con sistemi sanitari più deboli hanno sperimentato un ampliamento delle disuguaglianze sanitarie in periodi di crisi economica. Il caso più eclatante è rappresentato da quanto avvenuto in Europa durante la Grande Recessione del 2008-2014, con un incremento della mortalità evitabile nei paesi che hanno maggiormente ridotto il finanziamento alla sanità pubblica (Stuckler et al., 2017).

Negli ultimi quattro decenni le disuguaglianze di salute hanno quindi rappresentato un problema persistente e in continua evoluzione in tutta l'Europa. Definite come differenze sistematiche ed evitabili negli esiti di salute e nell'accesso ai servizi sanitari tra diversi gruppi di popolazione, queste dispa-

rità continuano a essere determinate da una complessa interazione di fattori socioeconomici, strutturali e politici. Le determinanti delle disuguaglianze di salute vanno oltre i comportamenti individuali legati alla salute, includendo indicatori socioeconomici più ampi come reddito, istruzione e occupazione. Inoltre, l'organizzazione del sistema sanitario, la stabilità economica e le politiche di welfare svolgono un ruolo fondamentale nel determinare l'entità delle disparità nell'accesso alle cure sanitarie e negli esiti di salute.

Nel panorama internazionale l'Italia rappresenta un caso interessante per capire come le diseguaglianze di salute si siano evolute nel tempo e come abbiano interagito con le strategie di sostenibilità finanziaria implementate dai vari governi. Infatti, sebbene l'introduzione del SSN nel 1978 in Italia abbia istituito un sistema sanitario universalistico con l'obiettivo di garantire parità di accesso ai servizi sanitari indipendentemente dallo status socioeconomico e sebbene lo stesso abbia negli anni determinato miglioramenti significativi negli esiti sanitari della popolazione, le evidenze prodotte in questo lavoro sembrerebbero indicare che nel lungo periodo il nostro SSN non sia riuscito a incidere sulle diseguaglianze sanitarie in termini di accesso alle cure sanitarie e stato di salute, anche se sembrerebbe aver protetto i cittadini rispetto ai principali shock macroeconomici avvenuti negli ultimi venti anni.

A tale conclusione siamo arrivati grazie a un'analisi approfondita dell'evoluzione delle disuguaglianze di salute in Italia dal 1985 al 2023, periodo perfettamente sovrapponibile a quello dell'istituzione del SSN, basata su microdati provenienti da fonti diverse delle statistiche ufficiali. Attraverso dati dettagliati a livello individuale, lo studio fornisce una comprensione più approfondita delle dinamiche delle disuguaglianze di salute tra diversi gruppi socioeconomici e demografici, offrendo così una prospettiva più chiara sui fattori che hanno modellato l'evoluzione delle disuguaglianze sanitarie in Ita-

lia e di cosa potrebbe essere necessario per provare a ridurle.

Nell'elaborazione dell'analisi empirica si è scelto di utilizzare esclusivamente fonti statistiche caratterizzate da un'ampia copertura sia temporale sia territoriale, al fine di garantire una ricostruzione solida e coerente delle dinamiche sanitarie nel contesto del Servizio Sanitario Nazionale (SSN), operativo in Italia dal 1978. In particolare, sono stati impiegati i microdati delle indagini "Aspetti della vita quotidiana" (1993–2023) e dei Bilanci delle Famiglie (1985–2023), entrambe prodotte dall'Istat, che rappresentano due tra le fonti più affidabili per la documentazione delle condizioni sociali ed economiche delle famiglie italiane. Queste indagini, oltre a disporre di una serie storica estesa, assicurano una rappresentatività territoriale a livello nazionale, permettendo analisi disaggregate per area geografica e, in molti casi, per singole regioni. La scelta di tali fonti risponde, quindi, all'esigenza di allineare l'orizzonte temporale dell'analisi con il periodo di funzionamento del SSN, cogliendone l'evoluzione e gli effetti sulla salute e sui comportamenti delle famiglie nel lungo periodo. L'adozione di fonti con ampia estensione temporale permette, inoltre, di cogliere con maggiore accuratezza le traiettorie delle disuguaglianze sanitarie e di valutare l'impatto cumulativo delle politiche pubbliche sulla salute delle famiglie.

Siamo tuttavia consapevoli del fatto che questa scelta metodologica può comportare alcune limitazioni. In particolare, l'esclusione di fonti dati potenzialmente più ricche sotto il profilo informativo — ad esempio, indagini mirate, archivi clinici o dati amministrativi settoriali — ma con una copertura più ristretta nel tempo o nello spazio, può ridurre la possibilità di esplorare in profondità specifici fenomeni emergenti o gruppi particolarmente vulnerabili. Tuttavia, si è ritenuto prioritario garantire la coerenza storica e la generalizzabilità nazionale dei risultati, in linea con gli obiettivi di un'analisi strutturale

e comparativa delle disuguaglianze sanitarie nel lungo periodo.

Nelle pagine che seguono il lavoro si articola come segue. La sezione 2 introduce il quadro teorico e definitorio relativo alle disuguaglianze sanitarie, chiarendone le principali dimensioni analitiche e i concetti chiave utili all'interpretazione empirica. La sezione 3 descrive in dettaglio i dati utilizzati e la strategia metodologica adottata, con particolare riferimento all'integrazione tra le indagini Istat "Aspetti della Vita Quotidiana" e "Bilanci delle Famiglie". La sezione 4 presenta i risultati dell'analisi empirica, soffermandosi sulle disuguaglianze misurate in termini di salute percepita, accesso e soddisfazione per i servizi sanitari e spesa sanitaria privata, con un'attenzione specifica alle differenze per livello socioeconomico, istruzione e territorio. La sezione 5 discute criticamente i risultati, collocandoli nel contesto della letteratura internazionale e delle traiettorie evolutive del SSN italiano. Infine, la sezione 6 riassume i principali contributi dell'articolo, evidenzia i limiti dell'analisi e propone alcune implicazioni per le politiche pubbliche orientate all'equità sanitaria.

2. Le diseguaglianze di salute

Quando si affronta il tema delle disuguaglianze sanitarie, risulta imprescindibile definire con rigore concettuale l'oggetto dell'analisi. Il termine "disuguaglianze di salute" è spesso impiegato in maniera generica o ambivalente, pur facendo riferimento a una molteplicità di accezioni e dimensioni analitiche. L'assenza di una specificazione chiara riguardo all'indicatore sanitario considerato e ai gruppi di popolazione tra cui tale indicatore risulta diseguale rischia di compromettere la comprensione del fenomeno e di condurre a

letture fuorvianti delle dinamiche sociali sottese. Una definizione precisa di cosa si intenda per disuguaglianza sanitaria costituisce, dunque, il prerequisito metodologico per l'individuazione delle sue determinanti, per la misurazione accurata dell'impatto e per la progettazione di politiche di contrasto efficaci. Solo attraverso una concettualizzazione solida e articolata del fenomeno è possibile analizzarne in modo sistematico l'evoluzione nel tempo, valutarne le implicazioni etiche e istituzionali e delineare strategie di intervento orientate alla riduzione delle disuguaglianze.

Secondo Williams et Al. (2022), esistono molteplici tipi di disuguaglianza sanitaria e diversi modi in cui questo termine viene utilizzato. Per questo motivo, quando si parla di "disuguaglianze di salute", è utile specificare chiaramente quale indicatore sanitario è distribuito in modo diseguale e tra quali gruppi di persone. Innanzitutto, occorre capire di quale tipo di diseguaglianza si parla (o "diseguaglianza di cosa"). Queste riguardano, in ultima analisi, le differenze nello stato di salute delle persone. Tuttavia, il termine viene spesso utilizzato anche per riferirsi alle differenze nelle cure che le persone ricevono e nelle opportunità che hanno di condurre una vita sana, entrambi fattori che possono influenzare il loro stato di salute.

Le disuguaglianze di salute possono quindi riguardare differenze in:

- Stato di salute, ad esempio, l'aspettativa di vita.
- Accesso alle cure, ad esempio, la disponibilità di determinati servizi.
- Qualità ed esperienza delle cure, ad esempio, i livelli di soddisfazione dei pazienti.
- Rischi comportamentali per la salute, ad esempio, i tassi di fumo.
- Determinanti più ampi della salute, ad esempio, la qualità delle abitazioni.

Ci sono poi le differenze nello stato di salute e nei fattori che lo determinano che possono essere vissute da persone raggruppate in base a diversi criteri ("disuguaglianze tra chi"). In generale, le disuguaglianze di salute vengono spesso analizzate e affrontate dalle politiche pubbliche secondo quattro principali fattori:

- Fattori socioeconomici, ad esempio, il reddito o l'istruzione.
- Fattori geografici, ad esempio, la regione di residenza o la distinzione tra aree urbane e rurali.
- Caratteristiche specifiche, comprese quelle protette dalla legge, come il sesso, l'etnia o la disabilità.
- Gruppi socialmente esclusi, ad esempio, persone che vivono in condizione di senzatetto.

Fatta questa tassonomia, emerge chiaramente che le persone possono essere influenzate da diverse combinazioni di fattori, con conseguenze significative sulle disuguaglianze di salute che possono affrontare. Di conseguenza, un gruppo di individui definito da un solo criterio, come la disabilità o l'appartenenza a un determinato gruppo etnico, non sarà omogeneo: al suo interno esisteranno variazioni nei profili di salute e nei rischi associati. L'interazione tra questi fattori e il modo in cui si sovrappongono contribuiscono ulteriormente a modellare le disuguaglianze sanitarie, facendoci capire che le esperienze di salute sono influenzate da molteplici dimensioni sociali.

Inoltre, la relazione tra status socio-economico e salute non dipende solo dall'accesso ai servizi sanitari, ma anche dalla capacità degli individui di "produrre" salute a partire dalle risorse disponibili (Grossman, 1972). L'ambiente gioca un ruolo cruciale: fattori come la qualità dell'aria e dell'acqua, le

condizioni abitative e lavorative e l'inquinamento acustico influenzano in modo significativo lo stato di salute (Almond & Currie, 2011; Galama & van Kippersluis, 2013). Le persone con uno status socioeconomico inferiore hanno meno risorse da investire nella propria salute e un costo opportunità più elevato nell'accesso alle cure. Di conseguenza, tendono a posticipare le visite mediche fino a quando i sintomi non diventano gravi, aumentando la probabilità di trattamenti invasivi e costosi nel lungo termine (Muurinen & LeGrand, 1985).

Le disuguaglianze sanitarie si manifestano anche nelle capacità individuali di navigare il sistema sanitario. Gli individui con maggiori risorse finanziarie ed educative sono spesso più abili nel negoziare con i fornitori di assistenza e ottenere trattamenti di migliore qualità (Grossman, 1972; Case & Kraftman, 2024). Questo fenomeno è particolarmente rilevante in sistemi sanitari complessi, dove la capacità di comprendere le politiche sanitarie e di accedere ai servizi migliori dipende dal livello di istruzione e dall'abilità di advocacy sanitaria.

Le differenze geografiche amplificano ulteriormente le disuguaglianze sanitarie. Negli Stati Uniti, esistono disparità regionali significative nei tassi di mortalità evitabile e nelle malattie croniche, legate a fattori economici e all'accesso ai servizi sanitari (Commonwealth Fund, 2024). Nel Regno Unito, le donne nelle regioni settentrionali vivono mediamente due anni in meno rispetto a quelle del sud, riflettendo la persistenza di disuguaglianze socioeconomiche e ambientali (Health Equity North, 2024). In Italia le regioni settentrionali, grazie a una maggiore capacità economica, a un più efficiente utilizzo delle risorse, alla maggiore disponibilità di servizi sanitari, a una rete ospedaliera più robusta, tempi di attesa più brevi e maggiore accesso alla diagnostica precoce presentano indicatori sanitari significativamente migliori

rispetto alle regioni meridionali (Blangiardo, 2021). In tal senso, la forte disparità regionale tra Nord e Sud, con differenze nell'aspettativa di vita di oltre 3 anni (Istat, 2025) tra la più longeva (Trentino Alto-Adige – 84 anni) e la meno longeva regione (Campania – 80,9 anni).

Relativamente alle disuguaglianze sanitarie tra diversi gruppi della popolazione, studi basati su microdati longitudinali, come il Turin Longitudinal Study (Stringhini, et al. (2014), Petrelli, et Al. (2024)), hanno documentato che mentre le disuguaglianze assolute nella mortalità sono diminuite negli ultimi quattro decenni, le disparità relative rimangono sostanziali, in particolare tra i gruppi socioeconomici svantaggiati. Queste disuguaglianze persistenti sono particolarmente accentuate nelle regioni meridionali, dove le popolazioni a basso reddito subiscono gli effetti combinati della povertà economica, delle infrastrutture sanitarie insufficienti e delle difficoltà di accesso alle cure specialistiche (Devillanova, C., & Frattini, T. (2016), Petrelli et Al. (2020), Petrelli et Al. (2024a,b)). Ad esempio, le disuguaglianze nella mortalità evitabile legate all'istruzione e al reddito sono costantemente più elevate nelle regioni meridionali rispetto alle regioni settentrionali (Devillanova & Frattini (2016), De Falco (2019), Petrelli et Al. (2020)). Le comunità emarginate, tra cui gli immigrati e le persone a basso reddito, incontrano notevoli ostacoli nell'accesso alle cure mediche. Le ricerche dimostrano che questi gruppi tendono a fare maggiore affidamento sui servizi di emergenza invece di ricevere cure mediche preventive o di elezione, il che contribuisce ulteriormente a peggiorare gli esiti sanitari. Le difficoltà economiche, le barriere istituzionali e gli ostacoli linguistici o culturali aggravano queste problematiche, portando a una minore fruizione delle cure specialistiche e dei servizi di prevenzione (Devillanova, C., & Frattini, T. (2016), Petrelli et Al. (2020)).

Inoltre, il crescente ruolo delle spese sanitarie out-of-pocket (OOP) ha

intensificato tali disuguaglianze. Negli ultimi tre decenni, i costi sanitari a carico del cittadino sono aumentati drasticamente, passando dal 6% della spesa sanitaria totale negli anni '90 a oltre il 23% nel 2019 (Ministero della Salute, 2020). Questo fenomeno ha avuto un impatto negativo sulle fasce più povere della popolazione, costrette a rinunciare a cure specialistiche a causa dei costi elevati. Inoltre, la crescita del settore sanitario privato ha creato un accesso privilegiato per chi può permettersi prestazioni a pagamento, determinando un sistema a doppia velocità: chi ha risorse economiche accede rapidamente alle cure, mentre chi non le ha deve affrontare lunghe liste d'attesa nel settore pubblico (De Falco, (2019), Ghislandi et al., (2021)).

Altro aspetto rilevante è che l'analisi delle disuguaglianze sanitarie richiede strumenti metodologici avanzati per distinguere tra differenze "appropriate" e "ingiuste" nell'accesso e nell'uso delle cure (Fleurbaey & Schokkaert, 2009). Un problema metodologico chiave è la misurazione del bisogno sanitario effettivo. Ad esempio, le persone con status socioeconomico inferiore tendono ad avere più problemi di salute, ma questi bisogni non sempre vengono adeguatamente rappresentati nei dati amministrativi (Cookson et al., 2015). Inoltre, molti studi cross-sectional forniscono una visione statica delle disuguaglianze, ignorando i processi dinamici che le alimentano. Ad esempio, il deterioramento della salute può ridurre il reddito futuro di un individuo, rafforzando il ciclo della povertà e dell'esclusione sanitaria (Stoye et al., 2021).

Infine, le politiche pubbliche giocano un ruolo cruciale nel mitigare o amplificare le disuguaglianze sanitarie. Misure di austerità, come quelle introdotte negli anni passati nel Regno Unito, hanno avuto effetti negativi sulla salute delle fasce più deboli della popolazione. Ad esempio, la riduzione dei finanziamenti per i servizi sociali è stata associata a un aumento della mortalità infantile e di problemi di salute neonatali nelle aree più povere (Walsh et

al., 2024).

Basandoci su questa tassonomia, nelle pagine che seguono, per cause riconducibili alla disponibilità dei dati, le analisi saranno condotte solo su alcuni degli indicatori qui riportati. In particolare, verranno analizzati indicatori di stato di salute soggettivo, accesso alle cure e soddisfazione nelle stesse e spesa sanitaria OOP. Tali indicatori verranno declinati per appartenenza territoriale (macro-regioni), sesso, età e livello di istruzione.

3. I dati

Le evidenze empiriche presentate in questo studio si basano su due importanti fonti statistiche prodotte dall'Istituto Nazionale di Statistica (Istat): l'indagine annuale "Aspetti della vita quotidiana" (AVQ)[1] e l'indagine sui Bilanci delle Famiglie.[2] Entrambe rappresentano strumenti fondamentali per l'analisi

1 L'indagine "Aspetti della vita quotidiana" condotta annualmente dall'Istat rappresenta una delle principali fonti di dati multidimensionali sul benessere, le condizioni sociali e le abitudini della popolazione residente in Italia. Avviata nel 1993 e inserita nel sistema integrato delle indagini sociali multiscopo, questa rilevazione si propone di cogliere, attraverso un approccio sistematico e comparabile, la complessità della vita quotidiana degli individui e delle famiglie, documentando una vasta gamma di comportamenti, percezioni e modalità di interazione con i servizi pubblici e privati. Le Indagini Multiscopo dell'Istat sono indagini campionarie trasversali a livello nazionale che coinvolgono ogni anno circa 20.000 famiglie italiane. La struttura dell'indagine prevede un nucleo fisso di domande, affiancato da moduli tematici a rotazione che trattano aspetti quali lo stato di salute, le condizioni abitative, l'occupazione e la partecipazione sociale. Grazie alla loro ampiezza tematica e alla continuità metodologica, le Indagini Multiscopo rappresentano uno strumento fondamentale per il monitoraggio dei cambiamenti demografici, sanitari e socioeconomici nel tempo e nei diversi territori del Paese.

2 L'indagine Istat sui Bilanci delle Famiglie costituisce una delle principali fonti statistiche per l'analisi dei comportamenti economici e delle condizioni di vita delle famiglie residenti in Italia. L'indagine si basa su un campione probabilistico stratificato della popolazione residente, progettato per garantire la rappresentatività a livello regionale. Il campione include mediamente circa 20.000 famiglie ogni anno, corrispondenti a oltre 50.000 individui, distribuiti su tutto il territorio nazionale. Si tratta di una rilevazione volta a raccogliere informazioni dettagliate sulla struttura della spesa per consumi, sulle caratteristiche sociodemografiche delle famiglie e sul contesto abitativo e territoriale in cui esse vivono. L'indagine ha l'obiettivo di descrivere in modo sistematico le modalità con cui le famiglie italiane allocano le proprie risorse economiche, con particolare riferimento ai con-

delle condizioni sociali ed economiche delle famiglie italiane, offrendo una copertura temporale estesa e una notevole profondità informativa.

Un aspetto metodologicamente rilevante del presente lavoro è consistito nel sistematico processo di raccolta e ricostruzione delle serie storiche delle due indagini fin dalla prima edizione, finalizzato a garantire la coerenza longitudinale dei dati e la confrontabilità degli indicatori nel tempo. In particolare, sono stati armonizzati e ricodificati i microdati delle indagini AVQ per il periodo 1993–2023, e quelli dei Bilanci delle Famiglie per il periodo 1985–2023. Questo lavoro ha richiesto un'attenta revisione della struttura dei questionari, delle definizioni adottate e delle modalità di rilevazione, al fine di uniformare le variabili chiave oggetto di analisi lungo l'intero orizzonte temporale.

Per quanto riguarda le indagini AVQ, esse raccolgono informazioni dettagliate su una vasta gamma di patologie croniche auto-riferite. Tra le condizioni rilevate figurano: diabete, ipertensione arteriosa, infarto del miocardio, angina pectoris o altre malattie del cuore, bronchite cronica, enfisema e insufficienza respiratoria, asma bronchiale, malattie allergiche, tumori (inclusi linfomi e leucemie), ulcera gastrica e duodenale, calcolosi del fegato o delle vie biliari, cirrosi epatica, calcolosi renale, artrosi e artrite, osteoporosi. In questo lavoro si è scelto di concentrare l'analisi su sei gruppi di malattie croniche particolarmente rilevanti per prevalenza, impatto sulla salute pubblica e

sumi monetari e non monetari, offrendo così un quadro approfondito delle scelte di spesa e delle disuguaglianze nei livelli e nelle composizioni dei consumi. I dati raccolti consentono di analizzare:

- l'importo totale delle spese familiari suddivise per oltre 400 voci di consumo;
- la composizione percentuale delle spese per tipologia di beni e servizi (alimentari, abitativi, sanitari, educativi, ricreativi, ecc.);
- le modalità di acquisto (acquisti diretti, autoconsumo, beni ricevuti gratuitamente);
- i comportamenti di risparmio, anche in relazione al reddito dichiarato e al contesto socio-territoriale.

L'indagine fornisce inoltre informazioni di contesto utili per l'analisi dei consumi, come la composizione del nucleo familiare, il livello di istruzione, l'occupazione dei membri della famiglia, la tipologia di abitazione e la disponibilità di beni durevoli.

disponibilità di dati stabili e comparabili nel tempo: malattie cardiovascolari (ipertensione, infarto, angina e altre cardiopatie), malattie respiratorie (bronchite cronica, enfisema, insufficienza respiratoria e asma), disturbi muscoloscheletrici (artrosi, artrite e osteoporosi), allergie, diabete e tumori.

Una volta ricostruite le serie storiche, sono stati utilizzati sei indicatori principali: i) lo stato di salute autodichiarato su scala da 1 (molto buono) a 5 (pessimo); ii) il numero di comorbidità riportate, ottenuto dal conteggio delle patologie croniche dichiarate dagli intervistati; iii) la frequenza delle ospedalizzazioni nei 12 mesi precedenti l'intervista; e iv) il grado di soddisfazione espresso dagli utenti in merito alla qualità dei servizi ospedalieri, con specifico riferimento al personale medico e infermieristico. Quest'ultimo indicatore, disponibile solo per il sottogruppo di individui che ha riportato almeno un ricovero, è stato trattato con attenzione particolare: data la bassa prevalenza di ospedalizzazione nella popolazione generale (circa il 3% annuo), i dati grezzi risultano affetti da forte variabilità statistica. Per tale motivo, le serie relative al grado di soddisfazione sono state filtrate utilizzando il filtro di Hodrick-Prescott, al fine di ridurre la componente di rumore e ottenere una rappresentazione più stabile del trend di lungo periodo. Tali variabili consentono di esplorare, in chiave comparativa, le dinamiche di accesso ai servizi e le disuguaglianze soggettive nella percezione del proprio stato di salute, disaggregate per caratteristiche sociodemografiche.

Nel caso dell'indagine sui "Bilanci delle Famiglie", l'attenzione si è concentrata sulle spese sanitarie di natura privata, sia in termini assoluti sia in relazione al reddito familiare. Gli indicatori analizzati sono rappresentati dall'incidenza delle spese sul totale dei consumi e dalla quota di famiglie che sostengono spese sanitarie. Le spese sanitarie sostenute direttamente dalle famiglie includono: a) l'acquisto di farmaci da banco e prescritti; b) il pagamen-

to di visite mediche specialistiche e prestazioni diagnostiche in regime privato o intramoenia; c) l'accesso a cure odontoiatriche, fisioterapiche e altri servizi sanitari non rimborsati dal Servizio Sanitario Nazionale; d) l'acquisto di ausili sanitari e strumenti terapeutici. Da queste variabili è stata poi ottenuta anche una variabile di spesa sanitaria totale. Anche in questo caso le variabili sono state poi declinate per sottogruppi sociodemografici rilevanti.

Queste informazioni risultano fondamentali per analizzare l'entità e l'incidenza della spesa sanitaria privata, individuare possibili fenomeni di rinuncia alle cure per motivi economici e valutare le disuguaglianze nell'accesso effettivo alla sanità. L'analisi longitudinale dei dati consente inoltre di osservare come i comportamenti di spesa in ambito sanitario si siano modificati nel tempo in risposta a fattori macroeconomici, riforme del sistema sanitario, evoluzione demografica e shock esogeni come la pandemia da COVID-19. Questo consente di analizzare l'evoluzione del peso economico sostenuto direttamente dalle famiglie per far fronte ai propri bisogni sanitari, con particolare attenzione agli aspetti redistributivi e alla sostenibilità economica della spesa in salute nel corso del tempo.

L'integrazione di queste due fonti consente di combinare la dimensione soggettiva (percezioni, accessi e comportamenti legati alla salute) con quella oggettiva (comportamenti di spesa, vincoli economici), offrendo un quadro analitico ricco e articolato. Tale approccio si rivela particolarmente utile per l'indagine delle disuguaglianze sanitarie, in quanto permette di studiare simultaneamente sia i profili di domanda (bisogni, percezioni, accessibilità) sia quelli di offerta e risposta economica (costi sostenuti, rinunce alle cure, effetto del reddito disponibile).

4. Evoluzione delle Disuguaglianze di Salute in Italia (1984-2023)

4.1 Diseguaglianze negli esiti di salute

Le disuguaglianze nelle condizioni di salute a lungo termine continuano a rappresentare una delle principali sfide per i sistemi sanitari globali. Malattie croniche come il diabete, le patologie cardiovascolari e le malattie respiratorie croniche non solo costituiscono una parte rilevante del carico di malattia e mortalità, ma si distribuiscono in modo diseguale nella popolazione, con una maggiore incidenza tra i gruppi socio-economicamente svantaggiati (Marmot, 2005; Stringhini et al., 2017; Bambra et al., 2020).

L'accesso alle cure, lo stile di vita e le condizioni di lavoro influenzano in maniera significativa sia la probabilità di sviluppare queste malattie, sia la capacità di gestirle efficacemente nel tempo. Le popolazioni con livelli di istruzione o reddito più bassi tendono a essere più esposte a fattori di rischio comportamentali e ambientali, come una dieta malsana, il fumo, la sedentarietà e l'inquinamento ambientale (WHO, 2008; Allen et al., 2018). Inoltre, il lavoro precario, lo stress occupazionale e le condizioni abitative sfavorevoli sono associati a un peggioramento della salute cardiovascolare e metabolica (Bolibar et al., 2021; Matilla-Santander et al., 2022; Pulford et al., 2022; Agarwal et al., 2024; Oddoet al., 2024).

Negli ultimi anni, nuove ricerche hanno confermato che la gestione della cronicità è anch'essa segnata da forti disuguaglianze (Wachtler et al., 2019). Le persone con minori risorse economiche e culturali incontrano maggiori ostacoli nell'aderire alle terapie, accedere alle innovazioni terapeutiche e mantenere uno stile di vita compatibile con la gestione della malattia. Durante la

pandemia di COVID-19, tali disuguaglianze si sono ulteriormente amplificate, evidenziando come la vulnerabilità sociale sia un potente determinante della prognosi nelle patologie croniche (Clark et al., 2020; Bambra et al., 2020). L'evidenza scientifica sottolinea l'urgenza di adottare politiche integrate che affrontino i determinanti sociali della salute lungo tutto il corso della vita. Interventi mirati su istruzione, lavoro, ambiente e sistema sanitario sono essenziali per ridurre le disuguaglianze nella diffusione e nella gestione delle malattie croniche.

Nelle pagine che seguono sono presentati i risultati relativi alle disuguaglianze nella salute auto-percepita e nell'accesso ai servizi sanitari in Italia, nel periodo compreso tra il 1993 e il 2022, sulla base dei dati provenienti dall'indagine AVQ condotta annualmente dall'Istituto Nazionale di Statistica (Istat). L'analisi considera la dimensione territoriale, di genere, di livello d'istruzione e di età, con l'obiettivo di fornire una lettura longitudinale e comparativa dell'evoluzione delle disuguaglianze sanitarie nel contesto italiano.

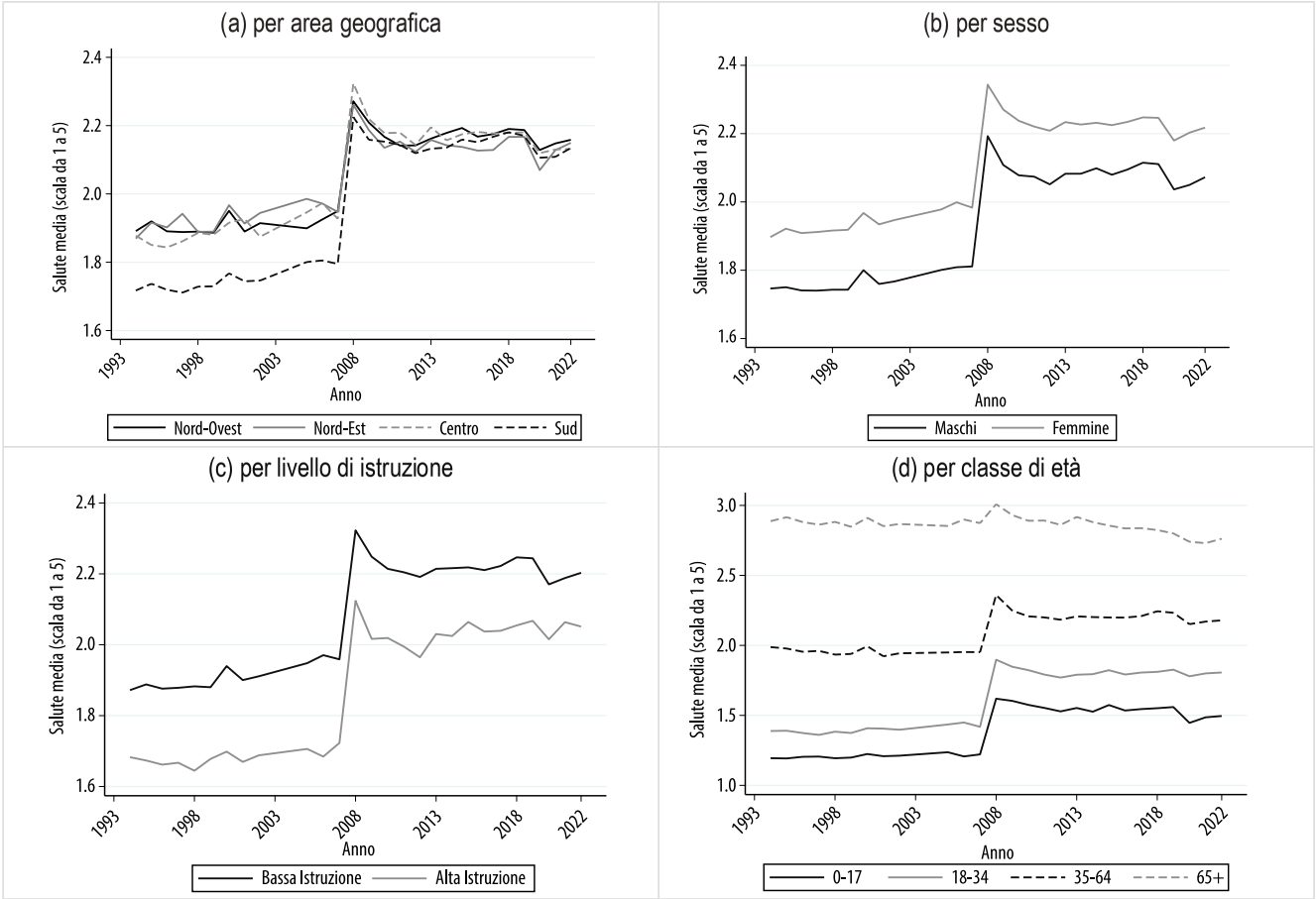
La Figura 1 mostra l'andamento temporale dello stato di salute auto-valutato dalla popolazione italiana nel periodo 1993–2022, disaggregato per area geografica, sesso, livello di istruzione e fascia d'età. I valori si riferiscono a una scala da 1 (salute migliore) a 5 (salute peggiore), e mostrano quindi un peggioramento all'aumentare del valore medio. Tuttavia, tale tendenza non è necessariamente indicativa di un deterioramento generalizzato delle condizioni sanitarie. Una lettura attenta dei dati suggerisce che l'incremento osservato sia attribuibile, in larga parte, all'invecchiamento progressivo della popolazione.

In particolare, il pannello (d) della Figura 1, che rappresenta lo stato di salute medio per classe di età, evidenzia un'informazione cruciale: all'interno di ciascun gruppo di età (0–17, 18–34, 35–64, 65+), i trend nel tempo risultano sostanzialmente stabili, con lievi fluttuazioni e nessuna tendenza crescente

marcata. Questo implica che le condizioni di salute auto-percepita, a parità di età, non sono peggiorate nel corso del periodo considerato. Al contrario, il peggioramento osservato nell'indicatore aggregato per l'intera popolazione può essere attribuito alla crescente quota relativa di individui nelle fasce di età più avanzate, le quali riportano sistematicamente una salute percepita peggiore.

Altra cosa importante da osservare è una tendenza relativamente stabile fino al 2007, seguita da un evidente salto verso valori peggiori, attribuibile a un cambio nella definizione e nella modalità di rilevazione dell'indicatore di salute soggettiva (riconducibile a una modifica del questionario) a partire da quell'anno, che ha generato un incremento artificiale nelle curve in quell'anno. Nonostante questa evidente discontinuità metodologica, i pattern strutturali di disuguaglianza si mantengono costanti nel tempo, evidenziando la necessità di interventi di sanità pubblica capaci di ridurre le disparità nella percezione e nelle condizioni reali di salute. L'unica eccezione è rappresentata dalla dimensione regionale, dove, prima del cambio di definizione, il Sud presentava uno stato di salute migliore rispetto alle altre macroaree, che si azzera con il cambio nella domanda del questionario.

Figura 1 **Stato di salute auto-valutato della popolazione per livello socio-economico.**



Fonte: nostre elaborazioni sull'indagine AVQ-Istat, diversi anni. L'indicatore dello stato di salute auto-percepito varia da 1 a 5, dove il valore 1 indica la condizione di salute migliore e il valore 5 quella peggiore.

Note: Il salto nella serie che si riscontra tra il 2007 e il 2008 è attribuibile a un cambio nella definizione e nella modalità di rilevazione dell'indicatore di salute soggettiva (riconducibile a una modifica del questionario) da parte dell'Istat a partire dall'anno 2008, che ha generato un incremento artificiale nell'indicatore senza apparentemente modificare le relazioni tra i vari gruppi esaminati (con qualche eccezione).

Per quanto riguarda il genere, nel grafico (b) si osserva una differenza costante tra uomini e donne nel periodo considerato. Le donne riportano valori medi più elevati (quindi una percezione di salute peggiore) rispetto agli uomini, con un aumento più marcato in corrispondenza del cambio metodologico del 2007. Questa differenza di genere nella percezione dello stato di salute potrebbe riflettere sia reali differenze nella salute fisica e mentale, sia una diversa soglia soggettiva nella valutazione del proprio stato di benessere. Nonostante le donne presentino, in media, una maggiore aspettativa di vita rispetto agli uomini, esse riportano peggiori condizioni di salute auto-percepita, una più alta prevalenza di malattie croniche non fatali e un maggiore utilizzo dei servizi sanitari (Case & Paxson, 2005; OECD, 2021).

Le differenze di salute tra i generi non sono solo una questione biologica, ma riflettono un ampio insieme di determinanti sociali, culturali, economici e istituzionali. Studi recenti hanno evidenziato come i ruoli di genere, le disuguaglianze nel mercato del lavoro e le responsabilità di cura gravanti sulle donne contribuiscano a un carico maggiore di stress psicosociale e a una maggiore vulnerabilità alle condizioni croniche, in particolare disturbi d'ansia, depressione e dolore cronico (European Institute for Gender Equality [EIGE], 2021; Gkiouleka et al., 2018).

Gli uomini, invece, sono più frequentemente esposti a comportamenti di rischio come il consumo eccessivo di alcol, il fumo e una dieta meno equilibrata, spesso incoraggiati da norme sociali legate alla mascolinità. Tuttavia, sono meno inclini a cercare assistenza medica tempestiva o a partecipare a programmi di prevenzione, il che può contribuire a diagnosi tardive e prognosi peggiori (Wang et al., 2020).

Infine, nel grafico (c) è possibile vedere il divario in termini di salute che deriva da diversi livelli di istruzione. La letteratura scientifica ha da tempo

riconosciuto il livello di istruzione come uno dei principali determinanti sociali della salute. Secondo Mirowsky e Ross (2003), e in linea con il modello di Grossman (1972), è l'istruzione a generare gran parte dell'associazione tra status sociale elevato e buona salute. Le persone istruite tendono a percepirsi come padrone della propria vita, il che favorisce e rende possibile uno stile di vita salutare. Inoltre, l'efficacia appresa – uno degli esiti pratici dell'istruzione – consente loro di accedere a lavori autonomi e creativi, che a loro volta promuovono il benessere. I benefici dell'istruzione sulla salute sono diffusi, cumulativi e auto-rinforzanti, crescendo lungo tutto il corso della vita. Questo contributo mette in discussione molte delle concezioni consolidate nella sociologia della salute e nella sanità pubblica, ampliando al contempo la comprensione degli effetti della stratificazione sociale.

Inoltre, numerosi studi mostrano che le persone con livelli educativi più elevati tendono a godere di una salute migliore, a essere meno esposte a fattori di rischio comportamentali e ambientali, e ad avere una maggiore capacità di accedere e interagire con il sistema sanitario in modo efficace (Cutler & Lleras-Muney, 2006; Mirowsky & Ross, 2003). Tali evidenze trovano un riscontro diretto nei risultati riportati nella Figura 1, grafico (c), dove si osserva che gli individui con basso livello di istruzione presentano sistematicamente valori più alti nell'indicatore di stato di salute auto-percepito (cioè una salute peggiore) rispetto a coloro con istruzione elevata, lungo tutto il periodo considerato.[3]

Il divario osservato nel grafico è coerente con quanto emerso in studi nazionali e internazionali, secondo i quali l'istruzione influenza la salute attraverso una molteplicità di meccanismi: accesso a risorse economiche e cultu-

3 Dopo il 2007, entrambe le curve mostrano un incremento nei valori medi, ma il divario tra i due gruppi si mantiene sostanzialmente stabile. Questo suggerisce che l'istruzione continua a essere un forte determinante della percezione dello stato di salute, anche al netto del cambio definitorio.

rali, adozione di comportamenti salutari, maggiore alfabetizzazione sanitaria e una migliore capacità di navigare il sistema delle cure (Mackenbach et al., 2008; Dahl et al., 2006). In particolare, i lavori di Atella, Goldman et al. (2021) e Atella, Belotti et al. (2021) relativi al contesto italiano evidenziano come le disuguaglianze educative siano persistenti nel tempo e rilevanti anche dopo aver controllato per reddito, occupazione e altre variabili socioeconomiche. Questi studi confermano che l'istruzione ha un impatto indipendente e diretto sulla probabilità di sviluppare patologie croniche e sull'efficacia con cui gli individui gestiscono il proprio stato di salute.

Un altro elemento rilevante, evidenziato nel grafico (c), è la relativa stabilità del divario tra i due gruppi di istruzione nel lungo periodo. Nonostante lievi fluttuazioni, la distanza tra le curve rimane ampia e costante, a conferma del fatto che le disuguaglianze educative in salute sono strutturali e difficilmente riducibili in assenza di interventi mirati. Questo è coerente con quanto emerso in studi recenti che sottolineano come, nei contesti ad alto reddito, le innovazioni mediche e l'accesso differenziale all'informazione tendano addirittura ad ampliare le disuguaglianze sanitarie anziché ridurle (Kinge et al., 2019).

In sintesi, la tendenza osservata nella Figura 1, grafico (c), riflette fedelmente quanto documentato dalla letteratura nazionale e internazionale: l'istruzione è un fattore chiave nella distribuzione delle condizioni di salute e rappresenta un asse di disuguaglianza particolarmente stabile e resistente. Per affrontare tali disuguaglianze, risulta fondamentale promuovere politiche intersettoriali che uniscano investimenti nell'istruzione a strategie di prevenzione sanitaria e di alfabetizzazione alla salute, con particolare attenzione ai gruppi più vulnerabili.

Un ulteriore aspetto da considerare nello studio delle diseguaglianze è l'interazione tra alcune delle varie dimensioni fin qui viste. Ad esempio, le disu-

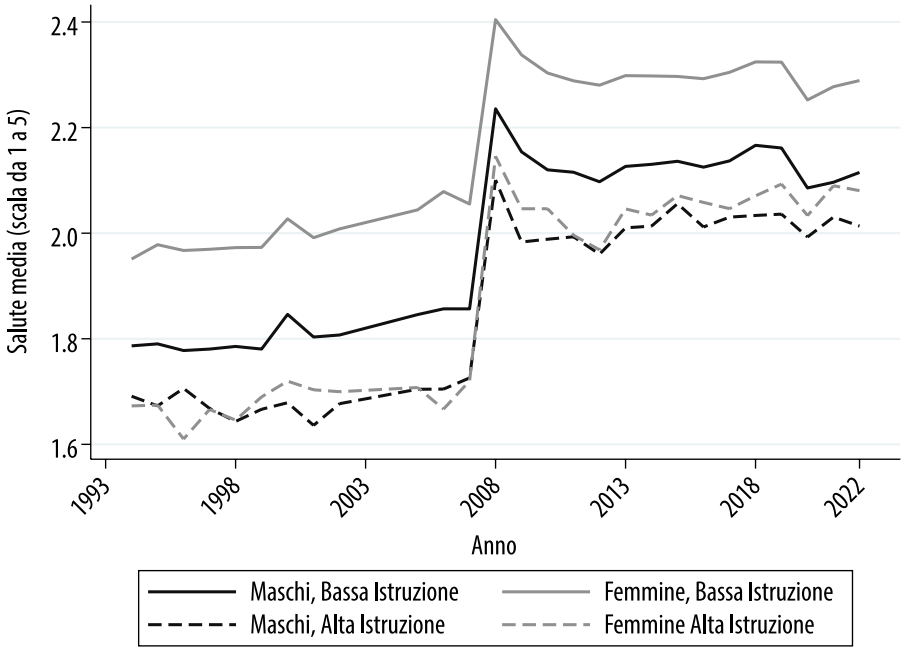
guaglianze di genere in salute sono ulteriormente amplificate da fattori intersezionali come lo status socioeconomico, l'etnia e la condizione migratoria. Le donne con basso livello di istruzione o reddito, ad esempio, sperimentano un doppio svantaggio, con un carico di malattia maggiore e minore accesso a cure efficaci (WHO, 2019a). Questa prospettiva intersezionale è sempre più riconosciuta come essenziale per comprendere la complessità delle disuguaglianze sanitarie e per progettare interventi mirati ed equi. Nella Figura 2 si vede chiaramente che nel periodo considerato l'andamento dello stato di salute, disaggregato per sesso e livello di istruzione, evidenzia la persistenza di diseguaglianze rilevanti legate al capitale educativo, con un'interazione marcata con il genere. Questa evidenza fa anche capire che il divario tra uomini e donne osservato nella Figura 1(b) è in gran parte spiegabile attraverso differenze nei livelli di istruzione.

Si nota infatti che, nel corso dell'intero periodo osservato, le donne con basso livello di istruzione (linea arancione) riportano sistematicamente i peggiori livelli di salute percepita, seguite dagli uomini con basso titolo di studio (linea rossa). Al contrario, le donne con istruzione elevata (linea verde) si collocano su livelli di salute simili – talvolta migliori – rispetto agli uomini della stessa condizione educativa (linea blu). Questo dato suggerisce che il cosiddetto "gender health gap" non può essere attribuito esclusivamente al genere biologico o a fattori comportamentali associati, ma riflette in misura sostanziale disuguaglianze strutturali legate al livello di istruzione.

Il divario osservato tra gruppi a bassa e alta istruzione rimane sostanzialmente stabile durante l'intero periodo, suggerendo che i meccanismi di disuguaglianza sanitaria legati all'istruzione sono profondamente radicati e difficilmente modificabili in assenza di interventi sistemici. Inoltre, l'improvviso aumento dei valori medi intorno al 2007 riconducibile a un cambio nella

definizione della variabile di salute auto-percepita, non altera la struttura relativa delle disuguaglianze tra i gruppi.

Figura 2 **Stato di salute auto-valutato della popolazione per genere e livello di istruzione**



Fonte: nostre elaborazioni sull'indagine AVQ-Istat, diversi anni. L'indicatore dello stato di salute auto-percepito varia da 1 a 5, dove il valore 1 indica la condizione di salute migliore e il valore 5 quella peggiore.

Note: Il salto nella serie che si riscontra tra il 2007 e il 2008 è attribuibile a un cambio nella definizione e nella modalità di rilevazione dell'indicatore di salute soggettiva (riconducibile a una modifica del questionario) da parte dell'Istat a partire dall'anno 2008, che ha generato un incremento artificiale nell'indicatore senza apparentemente modificare le relazioni tra i vari gruppi esaminati (con qualche eccezione).

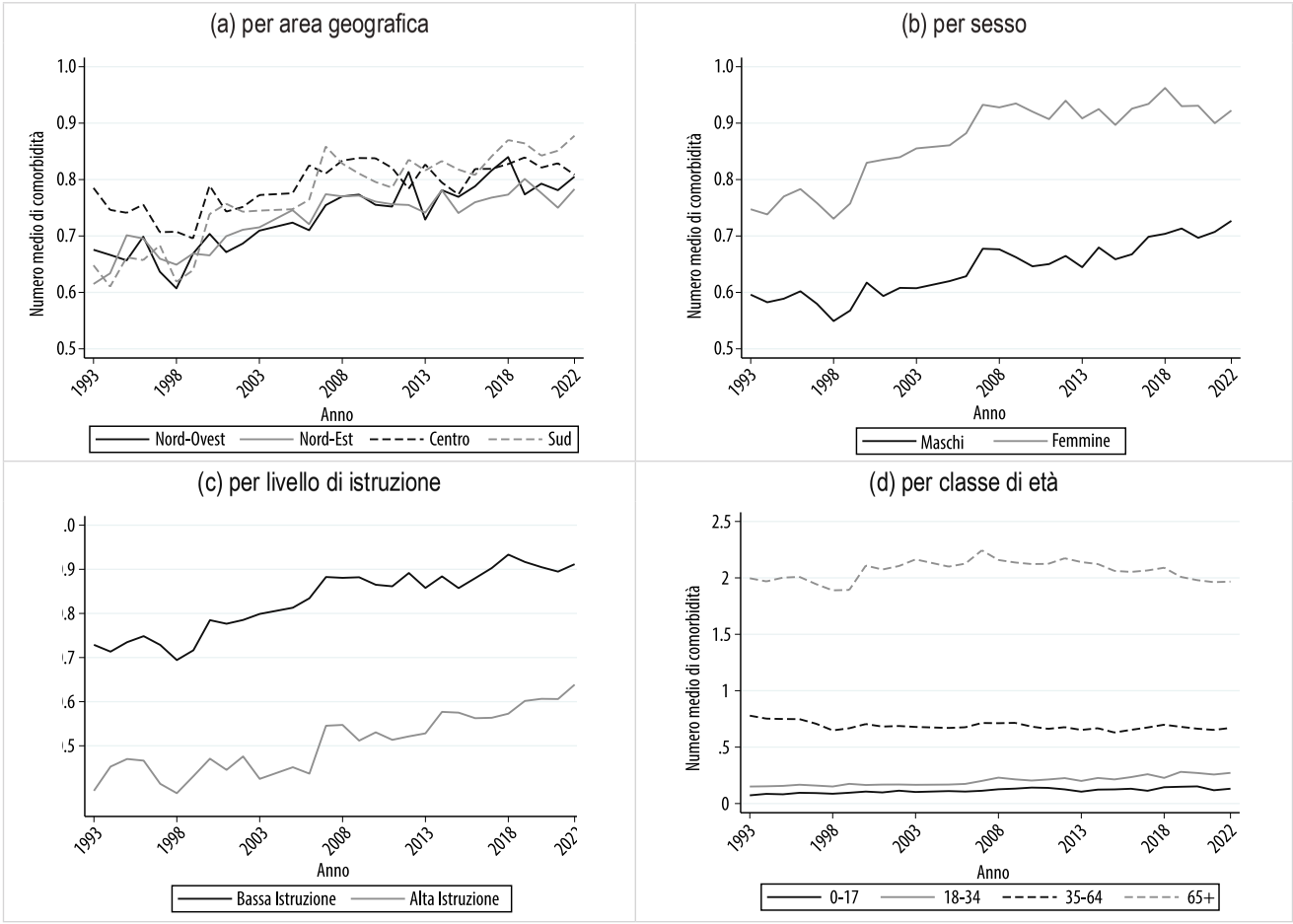
Infine, il grafico conferma che, a parità di livello di istruzione, le differenze di salute tra uomini e donne si riducono drasticamente, se non si annullano del tutto. Questo risultato richiama l'attenzione sull'importanza di adottare un approccio intersezionale nello studio delle disuguaglianze di salute, in

grado di cogliere la combinazione tra genere e status socioeducativo come dimensione cruciale per la comprensione e il contrasto delle disuguaglianze sanitarie. Le politiche sanitarie devono quindi adottare un approccio di genere consapevole, che riconosca la specificità dei percorsi di salute maschili e femminili e affronti in modo strutturale le fonti di diseguaglianza.

Tale interpretazione è coerente con quanto documentato nella letteratura. Studi internazionali e comparativi (Read & Gorman, 2010; Ross & Mirowsky, 2006) hanno ampiamente evidenziato come l'istruzione sia uno dei determinanti più potenti della salute individuale, agendo sia attraverso il miglioramento delle capacità cognitive e comportamentali nella gestione del rischio, sia tramite l'accesso a risorse economiche, occupazionali e sociali favorevoli. In particolare, l'istruzione sembrerebbe attenuare significativamente le differenze di salute tra uomini e donne, agendo come fattore di riequilibrio nel rapporto tra sesso e salute (Ross et al., 2012).

Risultati analoghi si osservano in termini di numero medio di comorbidità nella popolazione italiana. Come si può vedere dalla Figura 3, si registra un aumento generalizzato del numero medio di comorbidità in quasi tutti i gruppi analizzati. Tuttavia, come per l'indicatore dello stato di salute, questa crescita non riflette un peggioramento effettivo dello stato di salute, ma è in larga parte spiegata dall'invecchiamento della popolazione, essendo le comorbidità più comuni tra gli anziani, l'aumento della loro quota incide sulle tendenze complessive. Questa interpretazione è confermata dal fatto che il grafico (d) nella stessa figura mostra un andamento sostanzialmente stabile delle prevalenze di comorbidità per classe di età. Questi risultati si inseriscono coerentemente all'interno di un vasto corpo di letteratura che documenta come le disuguaglianze socioeconomiche e demografiche si riflettano nella distribuzione e nell'intensità della multimorbidità.

Figura 3 **Andamento della comorbilità nella popolazione per livello socio-economico**



Fonte: Nostre elaborazioni su dati AQV-Istat: vari anni.

Note: Il salto nella serie che si riscontra tra il 2007 e il 2008 è attribuibile a un cambio nella definizione e nella modalità di rilevazione dell'indicatore di salute soggettiva (riconducibile a una modifica del questionario) da parte dell'Istat a partire dall'anno 2008, che ha generato un incremento artificiale nell'indicatore senza apparentemente modificare le relazioni tra i vari gruppi esaminati (con qualche eccezione).

Le differenze territoriali osservate, con valori medi più elevati nel Centro e soprattutto nel Sud rispetto al Nord, riflettono disparità storiche in termini di condizioni socioeconomiche, accesso ai servizi sanitari, e diffusione di stili di vita salutari. Tali evidenze sono coerenti con quanto riportato da Álvarez-Gálvez et al. (2021) e Souza et al. (2021), i quali sottolineano la rilevanza dei determinanti strutturali e delle disuguaglianze regionali nei modelli di multimorbidità osservati in Europa. Questi studi evidenziano che la distribuzione della comorbidità non è neutra rispetto al contesto socio-territoriale, ma fortemente condizionata da fattori sistemici legati all'organizzazione dei servizi sanitari e alla deprivazione socioeconomica.

Differenze marcate emergono anche in relazione al genere: le donne presentano sistematicamente un numero medio più elevato di comorbidità rispetto agli uomini, lungo tutto il periodo osservato. Questa tendenza è ampiamente documentata in letteratura, dove la maggiore prevalenza di patologie croniche tra le donne, spesso legate a condizioni non letali ma invalidanti (es. dolore cronico, disturbi d'ansia e depressione), è considerata un fattore strutturale nella disparità di genere in salute (Souza et al., 2021).

Il livello di istruzione risulta essere un potente discriminante nella distribuzione delle comorbidità. I soggetti con basso titolo di studio presentano un numero medio di patologie significativamente superiore rispetto a quelli con istruzione elevata, con un divario che tende ad ampliarsi nel tempo. Questa evidenza è in linea con quanto riscontrato in numerosi studi che hanno mostrato una correlazione inversa tra livello di istruzione e carico di malattia cronica (Schiøtz et al., 2017; Heintz & Röding, 2024). In particolare, nel contesto italiano, l'analisi condotta da Pastore et al. (2023) su dati della sorveglianza PASSI dell'Istituto Superiore di Sanità conferma la maggiore prevalenza di comorbidità tra gli individui con minori risorse educative, sugge-

rendo un ruolo cruciale dell'istruzione nella prevenzione e nella gestione della salute a lungo termine.

Infine, la relazione tra età e comorbidità emerge in modo netto: la fascia 65 anni e oltre presenta livelli di multi-morbidità nettamente superiori rispetto a tutte le altre classi di età. L'associazione tra invecchiamento e accumulo di condizioni croniche è ben documentata in letteratura, e rappresenta uno dei principali fattori alla base dell'aumento della domanda di cure complesse nei sistemi sanitari avanzati (Souza et al., 2021). L'andamento stabile della multi-morbidità nelle fasce più giovani rafforza l'ipotesi che l'età agisca come principale vettore dell'accumulo patologico, ma sottolinea al contempo l'importanza di interventi precoci e mirati nei gruppi svantaggiati per prevenire l'escalation della cronicità in età adulta.

4.2 Diseguaglianze nell'accesso ai Servizi Sanitari

Il tema delle disuguaglianze nell'accesso ai servizi sanitari, con particolare riferimento alle ospedalizzazioni, rappresenta una questione centrale per la salute pubblica, in quanto riflette le disparità sociali nell'esposizione ai rischi, nella gestione delle malattie croniche e nell'effettivo utilizzo delle risorse sanitarie. Le ospedalizzazioni costituiscono un indicatore chiave sia della necessità clinica sia dell'adeguatezza dell'assistenza territoriale: un ricorso eccessivo o inappropriato all'ospedale può indicare un fallimento nella prevenzione e nella gestione precoce della malattia, fenomeno che colpisce in modo sproporzionato le fasce più vulnerabili della popolazione.

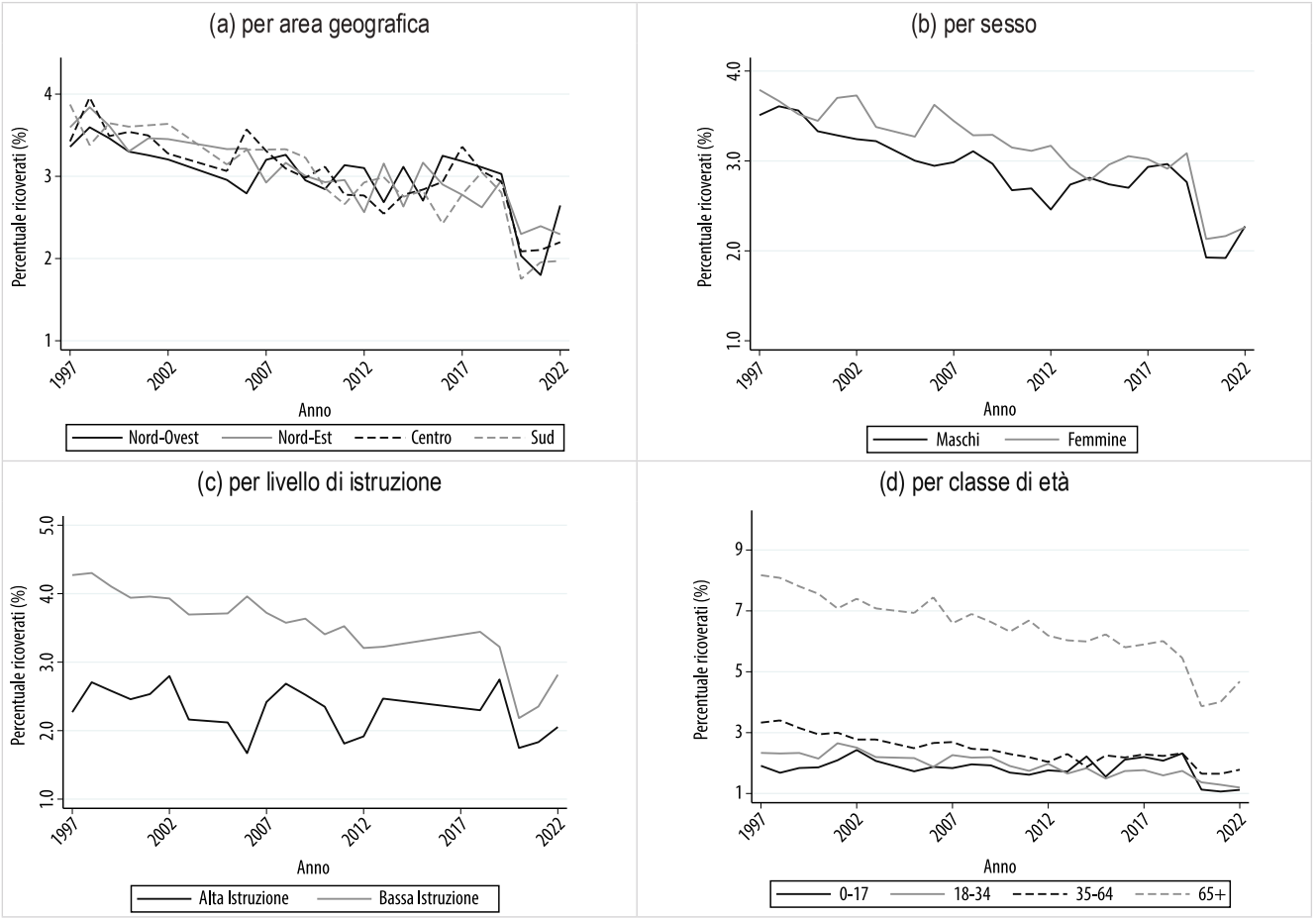
Numerose evidenze mostrano che il ricorso all'ospedalizzazione è influenzato non solo da fattori clinici, ma anche da variabili socioeconomiche, come

il livello di istruzione, il reddito e il contesto territoriale. Le persone con basso livello di istruzione o che vivono in aree svantaggiate presentano tassi di ospedalizzazione più elevati, spesso per condizioni evitabili, suggerendo barriere nell'accesso alla prevenzione, alla medicina generale e ai servizi specialistici (Petrelli et al., 2020; Stirbu et al., 2011). Questo fenomeno non riguarda solo paesi con sistemi sanitari selettivi, ma è presente anche nei contesti con sistemi universalistici, come quello italiano, dove diseguaglianze persistenti indicano limiti nell'effettiva equità del sistema. L'importanza del tema risiede anche nelle sue implicazioni sistemiche: diseguaglianze nell'accesso ai servizi determinano un utilizzo inefficiente delle risorse sanitarie, un aggravamento del carico di malattia e una maggiore pressione sul sistema ospedaliero. Tali squilibri si riflettono anche in una minore efficacia complessiva delle politiche di salute pubblica e in una maggiore vulnerabilità delle popolazioni a eventi sanitari imprevisti, come è stato evidente durante la pandemia da COVID-19.

L'analisi dei dati riportati nella Figura 4, relativi alla prevalenza di ospedalizzazioni in Italia tra il 1997 e il 2022, fornisce due importanti evidenze. La prima è una significativa riduzione del ricorso ai servizi ospedalieri in tutto il paese, con un calo particolarmente marcato durante la pandemia da COVID19 e una ripresa solo parziale nel 2022.[4] La seconda è che, nonostante la riduzione nelle ospedalizzazioni, permangono disuguaglianze strutturali nell'accesso ai servizi ospedalieri in Italia. I tassi di ospedalizzazione risultano più elevati tra i gruppi socioeconomici più svantaggiati, riflettendo una maggiore incidenza di patologie croniche e una minore disponibilità di alternative assistenziali territoriali. Questo pattern, che coinvolge variabili come area geografica, livello di istruzione, genere ed età, si è mantenuto stabile nel tempo, nonostante una riduzione complessiva delle ospedalizzazioni.

4 Relativamente ai dati di ricorso all'ospedalizzazione i dati contenuti nelle indagini AVQ sono disponibili solo dal 1997.

Figura 4 **Andamento della prevalenza dei ricoveri ospedalieri nella popolazione per livello socio-economico, 1997-2023**



Fonte: Nostre elaborazioni su dati AQV-Istat: vari anni.

Negli ultimi trent'anni, numerosi studi hanno documentato una riduzione generalizzata dei tassi di ospedalizzazione nei paesi ad alto reddito, attribuibile a una combinazione di fattori clinici, organizzativi e politici (Kasteridis et al., 2015; OECD, 2021). Anche nel contesto italiano, tale tendenza è evidente ed è stata interpretata come il risultato dell'adozione di politiche di contenimento della spesa sanitaria, del rafforzamento della medicina territoriale, dell'implementazione di tecnologie diagnostiche meno invasive e della diffusione di prestazioni ambulatoriali e in day hospital. Inoltre, il miglioramento delle terapie farmacologiche e l'introduzione di programmi di prevenzione e follow-up hanno consentito una gestione più efficace delle patologie croniche, come l'insufficienza cardiaca o il diabete non controllato (Loeb et al., 2016), contribuendo a evitare ricoveri ospedalieri.

Questo è stato particolarmente evidente nei paesi con sistemi sanitari pubblici e accessibili, dove il rafforzamento dei servizi di base ha permesso di intercettare i bisogni sanitari prima che questi si traducessero in necessità ospedaliere. Relativamente all'Italia, Petrelli et al. (2020) confermano una diminuzione strutturale dei tassi di ospedalizzazione nel lungo periodo, seppure con persistenti disuguaglianze legate a fattori sociali e territoriali. La riduzione è risultata più pronunciata nelle regioni con maggiore sviluppo dei servizi territoriali, suggerendo che il decentramento delle cure ha avuto un ruolo determinante nel modificare i pattern di utilizzo dell'ospedale. Tuttavia, come osservato anche da van den Akker et al. (1998), la riduzione complessiva dei ricoveri non ha prodotto automaticamente un appiattimento delle disuguaglianze. Al contrario, in alcuni contesti le fasce più svantaggiate della popolazione hanno continuato a ricorrere all'ospedale in misura relativamente maggiore, proprio per la minore accessibilità ad alternative assistenziali meno invasive e più prossimali.

L'analisi disaggregata per area geografica mostra che, mentre il Nord-Ovest, il Nord-Est e il Centro registrano trend decrescenti con livelli comparabili, il Sud presenta tassi sistematicamente più alti e una ripresa post-pandemica più lenta. Questi dati confermano quanto rilevato da Petrelli et al. (2020), secondo cui le regioni meridionali, pur presentando lo stesso fabbisogno sanitario, hanno un ricorso maggiore all'ospedale a causa della carenza di alternative assistenziali adeguate.

Dal punto di vista delle differenze di genere, i dati mostrano che le donne presentano tassi di ospedalizzazione lievemente superiori rispetto agli uomini. Questo risultato appare coerente con il cosiddetto "paradosso della sopravvivenza femminile", secondo il quale la maggiore longevità delle donne è associata a un carico più elevato di patologie croniche non letali e a un uso più frequente dei servizi sanitari (Alberts et al., 2014). Tuttavia, un'analisi più attenta della distribuzione dei ricoveri ospedalieri evidenzia un'ulteriore disparità. Il maggior ricorso all'ospedale da parte delle donne risulta infatti inferiore a quanto ci si aspetterebbe sulla base dei loro peggiori livelli di salute percepita, come documentato nelle analisi precedenti: a parità di condizioni di salute, gli uomini tendono a essere ricoverati più frequentemente. Questo dato apre a due ipotesi interpretative, entrambe meritevoli di approfondimento: da un lato, la possibilità che i ricoveri maschili siano talvolta inappropriati; dall'altro, il rischio che le donne incontrino maggiori barriere di accesso ai servizi ospedalieri. Purtroppo, le informazioni disponibili nell'indagine AVQ non consentono di distinguere con precisione tra queste due spiegazioni.

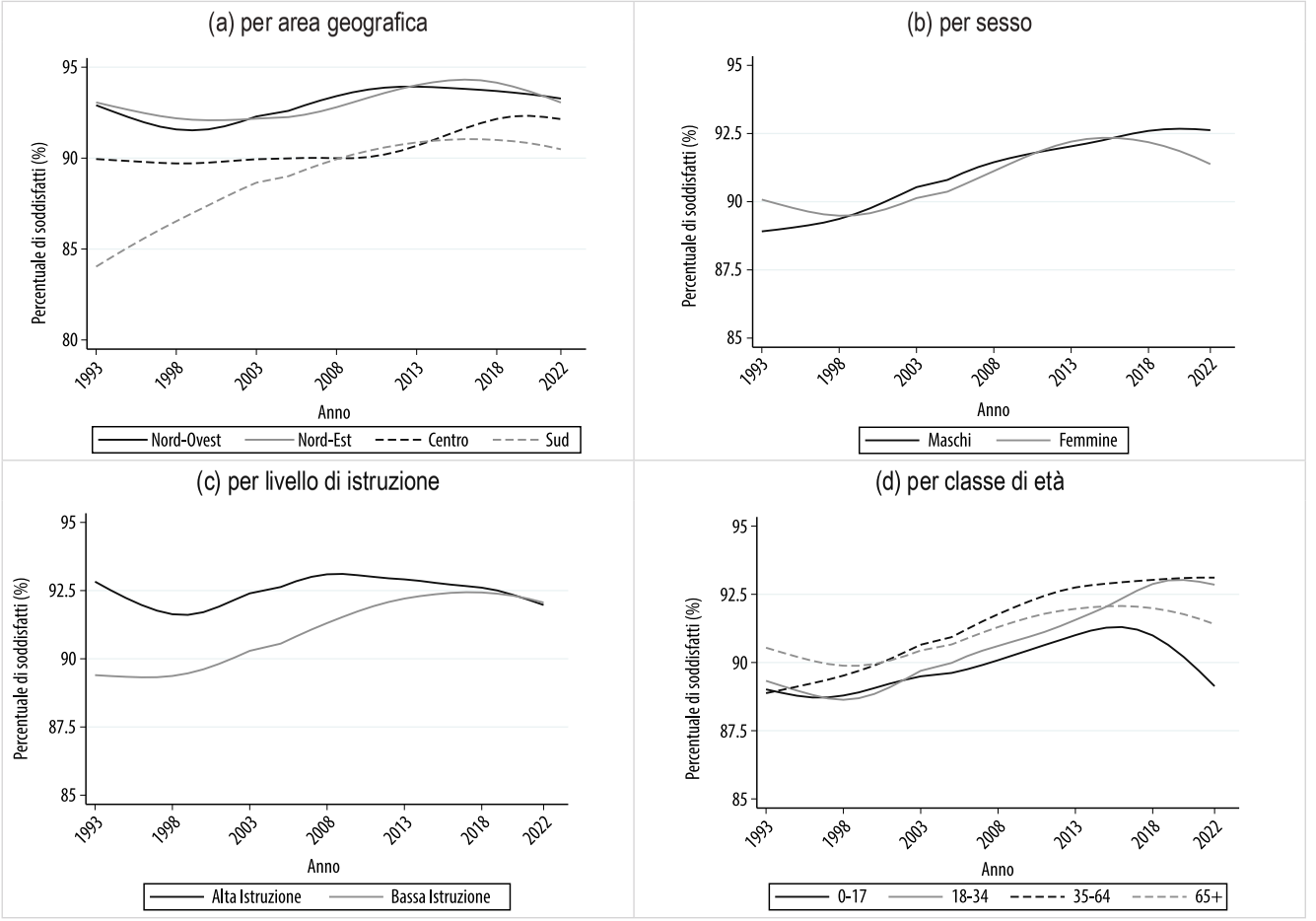
Il livello di istruzione si conferma, inoltre, come uno dei principali determinanti socioeconomici delle disuguaglianze nell'utilizzo dei servizi sanitari. Gli individui con un basso titolo di studio presentano tassi di ospedalizzazione significativamente più elevati (tra il 4% e il 5%) rispetto a quelli con livelli

educativi più alti (tra il 2% e il 3%). Sebbene il divario si sia lievemente ridotto nel tempo, esso ha conosciuto un'evidente compressione durante il biennio pandemico, per poi riemergere nuovamente – e con una tendenza ad accentuarsi – a partire dal 2021. Tali dinamiche sembrano riflettere una persistente iniquità sia nell'accesso sia nell'utilizzo appropriato dei servizi ospedalieri, in linea con quanto documentato da Petrelli et al. (2020) e da un ampio corpo di letteratura internazionale sulle disuguaglianze sanitarie.

Infine, l'età si configura come una dimensione cruciale nella distribuzione delle disuguaglianze nell'utilizzo dei servizi ospedalieri. In particolare, gli individui di età pari o superiore ai 65 anni mostrano i tassi di ospedalizzazione più elevati, coerentemente con l'accumulo di comorbidità associato al processo di invecchiamento e con il conseguente aumento della domanda di cure complesse e continuative (van den Akker et al., 1998; Souza et al., 2021). È tuttavia importante sottolineare che, nonostante i livelli più alti osservati nelle fasce più anziane della popolazione, i trend relativi ai tassi di ospedalizzazione risultano in calo per tutte le classi di età. Questo andamento suggerisce un progressivo cambiamento nella modalità di erogazione delle cure — potenzialmente riconducibile a una maggiore efficacia della prevenzione, al ricorso a forme alternative di assistenza territoriale o a criteri più selettivi per il ricovero ospedaliero — ma pone anche interrogativi sulla possibile sottoutilizzazione dei servizi da parte di alcune fasce della popolazione anziana, specie in un contesto di crescente pressione sul sistema sanitario.

Nel complesso, sebbene la riduzione dei ricoveri ospedalieri rappresenti un segnale di evoluzione del sistema sanitario, essa non ha comportato un abbattimento delle disuguaglianze nell'accesso. Le differenze osservate richiedono interventi strutturali volti a potenziare l'assistenza territoriale, migliorare la capacità di prevenzione e promuovere equità nell'accesso e nella fruizione dei servizi di cura.

Figura 5 **Andamento della soddisfazione per l'accesso ai servizi sanitari ospedalieri (assistenza medica) per livello socio-economico, 1993-2022.**



Fonte: Nostre elaborazioni su dati AQV-Istat: vari anni.

Note: I dati presentati nella Figura 6 sono stati ottenuti applicando il filtro di Hodrick-Prescott (HP) allo scopo di attenuare l'elevata variabilità annuale osservata nelle serie temporali. Tale variabilità è riconducibile al fatto che solo una quota molto ridotta del campione dell'indagine – ovvero gli individui che hanno effettivamente sperimentato un ricovero – risponde alla domanda relativa al grado di soddisfazione per i servizi ospedalieri. Considerando che la prevalenza di ospedalizzazione nella popolazione è mediamente intorno al 3%, il numero limitato di osservazioni introduce un elevato livello di rumore statistico nei dati grezzi, rendendo necessario l'utilizzo di tecniche di *smoothing* per una lettura più affidabile dei trend di lungo periodo. Il valore di *smooting* (λ) utilizzato per il filtro di HP è stato fissato a 400.

4.3 Soddisfazione nell'accesso ai servizi sanitari ospedalieri

La Figura 5 presenta i trend di soddisfazione per l'accesso ai servizi sanitari ospedalieri relativi all'assistenza medica in Italia, nel periodo compreso tra il 1993 e il 2022, sempre disaggregati per area geografica, sesso, livello di istruzione e fascia d'età. Complessivamente, si osserva un incremento nella soddisfazione in quasi tutti i gruppi, con alcune divergenze significative a seconda delle caratteristiche sociodemografiche.

Dal punto di vista territoriale, si riscontrano notevoli differenze nei livelli iniziali e nell'evoluzione dei trend. Le regioni del Nord-Est e del Nord-Ovest si attestano su livelli elevati di soddisfazione per l'intero periodo, con un aumento stabile fino a valori prossimi al 95%. Il Centro mostra un miglioramento più graduale, mantenendosi però su livelli leggermente inferiori rispetto al Nord. Il Sud, che nel 1993 partiva da una condizione sensibilmente più sfavorevole (circa 82%), evidenzia un aumento costante, pur rimanendo la macroarea con il livello di soddisfazione più basso nel 2022. Questo andamento conferma la persistenza di disuguaglianze territoriali nell'accesso e nella qualità percepita dell'assistenza medica ospedaliera, sebbene con segnali di convergenza nel lungo periodo.

Per quanto riguarda il genere, sia uomini che donne mostrano un miglioramento della soddisfazione fino a circa il 2013. Tuttavia, negli anni successivi si osserva una divergenza: mentre la soddisfazione tra gli uomini si mantiene stabile o in lieve crescita, quella tra le donne registra un calo. Questo dato suggerisce l'emergere di una differenziazione di genere nelle percezioni dei servizi sanitari, potenzialmente legata a dinamiche di accesso, qualità dell'assistenza o aspettative diverse tra i due gruppi.

Analizzando i dati per livello di istruzione, i soggetti con istruzione elevata

mostrano costantemente livelli superiori di soddisfazione fino al 2018, seguiti da un lieve calo. Al contrario, i soggetti con istruzione bassa, pur partendo da livelli inferiori, evidenziano un incremento graduale e continuo della soddisfazione, fino a raggiungere e allinearsi con il gruppo più istruito nel 2022. Questa dinamica può riflettere un miglioramento nell'equità percepita dei servizi o un livellamento delle aspettative tra diversi livelli di istruzione.

Infine, rispetto all'età, si osservano trend crescenti in tutte le fasce fino a circa il 2013, seguiti da una differenziazione. Le persone tra i 35 e i 64 anni risultano il gruppo più soddisfatto nel 2022, seguiti dagli over 65 e dai giovani adulti (18–34). Il gruppo 0–17, invece, mostra un livello di soddisfazione inferiore e un calo più marcato nell'ultima fase del periodo osservato. Tali risultati indicano una percezione più positiva dell'assistenza medica tra le fasce adulte e anziane, mentre i giovani e i minori sembrano beneficiare meno dei miglioramenti o percepire maggiori criticità.

Anche per l'assistenza infermieristica ospedaliera si rilevano disuguaglianze marcate nella soddisfazione dichiarata dagli utenti. I gruppi socioeconomici meno abbienti esprimono valutazioni mediamente peggiori, suggerendo una percezione di qualità dei servizi meno favorevole e una potenziale disparità nell'esperienza dell'assistenza.

Il grafico in Figura 6 mostra l'andamento della soddisfazione per l'accesso ai servizi sanitari ospedalieri (assistenza infermieristica) dal 1993 al 2022, disaggregato per area geografica, sesso, livello di istruzione e fascia d'età. Nel complesso, si osserva un trend crescente della soddisfazione in tutti i gruppi, sebbene con intensità e dinamiche differenti.

Dal punto di vista territoriale, tutte le aree geografiche registrano un miglioramento nel tempo, ma con livelli iniziali e traiettorie diseguali. Il Nord-Est e il Nord-Ovest presentano sistematicamente livelli di soddisfazione più elevati,

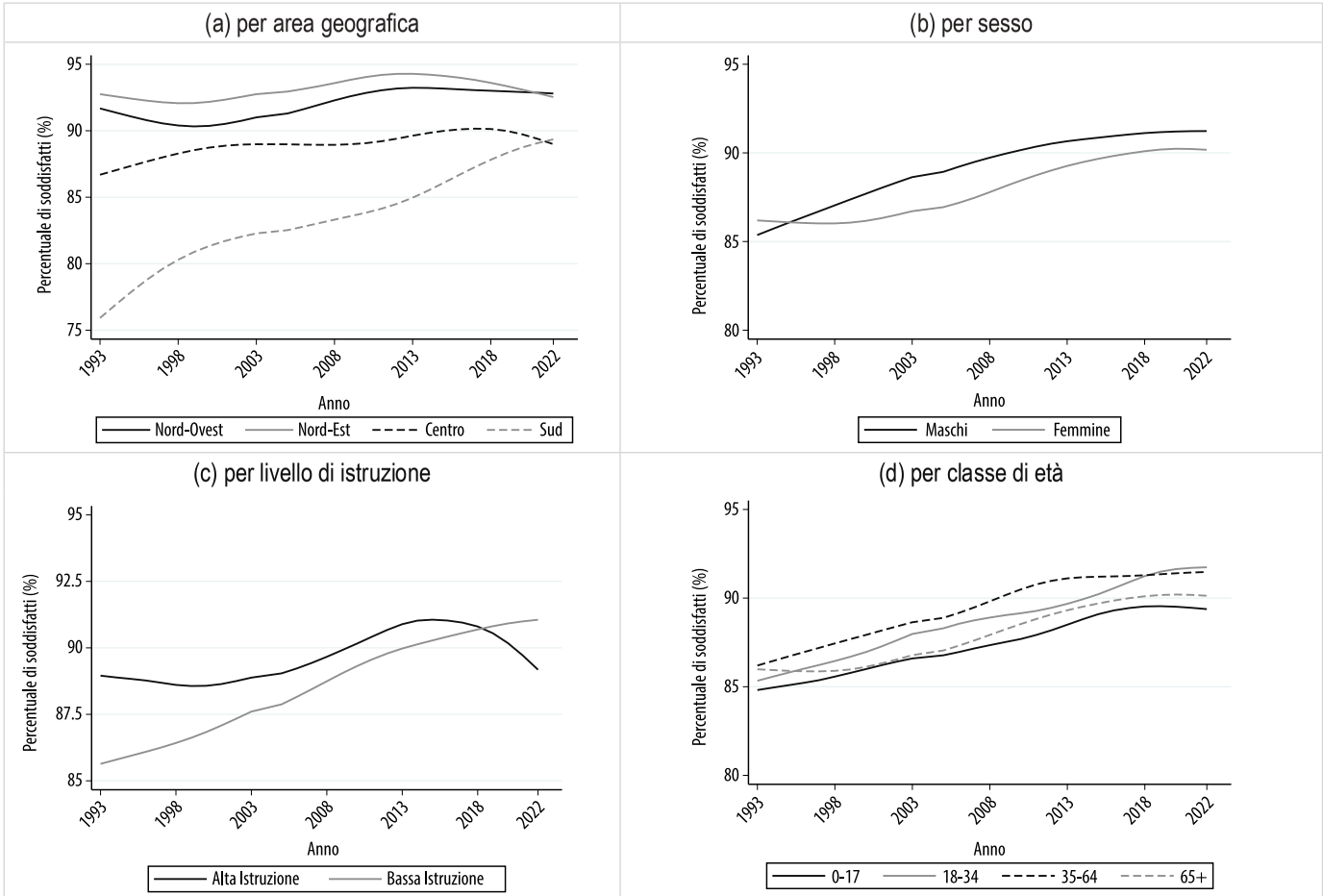
superiori al 90% negli anni più recenti. Il Centro mostra valori intermedi e relativamente stabili. Il Sud, pur partendo da un livello sensibilmente più basso nel 1993 (intorno al 77%), mostra un aumento costante della soddisfazione, riducendo progressivamente il divario rispetto alle altre aree, pur mantenendosi su valori inferiori nel 2022. Questo trend suggerisce un miglioramento percepito nell'accesso ai servizi nel Mezzogiorno, probabilmente legato a investimenti mirati o a una riduzione delle disuguaglianze infrastrutturali.

Per quanto riguarda il genere, si rileva un incremento della soddisfazione sia tra gli uomini sia tra le donne. Tuttavia, gli uomini mostrano sistematicamente livelli più alti di soddisfazione lungo tutto il periodo considerato. Sebbene il divario tra i sessi non sia ampio, la sua persistenza nel tempo indica la possibile presenza di differenze strutturali o percepite nell'esperienza dei servizi sanitari ospedalieri tra uomini e donne.

Analizzando il livello di istruzione, entrambi i gruppi mostrano un andamento crescente fino al 2018. In particolare, i soggetti con basso livello di istruzione partono da una posizione di minore soddisfazione ma mostrano un miglioramento costante, fino a superare il gruppo ad alta istruzione nel 2022. Quest'ultimo, al contrario, evidenzia un'inversione di tendenza con un leggero calo negli anni più recenti. Questo fenomeno può riflettere un miglioramento percepito nei servizi da parte dei gruppi più svantaggiati, o una maggiore aspettativa critica tra i più istruiti.

Infine, rispetto all'età, tutti i gruppi mostrano un aumento progressivo della soddisfazione. Le fasce 18–34 e 35–64 anni tendono a essere le più soddisfatte, mentre il gruppo degli over 65, pur mostrando un miglioramento costante, mantiene livelli leggermente inferiori. I minori (0–17 anni) risultano costantemente il gruppo meno soddisfatto, il che potrebbe riflettere una minore attenzione sistemica ai bisogni pediatrici nel contesto ospedaliero o una percezione indiretta mediata dai genitori.

Figura 6 **Andamento della soddisfazione per l'accesso ai servizi sanitari ospedalieri (assistenza infermieristica) per livello socio-economico, 1993-2022**



Fonte: Nostre elaborazioni su dati AQV-Istat: vari anni.

Note: I dati presentati nella Figura 6 sono stati ottenuti applicando il filtro di Hodrick-Prescott (HP) allo scopo di attenuare l'elevata variabilità annuale osservata nelle serie temporali. Tale variabilità è riconducibile al fatto che solo una quota molto ridotta del campione dell'indagine – ovvero gli individui che hanno effettivamente sperimentato un ricovero – risponde alla domanda relativa al grado di soddisfazione per i servizi ospedalieri. Considerando che la prevalenza di ospedalizzazione nella popolazione è mediamente intorno al 3%, il numero limitato di osservazioni introduce un elevato livello di rumore statistico nei dati grezzi, rendendo necessario l'utilizzo di tecniche di *smoothing* per una lettura più affidabile dei trend di lungo periodo. Il valore di *smooting* (λ) utilizzato per il filtro di HP è stato fissato a 400.

Nel complesso, i risultati empirici presentati si inseriscono in un quadro teorico e analitico consolidato, che riconosce la multi-morbidità come fenomeno socio-strutturale e stratificato. Le disuguaglianze osservate non sono casuali, ma riflettono processi cumulativi e sistemici legati a determinanti sociali e istituzionali. Le implicazioni per le politiche sanitarie sono rilevanti, richiedendo strategie di prevenzione e gestione integrate, orientate all'equità e alla differenziazione dei bisogni lungo l'arco della vita.

4.4 Diseguaglianze nelle spese sanitarie

Le disuguaglianze nelle spese sanitarie sostenute privatamente, come approfondito nel seguito, rappresentano indicatori utilizzati per valutare l'equità dei sistemi sanitari sul lato del finanziamento. La letteratura sull'equità lato finanziamento riporta due distinti possibili approcci alla questione: il primo assume una ottica ex-ante, stimando l'effetto equitativo a partire dalla progressività o regressività dei prelievi operati per finanziare la spesa sanitaria; il secondo ragiona, invece, ex-post, misurando l'impatto sui bilanci delle famiglie della spesa sanitaria privata OOP (Kakwani et Al. (1997), O'Donnell et Al. (2008), Xu et Al. (2003)).

In questa sezione faremo riferimento al secondo approccio, misurando la fairness del sistema sanitario (termine coniato per distinguersi dalle misure convenzionali di Equity), nel contesto definito del burden space (Murray et Al., 1999). Secondo tale approccio, la spesa privata è una componente del finanziamento (del complesso) delle prestazioni sanitarie e la rilevazione di disuguaglianza nell'impatto di essa sui bilanci delle famiglie è indice di fallimento della funzione principale dei sistemi di tutela sanitaria ovvero la protezione

dai rischi economici derivanti dalla malattia.

Nello specifico, dopo una descrizione della dinamica della spesa sanitaria privata OOP, nel seguito, sono stati elaborati e analizzati i seguenti indicatori:

- incidenza delle spese sanitarie OOP sul PIL nonché sul totale della spesa per consumi;
- quota di famiglie che sostengono spese sanitarie;
- differenziale nel numero di famiglie chiamate a sostenere spese sanitarie, nonché nell'incidenza della spesa sanitaria sulla spesa per consumi, per livello di istruzione familiare e quintile di consumo.

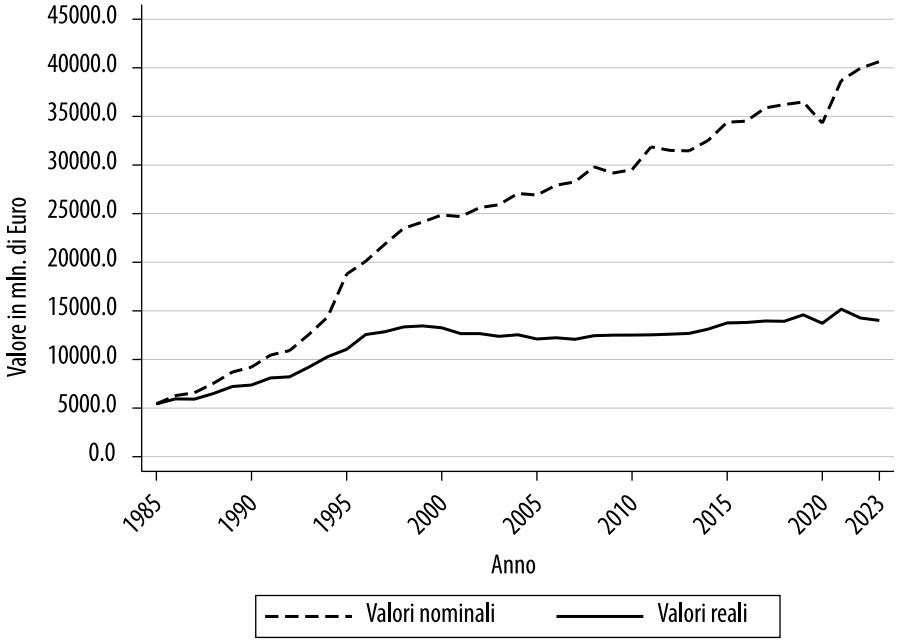
La fonte dei dati utilizzati è rappresentata dai microdati delle indagini condotte dall'Istat sui consumi e sulla spesa delle famiglie. Occorre far presente che le indagini Istat citate hanno subito modifiche rilevanti, e negli anni 2014-2021 lo stesso Istituto ha proceduto ad una ricostruzione delle serie per allinearla alla nuova classificazione di riferimento internazionale della spesa delle famiglie (COICOP). L'analisi degli indicatori è stata effettuata per il periodo 1985-2023, e per alcuni sottoperiodi che hanno permesso di valutare gli impatti derivanti da modifiche normative e/o fenomeni macroeconomici congiunturali.

4.4.1 La dinamica della spesa OOP

Nel complesso, nel periodo considerato la spesa OOP è cresciuta in termini nominali del 647,9%. Come si può vedere nella Figura 7, la crescita è stata più marcata nel periodo 1992-2001 (tasso medio annuo +9,5%), in

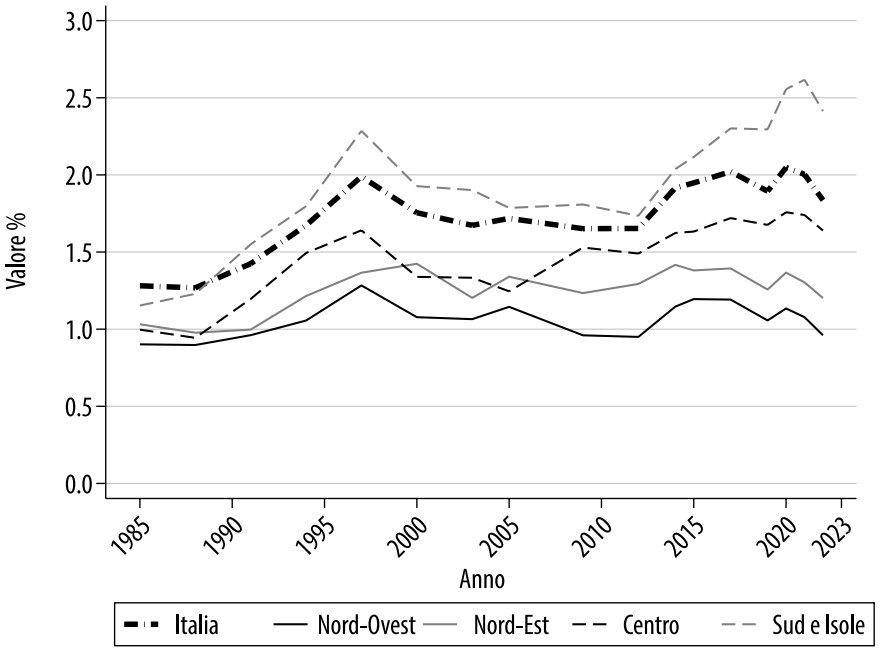
corrispondenza dell'esplicarsi degli effetti della prima riforma del SSN (d.lgss. n. 502/1992 e n. 517/1993), per poi portarsi, dopo l'approvazione della modifica del titolo V della Costituzione (L. Cost. n.3, 2001), su tassi di crescita medi annui pari al 2,5%. Analoghe osservazioni si possono fare analizzando la serie a prezzi costanti 1985: nel periodo 1992-1999 il tasso medio annuo reale di crescita della spesa si attesta al 7,8%; segue una fase di contrazione in termini reali pari allo -0,4% medio annuo fino al 2010; successivamente la crescita in termini reali diviene nuovamente positiva con un tasso medio annuo dell'1,3%.

Figura 7 **Andamento della spesa sanitaria privata out-of-pocket**



Fonte: OECD Health statistics

Figura 8 **Incidenza della spesa sanitaria OOP sul PIL per area geografica.**



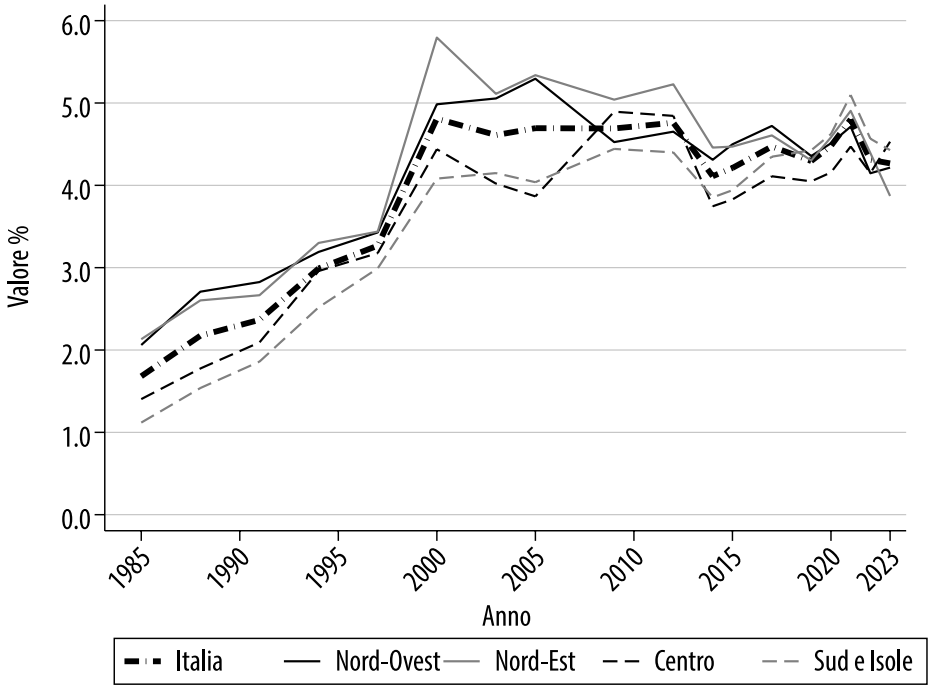
Fonte: Nostre elaborazioni su dati Indagini sui consumi - Istat

L'incidenza della spesa sanitaria OOP sul PIL nel 1985 risultava pari all'1,3%, e nel periodo considerato è cresciuta fino all'1,8% nel 2023; l'incremento è frutto di andamenti disomogenei nel tempo: la massima crescita pari a +0,33 punti percentuali (p.p.) si registra ancora nel periodo 1991-1999, a cavallo della riforma del SSN. Segue un periodo di riduzione fino al 2012 (-0,1 p.p.), e una ripresa fino all'inizio della pandemia (+0,24 p.p. 2012-2020); negli anni successivi l'incidenza si riduce nuovamente di -0,21 p.p.

Nella Figura 8 è invece possibile osservare come l'incidenza della spesa sanitaria sul PIL risulti costantemente più alta nel meridione e più bassa nel Nord-Ovest, corrispondentemente al gradiente positivo Sud-Nord che si registra nel PIL pro-capite; in termini dinamici, per effetto dei diversi andamenti

del PIL nelle ripartizioni geografiche, si può osservare come la differenza di incidenza (considerando le ripartizioni geografiche con valori minimi e massimi) si è allargata da 0,25 p.p. nel 1985, sino a 1,0 p.p. nel 1997; il differenziale si è poi ridotto fino al 2012 (0,78 p.p.), per poi riallargarsi nuovamente sino ad arrivare a 1,45 p.p. nel 2023.

Figura 9 **Incidenza della spesa sanitaria OOP sui consumi familiari per area geografica.**



Fonte: Nostre elaborazioni su dati Indagini sui consumi - Istat

Parallelamente, nella Figura 9 si può osservare come l'incidenza della spesa sanitaria OOP sul totale della spesa per consumi delle famiglie, sia passata dall'1,7% nel 1985 al 4,3% nel 2023. Tale incidenza, nel periodo considerato, ha subito una costante crescita, tranne che nel periodo 2012-2017, dove si

registra una riduzione di -0,3 p.p., dovuta principalmente all'espansione dei consumi totali. Si può anche apprezzare come, all'inizio del periodo considerato, l'incidenza della spesa per la salute su quella totale era maggiore, come lecito attendersi, nelle ripartizioni del Nord (Nord-Est 2,1%) e minima nel Sud e Isole (1,1%). Nel periodo considerato la crescita dell'incidenza è stata però maggiore nel meridione (+3,3 p.p., seguita dal Centro con +3,1 p.p., vs +1,7 p.p. del Nord-Est), tanto che dal 2020 risulta maggiore nel Meridione rispetto alle altre ripartizioni. L'osservazione di una maggiore incidenza della spesa sanitaria privata sui consumi delle famiglie nelle ripartizioni con PIL e consumi pro-capite totali inferiori segnala una crescita delle iniquità legate ai consumi di assistenza sanitaria. Una maggiore incidenza della spesa sanitaria sui nuclei familiari mediamente meno abbienti rappresenta un fallimento del SSN nella funzione di protezione dagli oneri economici legati alla malattia.

La tendenza osservata trova un sostegno indiretto nei dati riportati nella Figura 10, da cui emerge chiaramente che, nel periodo considerato, la quota di famiglie italiane che dichiarano di sostenere spese sanitarie OOP è aumentata significativamente a livello nazionale. In particolare, tale quota è passata dal 51,7% nel 1985 al 70,9% nel 2023, con un incremento complessivo pari a +19,2 p.p. L'andamento temporale di questo fenomeno risulta articolato: si registra una crescita marcata fino al 1997 (+17,9 p.p.), seguita da una fase di riduzione fino al 2012 (-8,8 p.p.), un nuovo picco nel 2014 (+28,7 p.p.) e, infine, un'ulteriore fase discendente nei periodi successivi (-18,6 p.p.).

Tuttavia, è opportuno esprimere una nota di cautela nell'interpretazione della fase più recente di riduzione delle spese sanitarie OOP. Tale dinamica, infatti, non necessariamente riflette un miglioramento dell'accessibilità economica ai servizi sanitari, ma potrebbe piuttosto essere attribuita alla crescita del fenomeno della rinuncia alle cure per motivi economici. Diversi studi,

infatti, hanno evidenziato che le difficoltà finanziarie, l'incertezza economica e le barriere di accesso al sistema sanitario possono indurre una quota crescente di popolazione a posticipare o rinunciare del tutto a prestazioni sanitarie necessarie, specialmente nel caso di visite specialistiche, cure odontoiatriche e diagnostica non urgente (Istat, 2023; C.R.E.A. Sanità, 2024).

Secondo l'"Indagine sul Benessere Equo e Sostenibile" (Istat, 2023), la percentuale di persone che dichiarano di aver rinunciato a cure sanitarie per ragioni economiche è aumentata in modo rilevante in alcuni segmenti della popolazione, in particolare tra le famiglie a basso reddito, le persone disoccupate o con bassa istruzione, e i residenti nelle regioni meridionali. Analogamente, il Rapporto Sanità del C.R.E.A. sottolinea che il fenomeno della rinuncia si è esteso anche ai ceti medi, spesso costretti a rivedere le proprie priorità di spesa sanitaria a causa dell'erosione del potere d'acquisto e dell'incremento dei ticket e delle spese a carico diretto (C.R.E.A. Sanità, 2024).

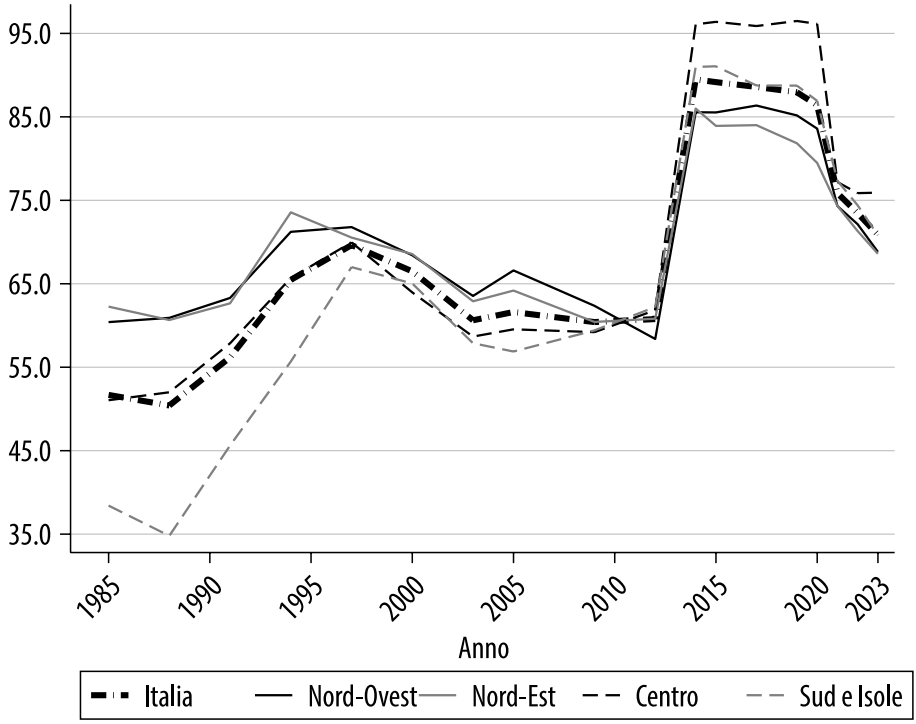
In letteratura, il fenomeno della rinuncia alle cure, soprattutto quelle legate al reddito, è ampiamente riconosciuto come un indicatore esplicito di ineguaglianza nell'accesso alla sanità e di vulnerabilità sociale (Devaux & Looper, 2012; Mackenbach et al., 2017; Propper, 2024). Esso rappresenta non solo una distorsione del principio di universalismo del sistema sanitario, ma anche un potenziale fattore aggravante per la salute pubblica, in quanto ritardi nelle cure possono tradursi in complicanze cliniche, trattamenti più invasivi e, nel lungo periodo, maggiori costi sanitari a lungo termine per il sistema nel suo complesso (van Doorslaer et al., 2006; Arcaya et al., 2015). Pertanto, la riduzione osservata nella quota di famiglie che sostengono spese sanitarie OOP negli anni più recenti non può essere interpretata univocamente come un segnale di miglioramento dell'accesso ai servizi sanitari, ma va analizzata nel contesto più ampio delle dinamiche sociali ed economiche che influenza-

no il comportamento sanitario delle famiglie. A conferma di questa lettura, come si può vedere nella Figura 10, la flessione della spesa sanitaria familiare tra il 2014 e il 2023 risulta particolarmente marcata nel Mezzogiorno, dove si registra una diminuzione di -20,2 p.p. nella quota di famiglie che dichiarano spese sanitarie, accompagnata da un aumento del fenomeno delle rinunce alle cure (+1,8 p.p.) e da un incremento del disagio economico legato alla spesa sanitaria privata (+0,2 p.p.). In questa area del Paese, infatti, la percentuale di famiglie che ha dichiarato di aver dovuto rinunciare a prestazioni sanitarie necessarie ha raggiunto il 10,3%, evidenziando una condizione di vulnerabilità più accentuata rispetto ad altre aree geografiche.

Tali dati rafforzano l'interpretazione secondo cui la contrazione della spesa OOP non riflette una diminuzione dei bisogni di salute o un ampliamento effettivo della copertura pubblica, ma piuttosto una riduzione della capacità delle famiglie di sostenere costi sanitari, con conseguenze potenzialmente negative sul piano dell'equità e degli esiti di salute. In questo senso, il Mezzogiorno rappresenta un caso emblematico delle disuguaglianze territoriali nell'accesso alle cure, già ampiamente documentate nella letteratura nazionale e internazionale, e mette in evidenza la necessità di leggere congiuntamente i dati sulla spesa sanitaria e quelli relativi al disagio economico e alla rinuncia, per evitare interpretazioni distorte della realtà empirica.

Per quanto riguarda la quota di famiglie che sostengono spese sanitarie private, si osserva un'inversione della distribuzione territoriale già evidenziata in precedenza. Nel 1985 la quota più elevata si registrava nel Nord-Est (62,3%), mentre il valore più contenuto era rilevato nel Mezzogiorno e nelle Isole (Figura 10). Nel 2023, invece, la quota più alta si riscontra nelle regioni del Centro (75,9%), seguite da quelle meridionali, le quali mostrano anche l'aumento più consistente rispetto al 1985 (+32,4 p.p.).

Figura 10 **Quota famiglie con spese sanitarie OOP per area geografica.**



Fonte: Nostre elaborazioni su dati Indagini sui consumi – Istat

L'analisi disaggregata della spesa sanitaria OOP per tipologia di famiglia mette in evidenza importanti dinamiche redistributive nel periodo 1985–2023. Come riportato nella Figura 11, la frequenza di spesa sanitaria privata è, come atteso, maggiore tra le famiglie appartenenti ai quintili superiori di consumo, con un picco dell'82,8% nel quinto quintile rispetto al 53,0% nel primo. Questo dato riflette la maggiore capacità di spesa delle famiglie più abbienti, coerentemente con quanto rilevato in letteratura sui consumi sanitari discrezionali (van Doorslaer et al., 2006; Devaux & Looper, 2012). Tuttavia,

un dato particolarmente rilevante è che il maggior incremento nella quota di famiglie "spendenti" si è verificato proprio nei gruppi economicamente più fragili, ossia nel primo e nel secondo quintile, suggerendo un crescente sforzo finanziario delle famiglie a più basso reddito per accedere a cure sanitarie.

Figura 11 **Incidenza della spesa sanitaria OOP sui consumi familiari, per quintile di consumo**

Fonte: Nostre elaborazioni su dati Indagini sui consumi – Istat

Tale tendenza trova conferma anche nell'analisi per livello di istruzione, utilizzando come riferimento il titolo di studio più elevato tra i componenti della famiglia. Nel 2023, il 77,0% delle famiglie con almeno un laureato ha effettuato spese sanitarie, rispetto al 65,8% di quelle con istruzione intermedia (diploma o licenza media). Tuttavia, è tra le famiglie con il più basso

livello di istruzione (al massimo licenza elementare) che si registra l'incremento più marcato nel periodo osservato: +19,5 p.p. Questa evidenza conferma che le famiglie meno istruite — spesso associate a livelli inferiori di reddito e minore alfabetizzazione sanitaria — sono state progressivamente più esposte ai costi diretti delle cure (OECD, 2019; Propper, 2024).

Analoghe considerazioni emergono analizzando l'incidenza della spesa sanitaria OOP sul totale della spesa per consumi: anche in questo caso, l'incidenza assoluta è maggiore nei quintili più alti (4,6% nel quinto quintile contro 3,0% nel primo). Tuttavia, l'incremento relativo più significativo nel periodo 1985–2023 si è verificato tra le famiglie del primo quintile, per cui l'incidenza è triplicata (da 1,0% a 3,0%), rispetto a un raddoppio nei quintili più alti. Il differenziale tra i quintili estremi è aumentato da 1,2 a 1,6 punti percentuali, segnalando un deterioramento dell'equità verticale.

Questa dinamica si ripropone nella dimensione educativa: nel 2023, le famiglie senza alcun titolo di studio registrano un'incidenza dell'8,4% della spesa OOP sui consumi totali, in netto aumento rispetto al 3,1% del 1985 (+5,3 p.p.), mentre nelle famiglie con istruzione elevata l'incidenza si attesta al 3,9% (+2,4 p.p.). L'incremento più pronunciato tra i gruppi socialmente svantaggiati indica un peggioramento del profilo redistributivo del sistema sanitario, che, invece di compensare le disuguaglianze, sembra averle amplificate.

Complessivamente, questi risultati appaiono in contrasto con i principi di equità che hanno ispirato la istituzione del SSN nel 1978. La progressiva crescita del numero di famiglie esposte a spese sanitarie OOP e l'aumento della loro incidenza sul budget familiare mettono in discussione la capacità del SSN di garantire una protezione economica efficace contro il rischio malattia (Mackenbach et al., 2018; WHO, 2019b). In particolare, il deterioramento

relativo delle condizioni delle famiglie meno abbienti e con minore capitale culturale evidenzia il fallimento dei meccanismi redistributivi impliciti nel disegno universalistico del sistema.

Naturalmente, occorre esprimere una precauzione interpretativa riguardo alla natura dei consumi sanitari: una quota non trascurabile potrebbe riflettere scelte non strettamente necessarie, ovvero consumi sanitari "inappropriati". Tuttavia, l'ipotesi di un'elevata inappropriatezza fra le fasce meno abbienti solleverebbe ulteriori interrogativi sul ruolo del SSN nella promozione dell'educazione sanitaria e dell'empowerment dei cittadini, aspetti fondamentali per un'effettiva equità di accesso (Brown, Hancock & Daniels, 2021).

Un'analisi per sottoperiodi conferma che la fase di maggiore incremento regressivo nella spesa sanitaria OOP si è verificata negli anni '90, in coincidenza con la prima riforma strutturale del SSN (d.lgs. 502/1992), orientata a criteri di efficienza e managerialismo. Tale riforma sembra aver realizzato gli obiettivi di contenimento della spesa pubblica in parte trasferendo costi sul settore privato, con effetti redistributivi negativi. Successivamente, l'introduzione del federalismo sanitario (2001) ha contribuito, almeno nel breve periodo, a mitigare tali dinamiche, ma l'avvento dei piani di rientro e dei commissariamenti regionali ha inaugurato una nuova fase di pressione sulle famiglie, soprattutto nelle regioni meridionali.

Infine, gli anni più recenti, segnati dalla pandemia da COVID-19, sembrano caratterizzati da una riduzione apparente del peso delle spese sanitarie OOP sui bilanci familiari. Tuttavia, come discusso in precedenza, tale tendenza è in larga parte attribuibile a una crescente rinuncia alle cure per motivi economici, fenomeno che segnala non un miglioramento della copertura pubblica, ma l'incapacità delle famiglie di compensare l'arretramento del welfare sanitario attraverso risorse proprie (Istat, 2023; C.R.E.A. Sanità, 2024).

5. Discussione e Implicazioni per le Politiche Sanitarie

Le disuguaglianze di salute rappresentano ancora oggi una sfida persistente nei paesi europei, riflettendo le differenze in termini di status socioeconomico, livello di istruzione, occupazione, localizzazione geografica e accesso alle cure. In risposta a queste disparità, i sistemi sanitari europei hanno adottato una varietà di strategie, modellate da strutture istituzionali differenti, priorità politiche eterogenee e diversi livelli di investimento pubblico. Sebbene l'Unione Europea (UE) abbia assunto un ruolo di coordinamento, le risposte nazionali sono state molto eterogenee in termini di ampiezza e di efficacia.

I paesi nordici come Svezia, Norvegia e Finlandia hanno da tempo posto l'universalismo e l'equità al centro dei propri sistemi sanitari. Questi paesi hanno implementato politiche "a monte" sui determinanti sociali della salute, come l'istruzione, l'abitazione e l'occupazione, accanto a servizi sanitari accessibili e finanziati attraverso la tassazione generale (van Doorslaer et al., 2004). Questo modello integrato di welfare ha contribuito a mantenere contenute le disuguaglianze di salute, pur con alcune criticità persistenti, in particolare tra le popolazioni immigrate (Van der Wel et al., 2018).

Al contrario, i paesi dell'Europa meridionale — in particolare Grecia, Italia e Spagna — hanno affrontato sfide più marcate a seguito della crisi economica del 2008 e delle misure di austerità che ne sono derivate. Tali tagli hanno colpito in modo sproporzionato le fasce più vulnerabili della popolazione, riducendo l'accesso ai servizi di prevenzione e aumentando il numero di bisogni sanitari insoddisfatti (Reeves et al., 2015; Doetsch et al., 2023). In Italia, ad esempio, si è registrato un ampliamento delle disuguaglianze regionali, con i residenti del Mezzogiorno che sperimentano peggiori esiti di salute e minore accesso ai servizi rispetto a quelli del Nord (Petrelli et al., 2018; De

Falco, 2019).

Germania e Francia adottano un sistema misto di assicurazione sanitaria obbligatoria e meccanismi redistributivi di finanziamento. Sebbene la copertura sanitaria sia estesa, persistono disuguaglianze, in particolare nell'utilizzo dei servizi e negli esiti di salute tra i gruppi a basso reddito (van Doorslaer & Koolman, 2004). In Francia, politiche mirate come la Couverture Maladie Universelle Complémentaire (CMU-C) hanno esteso l'assicurazione sanitaria complementare gratuita ai residenti a basso reddito, migliorando l'accesso, ma senza eliminare completamente le disuguaglianze (Devillanova & Frattini, 2016).

Il Servizio Sanitario Nazionale del Regno Unito (NHS) rappresenta un esempio peculiare di sanità universale finanziata tramite la fiscalità generale. Tuttavia, nonostante questa struttura, permangono disuguaglianze sostanziali, spesso radicate in condizioni sociali ed economiche più ampie. Strategie recenti come la Marmot Review e i documenti politici successivi hanno promosso interventi localizzati e investimenti mirati nelle aree più svantaggiate (Mackenbach et al., 2008).

Alcuni paesi hanno inoltre adottato quadri di monitoraggio delle disuguaglianze di salute: ad esempio, i Paesi Bassi utilizzano valutazioni dell'impatto equitativo delle politiche, mentre Spagna e Portogallo hanno potenziato la raccolta di dati per identificare meglio i gruppi a rischio (Sánchez Recio et al., 2022). La Commissione Europea ha sostenuto iniziative transnazionali come la Joint Action Health Equity Europe (JAHEE), finalizzate alla condivisione delle conoscenze e al rafforzamento delle capacità istituzionali.

Nonostante tali sforzi, l'efficacia delle strategie per ridurre le disuguaglianze sanitarie varia sensibilmente tra i paesi. Fattori strutturali, volontà politica e capacità amministrativa giocano tutti un ruolo cruciale. I paesi che integrano

la salute nei più ampi obiettivi di politica sociale tendono a ottenere risultati migliori, mentre quelli che si concentrano esclusivamente sull'accesso alle cure, senza affrontare i determinanti a monte, mostrano progressi più limitati (Bygbjerg, 2012; Doetsch et al., 2023). Per ottenere riduzioni durature delle disuguaglianze, è necessario orientarsi verso approcci multisettoriali, investimenti a lungo termine e meccanismi di valutazione robusti.

5.1 Strategie per la riduzione delle disuguaglianze sanitarie: esperienze da casi internazionali

La persistenza delle disuguaglianze di salute ha spinto ricercatori e decisori pubblici a cercare evidenze storiche di interventi efficaci. Bambra (2022) propone un'analisi comparata di cinque casi internazionali in cui si sono registrate riduzioni significative dei divari sanitari. Tali casi mostrano che riforme strutturali a livello macro, definite dall'autrice come "livellatori", sono state determinanti nel promuovere l'equità sanitaria.

Uno degli esempi più precoci e duraturi è offerto dai paesi nordici tra gli anni '50 e '70. In paesi come Svezia e Norvegia, l'espansione dei regimi di welfare socialdemocratico, comprendente sanità universale, redistribuzione del reddito e servizi pubblici accessibili, ha comportato una riduzione misurabile delle disuguaglianze sanitarie (Navarro & Shi, 2001, citato in Bambra, 2022). Questo caso evidenzia il ruolo centrale delle istituzioni del welfare nel promuovere l'equità attraverso i determinanti sociali della salute.

La riunificazione tedesca negli anni '90 costituisce un esempio distinto di riduzione delle disuguaglianze attraverso investimenti statali mirati. A seguito del crollo della Germania Est, le politiche di riunificazione hanno mirato a

armonizzare le condizioni di vita e le infrastrutture sanitarie tra Est e Ovest. Le evidenze riportate da Bambra mostrano che, nonostante i divari iniziali fossero ampi, la speranza di vita nell'Est è aumentata rapidamente, suggerendo l'efficacia di investimenti pubblici consistenti nei servizi sanitari e sociali (Grigoriev & Pechholdova, 2017).

Un esempio più recente è rappresentato dalla Strategia inglese per le disuguaglianze di salute (1997–2010), che ha costituito un tentativo politico esplicito di ridurre i divari sanitari in un contesto ad alto reddito. Questa strategia multisettoriale ha agito su prima infanzia, occupazione, istruzione e rigenerazione urbana, producendo una riduzione relativa del gap di salute, in particolare nei territori più svantaggiati (Barr et al., 2017).

Al di fuori dell'Europa, si segnalano due casi emblematici: Stati Uniti e Brasile. Negli USA, il movimento per i diritti civili e la "Guerra alla Povertà" degli anni '60 hanno rappresentato un momento chiave. Provvedimenti legislativi come il Civil Rights Act e la creazione di Medicare e Medicaid hanno migliorato l'accesso alle cure e alla protezione sociale, soprattutto per le comunità afroamericane. Studi citati da Bambra (es. Krieger et al., 2008) hanno rilevato una temporanea riduzione dei divari di mortalità tra bianchi e neri, suggerendo che le politiche antidiscriminatorie associate a riforme sanitarie possono generare benefici tangibili in termini di equità.

In Brasile, la democratizzazione degli anni '80 ha segnato un altro momento di svolta. La Costituzione del 1988 ha riconosciuto la salute come diritto universale e ha portato alla creazione del Sistema Unico di Salute (SUS), ampliando significativamente l'accesso ai servizi per le popolazioni precedentemente escluse. Come riportato da Bambra (2022), autori come Victora et al. (2011) hanno documentato miglioramenti nella mortalità infantile e in altri indicatori sanitari dopo l'adozione delle riforme.

Questi esempi storici suggeriscono tre meccanismi ricorrenti alla base delle riduzioni efficaci delle disuguaglianze di salute: espansione delle politiche di welfare, miglioramento dell'accesso equo alla sanità e inclusione politica dei gruppi emarginati. Bambra conclude che sono necessarie politiche strutturali di lungo periodo per ottenere risultati duraturi in termini di equità, avvertendo che interventi di breve periodo o troppo settoriali sono spesso insufficienti. Il progresso sostanziale verso l'equità sanitaria richiede dunque strategie integrate, che uniscano politiche sociali, redistribuzione economica e governance partecipativa.

6. Conclusione

L'analisi presentata in questo studio, basata sull'elaborazione delle indagini Istat "Aspetti della Vita Quotidiana" e "Bilanci delle Famiglie", ha messo in luce una persistente articolazione delle disuguaglianze sanitarie in Italia lungo le dimensioni socioeconomiche, territoriali ed educative. Nonostante l'istituzione del Servizio Sanitario Nazionale nel 1978 fosse orientata alla promozione dell'universalismo e dell'equità, i risultati empirici mostrano che il SSN italiano non è riuscito, nel corso dei decenni, a ridurre in modo significativo le disuguaglianze sanitarie misurate. Le disparità in termini di stato di salute auto-percepito, prevalenza di comorbidità, utilizzo dei servizi e soddisfazione per l'assistenza sanitaria restano significative e relativamente stabili nel tempo.

Un dato particolarmente rilevante è che le disuguaglianze più marcate e persistenti si osservano per livello di istruzione, utilizzato come proxy del reddito. Le famiglie con un basso titolo di studio presentano sistematicamente peggiori condizioni di salute percepita, minore accesso ai servizi sanitari e

maggiore esposizione alla spesa sanitaria privata, con pochi segnali di miglioramento nel tempo. Tali disuguaglianze si sono mantenute sostanzialmente immutate nel corso di oltre tre decenni, suggerendo che il SSN non ha agito in modo incisivo sui fattori strutturali che riproducono la vulnerabilità sociale in ambito sanitario.

Un caso emblematico riguarda l'interazione tra sesso e istruzione: se considerate separatamente, le differenze di genere nella salute percepita risultano significative; tuttavia, quando si tiene conto del livello di istruzione, tali differenze tendono a scomparire. Questo risultato suggerisce che la stratificazione educativa esercita un effetto più profondo e sistemico sulla salute della popolazione rispetto al solo fattore di genere, confermando l'importanza dei determinanti sociali come chiave interpretativa delle disuguaglianze sanitarie.

È importante, tuttavia, evidenziare che gli effetti strutturali di eventi recenti quali la pandemia da COVID-19 e la prolungata stagnazione economica potrebbero non essersi ancora pienamente manifestati sul piano dello stato di salute della popolazione. Le ripercussioni di questi shock — in termini di peggioramento delle condizioni cliniche, incremento delle malattie croniche non diagnosticate o aumento delle disuguaglianze di accesso — potranno essere osservate con maggiore chiarezza solo a distanza di tempo, quando saranno disponibili dati longitudinali aggiornati e più granulari.

Se le disparità nelle condizioni di salute sono rimaste sostanzialmente immutate, va altresì registrato che sul versante della spesa sanitaria privata (out-of-pocket), le analisi condotte sui Bilanci delle Famiglie evidenziano una crescente regressività del sistema di finanziamento implicito, con un numero sempre maggiore di famiglie — in particolare quelle a basso reddito e bassa istruzione — che sostengono una quota significativa delle proprie cure attraverso spese dirette. L'aumento nel tempo della quota di famiglie che spendono

per la salute, nonché dell'incidenza della spesa sui loro bilanci appare un fenomeno disallineato rispetto alle aspettative derivati dalla natura universalistica del SSN. Dato ancor più rilevante alla luce della crescita dei casi di rinuncia ai consumi sanitari per ragioni economiche. Ancor più critico, però, appare il fenomeno per cui l'incremento citato è maggiore, sia in termini di quota che di impatto sui bilanci familiari, per i nuclei dei primi quintili (meno abbienti): questo aspetto solleva interrogativi rilevanti circa la capacità redistributiva effettiva del sistema e la tenuta del principio di equità.

Al contempo, è necessario riconoscere i limiti informativi delle fonti utilizzate. Sebbene le indagini AVQ e "Bilanci delle Famiglie" offrano il vantaggio di una copertura temporale estesa (oltre tre decenni) e di una rappresentatività nazionale, esse non consentono di cogliere tutte le sfaccettature del fenomeno delle disuguaglianze di salute. Informazioni più dettagliate su condizioni cliniche, pattern diagnostici, esiti terapeutici o uso specifico dei servizi sanitari sono più facilmente rilevabili attraverso dati amministrativi o clinici, oggi ancora scarsamente accessibili per fini di ricerca pubblica integrata. Ciò implica che una parte importante delle dinamiche in atto potrebbe restare invisibile nell'analisi quantitativa svolta su basi campionarie, per quanto solide.

Tuttavia, anche in assenza di un controfattuale, è ragionevole ipotizzare che il SSN nel corso del tempo sia stato efficace nel contrastare le disuguaglianze di salute in un contesto di rapido invecchiamento della popolazione e di modificazioni sociali. Il confronto con la letteratura internazionale supporta questa ipotesi: mentre in altri paesi la contrazione del welfare ha prodotto un aumento delle disuguaglianze, i dati italiani mostrano una relativa tenuta delle condizioni medie. Non di meno, almeno in parte, il risultato sembra essere favorito da un peggioramento equitativo, misurabile con un incremento degli oneri sanitari a carico delle famiglie, e in particolare di quelle meno abbienti.

Come ultimo aspetto da sottolineare, in un'ottica storica, le evidenze sopra

riportate sembrano indicare che il progressivo arretramento pubblico, in termini di garanzie e copertura effettiva, abbia avuto la sua fase più acuta negli anni '90, in corrispondenza della prima grande riforma del SSN (D.lgs. 502/1992). Tale riforma, concepita formalmente per aumentare l'efficienza e razionalizzare la spesa, ha prodotto effetti di compressione dell'offerta pubblica e di ampliamento del ruolo del settore privato, con conseguenze potenzialmente negative sul fronte dell'equità. Sebbene non fosse finalizzata a ridurre l'universalismo del sistema, l'implementazione di meccanismi aziendali, logiche di mercato e vincoli stringenti di bilancio ha indirettamente contribuito a indebolire la capacità redistributiva del SSN, specialmente a carico delle fasce più vulnerabili.

Al contrario, e in controtendenza rispetto a molte letture critiche, l'introduzione del federalismo sanitario a partire dal 2001 — pur tra molte ambiguità e disomogeneità applicative — potrebbe aver contribuito a mitigare in parte le disuguaglianze, almeno nella prima fase della sua attuazione. Il decentramento ha infatti permesso ad alcune Regioni di rafforzare servizi territoriali e interventi di prevenzione, con effetti positivi sull'accessibilità. Tuttavia, tale potenziale correttivo si è progressivamente indebolito con l'avvio dei Piani di Rientro e dei commissariamenti regionali, che, pur perseguendo obiettivi di sostenibilità finanziaria, hanno comportato tagli significativi alla spesa sanitaria corrente in alcune aree del Paese, con un impatto più forte proprio nelle Regioni con maggiori fragilità sociali e peggiori indicatori sanitari.

Nel complesso, questi elementi evidenziano la necessità di valutare le politiche sanitarie non solo in base ai loro effetti sul bilancio, ma anche per il loro impatto redistributivo e sulla tenuta dell'equità territoriale e sociale. Una nuova stagione di riforme, se orientata a questi obiettivi, dovrebbe recuperare una visione integrata del sistema, in grado di bilanciare efficienza, universalismo e giustizia sociale.

In sintesi, l'evidenza empirica suggerisce che, a più di quarant'anni dalla

sua istituzione, il SSN italiano ha garantito il livello di universalismo e protezione di partenza, ma non ha prodotto gli effetti attesi in termini di riduzione delle disuguaglianze sanitarie. Il permanere — e in alcuni casi l'ampliarsi — dei divari, soprattutto nella componente economico-finanziaria, evidenzia la necessità di ripensare in modo strutturale le politiche di equità sanitaria, rafforzando la capacità del sistema di intervenire sulle determinanti sociali della salute, potenziando il monitoraggio integrato dei fenomeni e adottando un approccio più esplicitamente redistributivo nella progettazione delle politiche pubbliche.

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Appendice

A1. Una prospettiva comparata: l'Italia e gli altri Paesi dell'UE

A livello europeo, le analisi comparative tra paesi collocano l'Italia all'interno di schemi più ampi di disuguaglianze socioeconomiche in ambito sanitario. Studi che utilizzano dataset come la "Survey of Health, Ageing, and Retirement in Europe" (SHARE), lo "European Community Household Panel" (ECHP) e le "Statistiche dell'Unione Europea sul Reddito e le Condizioni di Vita" (EU-SILC) mettono in evidenza diseguaglianze sistematiche a favore dei più abbienti nell'accesso alle cure, in particolare per quanto riguarda l'assistenza specialistica (D'Uva et al., 2005; D'Uva et al., 2007; van Doorslaer et al., 2004; van Doorslaer & Koolman, 2004). Le performance dell'Italia su questi indicatori risultano in linea con quelle degli altri paesi dell'Europa meridionale, che tendono a presentare gradienti socioeconomici più marcati negli esiti di salute e un maggior livello di bisogni sanitari insoddisfatti rispetto ai paesi dell'Europa settentrionale e occidentale (Borboudaki et al., 2024; Zantomio & Tavares, 2017; Reeves et al., 2015).

Gli studi longitudinali indicano che le misure di austerità introdotte in seguito alla Grande Recessione hanno amplificato queste disuguaglianze, con riduzioni consistenti del finanziamento sanitario pubblico che hanno colpito in modo sproporzionato le fasce a basso reddito, gli anziani e gli abitanti del Mezzogiorno o di altre aree periferiche (Zantomio & Tavares, 2017; Rizzi et al., 2019; Doetsch et al., 2023; De Falco, 2019). Al contrario, i paesi dell'Europa settentrionale più ricchi hanno mostrato una maggiore resilienza agli shock fiscali, riuscendo a proteggere l'accesso equo alle cure grazie a sistemi di

welfare più solidi e finanziamenti sanitari più stabili (van Doorslaer & Koolman, 2004; Borboudaki et al., 2024).

Il ruolo delle crisi economiche come acceleratori delle disuguaglianze è ampiamente documentato. In Italia, la "Grande Recessione" ha avuto un impatto particolarmente grave, innescando tagli alla spesa sanitaria pubblica, un aumento delle spese out-of-pocket e una crescita dei bisogni sanitari insoddisfatti (Borboudaki et al., 2024; Zantomio & Tavares, 2017; De Falco, 2019). Ricerche basate su dati SHARE hanno evidenziato un aumento marcato delle disuguaglianze pro-ricchi nell'accesso all'assistenza specialistica e nei bisogni insoddisfatti, con un impatto particolarmente rilevante nelle regioni meridionali (Zantomio & Tavares, 2017; Rizzi et al., 2019). Allo stesso modo, le politiche di austerità hanno comportato una riduzione dei servizi di prevenzione, penalizzando ulteriormente i nuclei familiari più poveri e i soggetti affetti da patologie croniche (Borboudaki et al., 2024; Doetsch et al., 2023; De Falco, 2019).

La pandemia di COVID-19 ha ulteriormente accentuato le disuguaglianze socioeconomiche in ambito sanitario, sebbene con modalità differenti. Gli studi hanno quantificato un peggioramento delle disuguaglianze legate al reddito nei bisogni sanitari non soddisfatti in tutta Europa, inclusa l'Italia. Nelle fasi iniziali della pandemia, le popolazioni a basso reddito hanno affrontato maggiori barriere all'accesso alle cure a causa della sotto-capacità sistemica, soprattutto nel Sud del Paese. Tuttavia, sono emerse anche dinamiche inattese, come disuguaglianze "pro-poor" nelle cure posticipate, in parte dovute al fatto che le fasce più agiate hanno rinviato volontariamente trattamenti sanitari non urgenti (Borboudaki et al., 2024; González-Touya et al., 2021; De Falco, 2019).

Questa letteratura mette in evidenza anche gli indicatori e le metodologie

utilizzati per analizzare la dinamica delle disuguaglianze. Strumenti quantitativi come gli indici di concentrazione, gli indici di inequità orizzontale e le tecniche di scomposizione (es. scomposizione di Wagstaff) sono ampiamente impiegati per identificare i fattori alla base delle disuguaglianze sanitarie e monitorarne l'evoluzione nel tempo (Bago d'Uva et al., 2007; Petrelli et al., 2024a; Petrelli et al., 2024b; van Doorslaer & Koolman, 2004). Gli indici di concentrazione e inequità rivelano la persistenza di gradienti pro-ricchi nell'utilizzo dell'assistenza specialistica, mentre gli indici relativi e assoluti di disuguaglianza (RII/SII) quantificano i divari negli esiti di salute, come la mortalità evitabile (Stringhini et al., 2014; Petrelli et al., 2024a; Petrelli et al., 2024b). Tali approcci vengono spesso integrati con indicatori economici, come il coefficiente di Gini e le misure di spesa pubblica in sanità, per contestualizzare le disuguaglianze sanitarie nei più ampi quadri socio-politici ed economici (Van der Wel, 2018; Zantomio & Tavares, 2017; Doetsch et al., 2023; van Doorslaer & Koolman, 2004).

Nonostante la robustezza di queste analisi, persistono alcuni vuoti conoscitivi rilevanti. Pochi studi coprono l'intero periodo successivo al 1980, lasciando in parte inesplorata l'evoluzione di lungo periodo delle disuguaglianze sanitarie. La letteratura si concentra prevalentemente su episodi critici, come la recessione del 2008 o la pandemia di COVID-19, offrendo scarsa visibilità sulle trasformazioni strutturali nel corso di orizzonti temporali più estesi (Borboudaki et al., 2024; Bago d'Uva et al., 2005; Zantomio & Tavares, 2017). Inoltre, le comparazioni internazionali faticano spesso a cogliere la specificità del contesto italiano, in particolare la persistente frattura Nord-Sud, all'interno dei più ampi modelli europei di disuguaglianza (Kunst et al., 2005; Petrelli et al., 2024b; van Doorslaer et al., 2004).

Un'ulteriore lacuna riguarda la carenza di studi approfonditi su sottopopolazioni specifiche, come gli immigrati, i disoccupati o altri gruppi vulnerabili, il che limita la possibilità di generalizzare i risultati all'intero panorama sanitario italiano (Zantomio & Tavares, 2017; Rizzi et al., 2019; Petrelli et al., 2020).

Nel complesso, questa produzione scientifica documenta l'esistenza di persistenti e, in alcuni casi, crescenti disuguaglianze socioeconomiche nell'accesso ai servizi sanitari e negli esiti di salute in Italia e in Europa. Tali disparità sono influenzate da una combinazione di fattori strutturali, come il disegno dei sistemi sanitari e le politiche di austerità, e fattori contingenti legati alle crisi, che colpiscono in modo sproporzionato le popolazioni più svantaggiate. L'Italia rappresenta un caso particolarmente rilevante per lo studio di queste dinamiche, data la sua eterogeneità territoriale, il modello sanitario misto di tipo Beveridge, e la vulnerabilità a shock economici e politici. La sintesi di questi risultati consente di offrire una visione integrata dell'evoluzione delle disuguaglianze di salute negli ultimi quarant'anni, con un'attenzione particolare alle disparità legate allo status socioeconomico in Italia e al confronto con altri paesi europei.

Optimizing Population Health Through Strategic Use of Health Data

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Abstract

The article explores the transformative potential of health data in improving population health, highlighting its applications in prevention, personalized medicine, care quality, crisis management, and equity. It emphasizes how digital technologies and data integration can enhance clinical decision-making, reduce costs, and drive systemic efficiency. Despite these benefits, strict privacy regulations—particularly in Italy—often hinder data reuse for research, slowing innovation and limiting the impact of public health policies. The authors examine the legal complexities surrounding the GDPR and national legislation, calling for more harmonized and pragmatic frameworks. Case studies, such as the Finnish and Danish models, demonstrate how data access can coexist with robust privacy protection. The chapter also introduces synthetic data and secure data environments as promising solutions to circumvent bureaucratic constraints while preserving privacy. It concludes

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with a call for centralized coordination, infrastructure development (like the EHDS), and improved data linkage to overcome the persistent "data gap" that impedes the measurement of important health phenomena. Ultimately, the work argues that balancing ethical data use with accessibility is crucial for enabling evidence-based, equitable, and innovative healthcare across Europe.

Sintesi - L'ottimizzazione della salute della popolazione attraverso l'uso strategico dei dati sanitari

Questo articolo esplora il potenziale trasformativo dei dati sanitari nel migliorare la salute della popolazione, evidenziandone le applicazioni nella prevenzione, nella medicina personalizzata, nella qualità delle cure, nella gestione delle crisi, e nell'equità. L'articolo sottolinea come le tecnologie digitali e l'integrazione dei dati possano migliorare il processo decisionale clinico, ridurre i costi e favorire l'efficienza del sistema. Nonostante questi benefici, alcune normative sulla privacy molto restrittive - soprattutto in Italia - spesso ostacolano il riutilizzo dei dati per la ricerca, rallentando l'innovazione e limitando l'impatto delle politiche di sanità pubblica.

Gli autori analizzano la complessità legale del Regolamento generale sulla protezione dei dati (GDPR) e della normativa nazionale, auspicando quadri normativi più armonizzati e pragmatici. Casi di studio, come i modelli finlandese e danese, dimostrano che l'accesso ai dati può coesistere con una solida protezione della privacy. Il capitolo introduce anche l'utilizzo di dati sintetici e l'uso di dati in ambienti sicuri come soluzioni promettenti per superare i vincoli burocratici, mantenendo la tutela della privacy.

Si conclude con un appello a una maggiore coordinazione centrale, allo sviluppo di infrastrutture (come lo Spazio europeo dei dati sanitari, EHDS) e al miglioramento del collegamento tra i dati, per superare il persistente "data gap" che ostacola la misurazione di fenomeni sanitari rilevanti. In ultima analisi, il lavoro sostiene che bilanciare l'uso etico dei dati con l'accessibilità sia fondamentale per supportare un sistemo sanitario basato sull'evidenza empirica, equo e innovativo a livello europeo.

JEL Classification: I18; K29; K39.

Parole chiave: *Dati di salute; Riservatezza; Regolamento sullo spazio europeo dei dati sanitari (EHDS); Digitalizzazione; Ricerca; Italia.*

Keywords: Health data; Privacy; EHDS; Digitalization; Research; Italy.

"The utility of health information, research evidence and knowledge (collectively described as knowledge) is to better inform and thus empower individuals and the public to make the right decisions regarding their health and well-being; influence public health policy and decision making; advance the frontiers of knowledge to develop products and tools for the promotion, maintenance, protection and restoration of health."

The Commission on Health Research for Development

Introduction [1]

In the digital age, healthcare systems generate immense volumes of data—ranging from electronic health records (EHRs) and genetic information to public health databases and clinical research outputs. When effectively harnessed, this health data holds transformative potential to improve both individual patient care and systemic healthcare performance. It enables researchers to study trends, assess treatment effectiveness, monitor disease spread, and identify inequities in access and outcomes. The generation, integration, and intelligent use of health data—not the digital tools themselves—are the real drivers of transformation in healthcare. Data of various kinds—clinical, behavioral, genomic, environmental—underpins evidence-based decisions, better resource allocation, and more tailored interventions. Digital technologies

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like EHRs, telemedicine, and wearable devices serve primarily as engines to generate continuous, structured, and interoperable data, which can inform both clinical and policy decisions (Topol, 2019; WHO, 2023).

Properly used, this data supports early-warning systems, predictive analytics, and performance evaluation, which enhance surveillance and readiness during health crises (OECD, 2021). It also helps target disparities by identifying underserved populations and tracking outcome gaps (Mehrotra et al., 2020). The promise of personalized medicine depends on the integration of diverse data sources—genomic, behavioral, clinical—allowing for more precise diagnostics and treatments (Torous & Roberts, 2017). Data analytics further supports cost containment by eliminating redundant procedures and optimizing workflows. For example, interoperable EHRs and remote care platforms have improved efficiency by up to 15% through better access to relevant patient data (McKinsey & Company, 2021).

Three developments suggest this is the right moment to unlock the full value of health data:

- Improved capabilities to produce high-quality, usable data.
- Innovation pressures to deliver better services under tighter constraints.
- Lessons from the COVID-19 pandemic that demonstrated digitalization's real-world impact.

Still, major barriers persist in converting data into actionable knowledge—a gap often referred to as the "know-do gap." In today's digital era, this gap is less about insufficient information and more about the underuse of existing data. Rich sources such as administrative databases and real-world evidence remain underexploited due to privacy regulations, legal uncertainties, and fragmented governance (Vayena et al., 2018; Mittelstadt, 2019).

The paradox is clear: health systems are data-rich but insight-poor. Legal protections like the GDPR, while vital for individual privacy, can hinder beneficial data use if implemented without flexibility (Shabani et al., 2018). The challenge is to build governance systems that protect individual rights while enabling responsible data reuse for research and public health. Doing so requires long-term commitment to interoperability, ethical data sharing, and collaboration between data custodians, policymakers, and researchers. Health data must therefore be treated as the backbone of modern healthcare. While digital tools capture and manage information, true innovation stems from how well that data is governed and applied. Systems that are "data mature"—able to collect, link, analyze, and act on data—perform better in responsiveness, efficiency, and outcomes (Kelley et al., 2019; OECD, 2021).

Moreover, reusing health data for secondary purposes such as public health surveillance, research, and policy evaluation can produce significant returns. It accelerates discovery, informs interventions, and promotes accountability (Rothstein, 2015). But realizing this potential requires not only investment in data infrastructure but also ethical frameworks for sharing and protection (Knoppers & Joly, 2022).

Ultimately, closing the know-do gap and achieving learning health systems demands more than technology—it calls for strategic vision, ethical stewardship, and sustained cross-sector collaboration. Health data, when treated as a strategic asset, becomes not just a tool for treating illness but a foundation for building adaptive, equitable, and resilient health systems (Friedman et al., 2017).

1. Why the Use of Health Data Is Important in Today's Healthcare

As mentioned in the introduction section, the use of health data has become a cornerstone of modern healthcare systems, revolutionizing how medical decisions are made, how resources are allocated, and how public health challenges are addressed (Appari et al., 2010). In an era shaped by demographic shifts—most notably aging populations—and the rising incidence of chronic diseases, the capacity to collect, analyze, and apply health data is increasingly critical for the sustainability, quality, and efficiency of healthcare delivery. Technological advancements, particularly in artificial intelligence (AI) and big data analytics, have significantly expanded the capabilities of health data, offering transformative potential in personalized medicine, predictive modeling, and evidence-based intervention strategies (Rehman, Naz, & Razzak, 2020). The integration of electronic health records (EHRs), genomic data, and real-time monitoring devices not only strengthens individual clinical care but also fuels large-scale research initiatives targeting multifactorial diseases (Longitools Consortium, n.d.).

Along these lines, Bailey, Currie, and Schwandt (2024) highlight that using individual-level data not only deepen our understanding of health trajectories but also illuminate long-term economic outcomes such as labor market participation, income dynamics, and intergenerational mobility. Their work demonstrates that early-life health shocks and neighborhood-level exposures have measurable consequences on adult economic productivity and social welfare dependence. This evidence underscores the value of linking health and socioeconomic data longitudinally, but it also suggests the untapped potential of real-time data systems. If policymakers could access and analyze individual data streams as events unfold—such as school absences, hospital

admissions, or localized environmental stressors—they might anticipate and mitigate negative economic trajectories with targeted, time-sensitive interventions. In this sense, real-time data integration would not only support personalized medicine but also enable dynamic and more equitable health and economic policymaking.

Beyond individual patient outcomes, health data serves as a strategic asset in advancing public health, especially in disease prevention and emergency preparedness. The COVID-19 pandemic made clear the indispensable role of real-time data in tracking disease progression and informing dynamic policy decisions. The work by Chetty et al. (2020) illustrates how real-time, high-frequency individual data, drawn from private sector sources such as credit card processors and payroll firms, can be used to uncover the immediate economic consequences of public health crises. Their analysis of the COVID-19 pandemic revealed how consumer spending, employment, and small business revenue reacted sharply and unevenly to the spread of the virus and associated public health interventions—well before traditional statistics could capture these shifts. This approach highlights the transformative potential of real-time data not only for understanding economic outcomes but also for informing health policy decisions with economic foresight. If real-time data infrastructures were more tightly integrated with public health systems, they could support more agile, spatially targeted interventions—balancing economic risk and health protection. In this way, individual-level data become a critical lever not only for epidemiological monitoring, but also for anticipating and managing broader socioeconomic disruptions, ultimately enabling more responsive and equitable health and economic policy. Within the framework of Learning Health Systems (LHS), health data is continually leveraged to refine medical practices and elevate patient outcomes through itera-

tive feedback loops (McLachlan, Dube, & Gallagher, 2018). However, while the benefits of health data are substantial, they are accompanied by complex ethical, legal, and social challenges. Concerns around data privacy, ownership, consent, and potential misuse must be carefully navigated to maintain public trust and ensure equitable use (BaHammam, 2023). Thus, the path toward effective integration of health data into contemporary healthcare systems requires not only technical innovation but also robust governance frameworks that prioritize ethical responsibility.

This section examines the multifaceted role of health data in shaping healthcare today, emphasizing its capacity to enhance decision-making, optimize resources, and promote health equity, while acknowledging the risks that must be managed in its application.

1.1 Early Detection and Prevention

Health data plays a fundamental role in the early detection and prevention of disease, serving as a critical tool for reducing morbidity, improving clinical outcomes, and minimizing healthcare costs. The capacity to collect and analyze large-scale health datasets, including electronic health records (EHRs), biometric monitoring, and population-level databases, enables researchers and clinicians to identify subtle physiological and behavioral changes that may signal the onset of chronic diseases such as diabetes, cardiovascular disease, and certain cancers (Topol, 2019; Chen et al., 2022). For example, data from wearable devices—which monitor metrics such as heart rate variability, sleep quality, blood pressure, and physical activity—are increasingly being used to flag early warning signs in real-time. These insights allow for proactive

interventions, helping clinicians deliver preventive care before disease symptoms escalate, particularly in high-risk populations (Steinhubl et al., 2015; McKinsey & Company, 2021).

Beyond individual-level prevention, health data enables researchers to analyze risk factors across diverse populations, facilitating a deeper understanding of social, environmental, and genetic determinants of health. These insights inform public health strategies, such as targeted screening programs, behavioral interventions, and resource allocation, which can mitigate risks and promote healthier lifestyles on a community-wide scale (Khoury et al., 2018; Marmot et al., 2020). Thus, by harnessing the predictive and diagnostic power of data, health systems can transition from reactive to preventive care models, ultimately enhancing population health and equity.

1.2 Personalized and Precision Medicine

One of the most promising and transformative applications of health data lies in the domain of personalized and precision medicine. This approach utilizes detailed, individual-level data—including genomic profiles, clinical histories, environmental exposures, and behavioral factors—to tailor diagnostic, preventive, and therapeutic strategies to the unique characteristics of each patient. The integration of such heterogeneous data enables healthcare providers to move beyond the "one-size-fits-all" model and deliver care that is both more targeted and more effective (Collins & Varmus, 2015; Torkamani et al., 2018).

In oncology, for instance, treatments are increasingly based on the molecular and genetic makeup of specific tumors. This has led to significant improve-

ments in treatment efficacy and a reduction in adverse effects, as therapies are aligned with the biological behavior of the cancer in a given patient (Ashley, 2016). Moreover, by reducing the reliance on trial-and-error prescribing and minimizing ineffective interventions, precision medicine can contribute to cost savings and more efficient resource utilization across health systems (Ginsburg & Phillips, 2018). As health data becomes more comprehensive and interoperable, the potential for real-time learning and adaptive treatment refinement will only increase. This data-driven evolution stands to redefine not only how diseases are treated, but also how they are prevented and understood at a population level.

1.3 Improving the Quality of Care

Health data provides valuable insights into the quality and effectiveness of healthcare services. By systematically analyzing data on clinical outcomes, hospital admissions, treatment efficacy, and patient satisfaction, healthcare providers and researchers can identify inefficiencies, uncover patterns of suboptimal care, and implement targeted improvements (Kruk et al., 2018; Dixon et al., 2016). This evidence-based approach enables the continuous monitoring of health system performance, allowing for benchmarking against standards and peers, and supporting the shift toward more accountable and transparent healthcare delivery (Berwick et al., 2008).

One example of data-driven quality improvement is the analysis of hospital readmission rates. By identifying the underlying causes of avoidable readmissions, health systems can implement preventive strategies, improve discharge planning, and enhance continuity of care (Jencks et al., 2009). Health

data can also expose disparities in access, outcomes, and service utilization across different demographic groups, helping systems address inequities and ensure that all populations receive high-quality care (Artiga et al., 2020). Importantly, the use of health data supports a transition from volume-based to value-based care, where performance is judged by health outcomes rather than service quantity. This model promotes more efficient use of resources, better patient experiences, and improved population health (Porter, 2010).

1.4 Predicting and Managing Public Health Crises

The COVID-19 pandemic demonstrated the vital role of real-time health data in managing public health emergencies. Access to up-to-date information on infection trends, hospital capacity, and vaccine deployment enabled authorities to make evidence-based decisions on containment strategies, resource distribution, and vaccination campaigns (Scudellari, 2020; Salathé et al., 2020). Data-driven models were instrumental in slowing the virus's spread and preventing healthcare system collapse in many regions.

Looking ahead, health data will remain essential for anticipating and responding to future crises. Predictive analytics based on historical and real-time data can identify patterns in disease transmission, supporting early interventions and more accurate epidemiological forecasting (Chinazzi et al., 2020). Global integration of health data, paired with early-warning systems, could facilitate rapid detection of emerging pathogens, giving governments critical lead time to implement containment measures (Kraemer et al., 2020).

1.5 Promoting Health Equity

Health data is a key resource for detecting and addressing health disparities. By integrating information on social determinants—such as income, race, education, and geography—with clinical outcomes, researchers can uncover the structural and environmental drivers of health inequities (Bailey et al., 2017). For instance, data analysis may reveal that asthma prevalence is higher in low-income neighborhoods due to poor air quality, guiding targeted interventions like pollution control and enhanced access to care (Artiga & Orgera, 2019).

Using this knowledge, policymakers and healthcare providers can design equitable health interventions, such as expanding services in underserved areas and tailoring prevention programs to the needs of vulnerable communities (Marmot et al., 2020). The responsible use of such data ensures that interventions are inclusive and aligned with diverse population needs, promoting fairness and improving population health outcomes (Braveman et al., 2011).

1.6 Advancing Research and Innovation

Health data is an invaluable asset for accelerating medical research and driving innovation. Large, high-quality datasets enable studies with broader scope and greater statistical power, supporting discoveries in diagnostics, therapeutics, and public health strategies (Lo & DeMets, 2016). Merging real-world data with clinical trial results enhances external validity and enables the evaluation of treatment performance in routine settings (Sherman et al., 2016).

In particular, the rise of artificial intelligence (AI) and machine learning has expanded the potential of health data. These technologies can process vast datasets rapidly, identifying complex associations that may elude traditional analysis. AI is increasingly used for drug discovery, patient risk stratification, and disease prediction, enhancing the precision and speed of innovation (Esteva et al., 2019; Topol, 2019). By unlocking new insights, data-enabled research is reshaping how health challenges are addressed.

1.7 Challenges and Ethical Considerations

Despite these benefits, the use of health data raises significant ethical and privacy concerns. Protecting patient confidentiality, securing informed consent, and ensuring transparency in data collection and use are foundational to public trust (Floridi & Taddeo, 2016). Strong data governance, guided by principles of fairness, accountability, and transparency, is essential to safeguard against misuse and ensure responsible innovation (Vayena et al., 2018).

Moreover, balancing data accessibility with privacy protection remains a core challenge. Policies must enable data sharing for societal benefit while preserving individual rights. Ethical frameworks and technical safeguards—such as anonymization, data minimization, and secure data environments—can help strike this balance (Shabani et al., 2018). Ultimately, advancing data-driven healthcare requires an ongoing commitment to both innovation and ethical responsibility.

2. Protecting Privacy, Delaying Progress? Health Data Regulation and Its Effects on Population Well-being

Health data, when effectively used, holds the potential to revolutionize healthcare by enhancing disease prevention, diagnosis, and treatment. However, the use of personal health information entails inherent risks related to privacy and security. To mitigate these risks, numerous countries have implemented strict privacy regulations. While these laws are essential to safeguarding individual rights and maintaining public trust, they can simultaneously restrict researchers' access to critical health data, potentially impacting public health outcomes (Vayena & Blasimme, 2017; Mittelstadt, 2019).

2.1 The Importance of Privacy Regulations

Privacy regulations such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States and the General Data Protection Regulation (GDPR) in the European Union are designed to ensure that personal health data is processed with the highest ethical standards. These frameworks protect patients from data breaches, unauthorized access, and misuse, encouraging individuals to share their health information more openly, thereby improving the quality of care and research participation (Gostin et al., 2019). Moreover, transparency provisions in these regulations empower patients by informing them about data usage and granting them control over their personal information (Shabani & Marelli, 2019).

2.2 Challenges for Researchers

Although privacy regulations are crucial for protecting patients, they also pose significant challenges for researchers who rely on access to health data to conduct studies that benefit public health. These laws often restrict access to large datasets or impose stringent requirements for anonymization and de-identification, which can slow down research or prevent certain studies altogether (Shabani et al., 2018). Researchers may be required to undergo lengthy approval processes or obtain explicit consent from individuals before accessing their health data. This can delay study initiation and reduce sample sizes, making it difficult to draw statistically significant conclusions. In cases where consent is impractical—such as retrospective studies or research involving large populations—researchers may be denied access to vital data (Porsdam Mann et al., 2016). Furthermore, while de-identification is necessary to protect privacy, it can reduce data utility by removing crucial contextual details such as age, location, or socioeconomic background, which are essential for studying health disparities and social determinants of health (Mello et al., 2018).

2.3 Impact on Population Health

Restrictions imposed by privacy regulations can have a direct impact on population health. When researchers lack access to comprehensive datasets, they may miss critical information on disease trends, risk factors, and treatment effectiveness. This can delay the development of new therapies or public health interventions, ultimately affecting health outcomes on a broad scale

(Dove et al., 2017). The COVID-19 pandemic underscored the importance of rapid data sharing for crisis management; countries with more flexible data governance frameworks responded more swiftly and effectively (Salathé et al., 2020). In countries where privacy laws were more restrictive, data-sharing efforts were sometimes hampered, slowing the response and endangering lives. Moreover, restricted data access hinders the ability to identify and address health disparities, exacerbating existing inequities and limiting targeted policy responses (Bailey et al., 2017).

2.4 Balancing Privacy and Research Needs

The challenge for policymakers and healthcare organizations is to strike a balance between protecting individual privacy and enabling the use of health data for research that benefits public health. Several strategies can help achieve this equilibrium. First, ensuring that data is properly anonymized or pseudonymized can help safeguard privacy while preserving research utility (Shabani & Marelli, 2019). However, it is essential that the de-identification process does not eliminate information critical to meaningful analysis. Second, developing clearer consent frameworks—such as broad consent models that allow individuals to authorize the use of their data for multiple research purposes under secure conditions—can streamline data access for researchers (Grady et al., 2015). Third, secure data-sharing platforms that meet regulatory requirements can facilitate research without compromising patient privacy. These platforms should include encryption, access controls, and audit mechanisms to ensure that data is used only for authorized purposes (Knoppers, 2014). Fourth, engaging and educating the public about the benefits of health

data research and how their privacy is protected can build trust and encourage participation. Transparency about data use and the measures taken to protect it reassures individuals that their information is handled responsibly (Vayena et al., 2015).

As we will see, these strategies, while ambitious, are not merely theoretical: several Nordic countries have already operationalized this balance through well-established frameworks that combine robust data protection with high-quality, ethically governed data access for research—demonstrating that privacy and responsible data openness can, in fact, successfully coexist in practice.

2.5 The Future of Health Data and Privacy Regulations

As healthcare becomes increasingly data-driven, privacy regulations must evolve to accommodate emerging technologies like artificial intelligence and machine learning, which depend on access to large, high-quality datasets (Topol, 2019). Future privacy frameworks must enable the ethical and secure use of such technologies in health research. Emerging technologies like blockchain may also offer new ways to create more secure and transparent systems for managing health data (Agbo et al., 2019). By giving patients control over their own data and allowing them to selectively share it with researchers or providers, these systems could enhance privacy while enabling valuable research. Ultimately, while protecting privacy remains a fundamental obligation, rigid regulatory barriers must be addressed to avoid stifling scientific discovery and delaying health innovations that could benefit society at large (Floridi, 2020). By embracing secure data-sharing solutions, reforming consent models, and

fostering public dialogue, healthcare systems can achieve a sustainable balance between safeguarding rights and advancing medical science.

3. The Legislation on Health Data in Europe: Does Privacy Regulations Hinder Their Reuse?

The conduct of biomedical, clinical, epidemiological, and digital health research in Europe is profoundly influenced by the GDPR legislation. The GDPR provides specific provisions for processing sensitive health data for research purposes, such as the "research exemption" under Article 9(2)(j), but its application is subject to interpretation by national and regional authorities, resulting in substantial fragmentation across member states (Péloquin et al., 2020; Scheibner et al., 2020). This divergence manifests in variable consent requirements, differing standards for pseudonymisation and anonymisation, and a lack of harmonized guidance for secondary data use, particularly impacting multicenter, cross-border, and registry-based studies (Péloquin et al., 2020; Scheibner et al., 2020; Doetsch et al., 2021; van der Wel et al., 2019).

Empirical studies provide evidence of these regulatory barriers. Surveys and interviews with clinical research stakeholders across the EU highlight persistent legal uncertainty, administrative delays, and operational burdens arising from the interplay between GDPR, the Clinical Trials Regulation, and national laws—obstacles often unrelated to crisis-specific measures such as those introduced during the COVID-19 pandemic (Lalova-Spinks et al., 2022; Bak et al., 2023; Richards, 2022). In Finland, for example, the implementation of stricter data access laws was associated with a 47% reduction

in new registry data permits, illustrating the measurable negative impact of privacy regulations on research capacity (Brück et al., 2024).[2] Comparative legal analyses show that countries such as Portugal, Finland, Norway, and the Netherlands impose widely varying requirements for the linkage of cohort and routine health data, leading to administrative delays from as little as seven days to as much as 300 days (Doetsch et al., 2021). Similarly, in Italy, restrictive and heterogeneous interpretations by data protection authorities and ethics committees create uncertainty and have led to the suspension of epidemiological projects, placing Italian researchers at a competitive disadvantage in European collaborative efforts (Cagnazzo et al., 2023; Bisceglia et al., 2023).

The increasing focus on cross-border collaboration and data sharing, including international transfers to non-EU countries such as the United States, has highlighted additional legal and operational challenges. The uncertainty surrounding adequacy decisions—especially after developments like Schrems II—and the complexity of applying Standard Contractual Clauses continue to impede transatlantic research (Bradford et al., 2020; Lalova-Spinks et al., 2024; Molnár-Gábor & Korbel, 2020). The rise of new EU acts and proposals, such as the Data Governance Act (DGA) and the European Health Data Space (EHDS), further complicates the landscape. While initiatives like data altruism and centralized data access bodies are intended to promote harmonization and data sharing, legal analyses and stakeholder interviews suggest they may add new layers of uncertainty unless carefully coordinated and clarified (Lalova-Spinks et al., 2023; Slokenberga, 2022; Rak, 2024).

2 It is worth mentioning that the analysis presented by Brück et al. (2024) may be misleading, as it appears to suggest that the introduction of FinData led to a reduction in access. However, their study focuses solely on the immediate years following the implementation of the service, without considering longer-term trends. Moreover, their comparison lacks robustness, as it conflates hospital permits with other types of permits, thereby limiting the validity of their conclusions. Following interaction with FinData, we got access to the number of applications and permits from 2021 to 2025, and the downward trend discussed in Brück et al. (2024) did not show up.

Overall, the literature demonstrates a persistent disconnect between the theoretical flexibilities available under the GDPR and the fragmented, often burdensome reality faced by researchers in practice (Péloquin et al., 2020; Lalova-Spinks et al., 2022; Doetsch et al., 2021). Below we report in synthesis the Key Mechanisms and Barriers Identified for a smooth utilization of the data:

- Legal Fragmentation and Divergence EU-level rules (GDPR, sectoral directives). These rules allow broad "research exemptions" but are inconsistently interpreted and implemented at national and even subnational levels, creating practical uncertainty and administrative burden for researchers.[3] Italy stands out as especially restrictive, with heterogeneous and sometimes subjective interpretations by regional authorities and data protection offices, hampering observational and epidemiological studies.
- Consent and Secondary Use Challenges. Despite GDPR art. 9(2)(j) and "broad consent" notions, many Member States—including Italy—still require narrow, project-specific consent, re-consenting, or new ethics approvals for uses of existing data, particularly for registries and biobanks. The lack of harmonized guidance leaves researchers exposed to variable criteria on when consent can be waived or what technical/organizational safeguards suffice (Smit et Al., 2023a,b).
- Data Access and Administrative Delays. Substantial delays (ranging from weeks to years), repetitive ethics/data-access reviews, and increased costs are empirically documented in multi-country comparisons, especially for record linkage and registry-based studies (van der Wel (2019),

3 This difference in interpretation is quite significant. For example, even within Finland, different ministries operate under varying rules. Health data, overseen by the Ministry of Health and Welfare, is treated differently from socioeconomic registers, which fall under the Ministry of Finance.

Doetsch et Al. (2021)). Centralized data authorities (e.g. Finland) can ease linkage, but new privacy acts have sometimes reduced data access rather than expanded it (van der Wel (2019)).

- Cross-Border & International Data-Sharing Barriers. Both intra-EU and transatlantic (EU–US) research are hampered by uncertainty over adequacy decisions, Standard Contractual Clauses, and shifting regulatory environments following Schrems II; these challenges are particularly acute for health and genomic data (Scheibner et al., 2020; Bradford et al., 2020; Lalova-Spinks et al., 2024; Molnár-Gábor & Korbel, 2020). Efforts toward harmonization remain elusive, and European consortia are frequently required to undergo repeated legal review and technical adaptation in response to divergent national and international data protection standards (Lalova-Spinks et al., 2022; Bradford et al., 2020; Richards, 2022; Cathaoir et al., 2021; Molnár-Gábor & Korbel, 2020).
- Emerging Regulatory Trends (EHDS, DGA, Data Altruism). The proposed European Health Data Space (EHDS) and Data Governance Act (DGA) are intended to facilitate future harmonization but currently introduce new ambiguities—such as the scope of Health Data Access Bodies, data altruism organizations, and technical standards—and risk adding complexity unless their implementation is thoroughly coordinated (Lalova-Spinks et al., 2023; Slokenberga, 2022; Rak, 2024; Kertesz, 2024; Terzis & Santamaria Echeverria, 2023; Terzis, 2022). Initial stakeholder perspectives indicate skepticism that these frameworks alone will rapidly resolve entrenched legal and operational fragmentation (Lalova-Spinks et al., 2023; Richards, 2022; Slokenberga, 2022).

Ongoing reforms aim to address these issues, but empirical and conceptual studies emphasize the need for further harmonization, streamlined administrative processes, and clearer EU-level implementation guidance to ensure that regulatory protections do not continue to hinder vital health research across Europe. The recent publication of the European Health Data Space (EHDS) Regulation in the Official Journal of the European Union marks a pivotal development in the European Union's efforts to create a unified digital health ecosystem (European Commission, 2025). As part of a broader strategy to enhance cross-border healthcare and stimulate data-driven innovation, the EHDS establishes a legal framework for the access, exchange, and use of electronic health data across EU Member States. The Regulation aims to reinforce the EU's leadership in digital health technologies while addressing urgent systemic challenges such as population aging and healthcare workforce shortages (European Union, 2025).

From a theoretical perspective, a cornerstone of the EHDS is the empowerment of individuals through greater control over their personal health data. Citizens will benefit from seamless access to their medical records across borders, facilitating the delivery of high-quality healthcare anywhere within the Union (European Commission, 2025). This patient-centered model promotes continuity of care and ensures that individuals can exercise their health data rights uniformly throughout the EU. In addition to enhancing primary care delivery, the EHDS supports the secondary use of health data—including anonymized and pseudonymized information—for purposes such as scientific research, innovation, public health planning, and evidence-based policymaking. These secondary uses are tightly regulated to ensure compliance with the EU's stringent data protection, ethical, and cybersecurity standards (European Union, 2025).

The Regulation envisions a phased implementation strategy to ensure operational viability. It officially enters into force on 26 March 2025, with data exchanges for the initial priority categories—such as patient summaries—beginning by March 2029. By that time, rules on the secondary use of data will also become applicable to most categories, and additional expansions are expected by March 2031 (European Commission, 2025). To support this complex rollout, over twenty Implementing Acts are expected, alongside the establishment of dedicated EHDS governance structures. These will coordinate with Member States, healthcare providers, researchers, and industry actors to promote adherence, technical compatibility, and trust across national systems.

Ultimately, the EHDS Regulation signifies a foundational shift in how health data is conceptualized and utilized in the EU. By balancing individual privacy rights with the societal benefits of data reuse, the EHDS lays the groundwork for a secure, efficient, and innovative health system that is better equipped to respond to current and future health challenges (European Union, 2025). This initiative stands as a testament to the EU's commitment to fostering a data-driven, inclusive, and resilient digital health future.

4. Health Data in Italy: Privacy Regulations Hinder Their Reuse

The regulation of access to and use of health data in Italy has undergone significant evolution over the past two decades, reflecting broader shifts at the European level as well as domestic legal, ethical, and political considerations. Initially, Italy's regulatory framework was built around strong privacy protec-

tions, influenced by the enactment of the "Codice in materia di protezione dei dati personali" (Personal Data Protection Code) in 2003 (Legislative Decree No. 196/2003). This Code established detailed provisions for the handling of personal and sensitive data, including health data, emphasizing informed consent, data minimization, and purpose limitation as key principles (Garante per la Protezione dei Dati Personali, 2003).

The General Data Protection Regulation (GDPR), implemented in 2018, significantly reshaped the Italian data protection landscape. While the GDPR introduced harmonized rules across the European Union for processing personal data, including health data under its special categories (Article 9), Italy adapted its national legislation through Legislative Decree No. 101/2018, which amended the 2003 Code to align with the GDPR (Garante per la Protezione dei Dati Personali, 2018). However, Italy's Data Protection Authority (Garante per la Protezione dei Dati Personali) maintained a cautious and often conservative approach, particularly concerning the secondary use of health data for research purposes. This conservatism led to frequent requirements for explicit, project-specific informed consent, even when the GDPR would have permitted broader consent models or derogations under appropriate safeguards (Florindi et al., 2023).

As a result, researchers in Italy faced substantial administrative burdens and uncertainty. Delays in obtaining approvals, divergent regional practices, and inconsistent interpretations of what constituted adequate anonymization or pseudonymization often hindered the efficient use of existing health datasets for scientific research. Comparative studies found that Italian researchers were disadvantaged relative to their counterparts in countries with more streamlined health data governance models, such as Denmark or the Netherlands (Gkotsi & Gasser, 2021).

In response to mounting pressure from the scientific community and in anticipation of the forthcoming European Health Data Space (EHDS), Italy has initiated reforms to facilitate greater access to health data while maintaining robust privacy protections. From 2024 onward, new guidelines allow the reuse of health data without requiring prior explicit consent when contacting data subjects would be impossible or would risk compromising the scientific objectives of the research (Garante per la Protezione dei Dati Personali, 2024). In line with the GDPR, health data reuse must be based on one of several recognized legal grounds, including explicit consent from the data subject (which must be informed, freely given, specific, written, and revocable), contractual necessity related to care or employment, protection of vital interests, public interest in the field of public health, or scientific research (Regulation (EU) 2016/679). In such cases, researchers must conduct a Data Protection Impact Assessment (DPIA) and publicly justify their decision-making processes, promoting transparency and accountability. The DPIA remains mandatory whenever high risks to individual rights and freedoms are identified, in compliance with Articles 35 and 36 of the GDPR. Depending on the case—especially when intellectual property rights are concerned—the DPIA can be fully or partially published and must be available for consultation by the Garante in cases of significant risk.

For institutions such as the IRCCS (Scientific Institutes for Research, Hospitalization, and Healthcare), research activities are considered part of their core institutional functions (Garante per la Protezione dei Dati Personali, 2022). Nonetheless, compliance with Article 9 of the GDPR, which prohibits the processing of sensitive health data unless specific conditions are met, remains essential. When required, consent must relate specifically to each research project and be renewed as needed.

At the European level, additional legislative initiatives have been launched to strengthen the broader ecosystem for data sharing and security. The Data Governance Act (Regulation (EU) 2022/868), currently active, establishes mechanisms for the safe sharing of public sector data, sensitive data, and data held by companies for altruistic purposes. It introduces the concept of "data intermediaries" to facilitate voluntary data sharing under trustworthy conditions (European Commission, 2022b). This act sets the groundwork for fostering a European data economy by building trust between data holders and users. The forthcoming Data Act, still under negotiation, aims to further regulate access and use rights for data generated by connected devices and services, thus facilitating the functioning of data-driven initiatives like the EHDS (European Commission, 2022b). The Data Act will address issues such as data portability, data access obligations, and fairness in contracts regarding data sharing, especially critical for ensuring equitable participation of all stakeholders in health innovation.

Complementing these efforts are new regulations focused on cybersecurity. The NIS2 Directive, adopted in December 2022, seeks to strengthen cybersecurity resilience across sectors considered critical, including healthcare, by imposing more stringent security requirements and incident reporting obligations on essential service providers (European Commission, 2023a). Furthermore, the proposed Cyber Resilience Act aims to ensure that connected digital products and services meet mandatory cybersecurity requirements throughout their lifecycle (European Commission, 2023b).

Given the increasing digitalization of healthcare systems, Italy is investing in technical infrastructure to support secure data sharing environments that align with EU standards, such as the use of certified secure processing environments where data cannot be downloaded, and access is limited

to pseudonymized information unless anonymization is impossible. These developments are intended to prepare Italy for integration into the EHDS framework, which aims to create a unified European system for primary and secondary health data use (European Commission, 2025).

Nevertheless, challenges persist. The Italian healthcare system's decentralization into regional administrations complicates efforts to harmonize practices nationwide. Variations in digital maturity, interoperability of electronic health records (EHRs), and regional data governance policies continue to create disparities in researchers' access to health data (Osservatorio Innovazione Digitale in Sanità, 2023). Moreover, ongoing public skepticism about data sharing and privacy risks, partly fueled by historical concerns over state data surveillance, necessitates continued efforts to build public trust through transparency, engagement, and ethical governance.

In conclusion, the evolution of Italian regulation governing access to health data reflects a complex balancing act between protecting individual rights and enabling scientific advancement. The vast repositories of health data already collected and stored in databases by hospitals and clinical centers represent a "gold mine" for scientific research—a potential treasure trove for advancing medical knowledge and serving the public good. However, in Italy, much of this data remains inaccessible due to what many researchers consider overly restrictive privacy protections. These regulations, though well-intentioned in safeguarding individual rights, often prevent researchers from utilizing already-available data, collected at no additional cost, for projects with no commercial interest but significant societal benefit (Florindi et al., 2023; Shabani et al., 2018). Moreover, inconsistencies in the approval processes for data access—even among institutions with similar characteristics—further frustrate Italian researchers, who perceive themselves at a disadvantage compared

to peers in countries where data reuse protocols are more flexible (Vayena & Blasimme, 2017). Recent reforms, coupled with the alignment to broader European digital strategies, signal a transition toward a more research-enabling environment. Nevertheless, achieving the full potential of health data for innovation and public health improvement will require not only regulatory updates but also deep systemic coordination, infrastructure investments, and sustained efforts to promote public trust and ethical stewardship of personal health information.

5. The Digitalization of Healthcare in Italy: Where Do We Stand?

Centralizing health data (and services) at the European level requires foundational steps in digitalizing the national healthcare system—steps that, despite the acceleration triggered by the pandemic and the funding provided by the National Recovery and Resilience Plan (PNRR, Mission 6: "Health"), appear to be progressing slowly. In Italy, one of the key drivers of healthcare innovation is the Electronic Health Record (Fascicolo Sanitario Elettronico, FSE), which allows citizens to access their medical history while enabling healthcare professionals to view patient information in a comprehensive way to guide medical decisions.

Despite its potential, the FSE remains underutilized. According to the latest Digital Innovation in Healthcare Observatory, only 38% of the population is aware of it, and just 12% knowingly use it. Beyond awareness, one of the main inefficiencies lies in the lack of central coordination, which has hindered integrated and consistent regional adoption. Healthcare is a mat-

ter of concurrent jurisdiction between the State and the Regions in Italy. To date, regional governments have widely exercised regulatory discretion, implementing national guidelines inconsistently and without a clearly defined interoperability framework.

The PNRR has allocated specific investments ("Strengthening technological infrastructure and tools for data collection, processing, analysis, and simulation") to harmonize Regional Health Records and ensure widespread adoption nationwide. The goal is to achieve interoperability and connect Italy's digital health infrastructure with the European dimension (MyHealth@EU), as outlined in the forthcoming European Health Data Space (EHDS).

Interoperability and FSE management are already in motion. The next step, aligned with EU-level planning, is to implement a new technological infrastructure under the Ministry of Health, through the New Health Information System (NSIS), which will host Italy's health data assets and enable advanced analyses for the EHDS's secondary purposes—namely, research, innovation, and health policy development.

5.1 – PNRR Objectives and EHDS Implementation: The Need for Central Coordination

The PNRR stipulates that all Italian regions must adopt and implement the Electronic Health Record system in accordance with standardized national criteria by mid-2026. This ambitious timeline will require a strong push from the Ministry of Health and active cooperation from implementing bodies. According to a study by The European House – Ambrosetti's PNRR Observatory, as of December 31, 2022, only 6% of available funds had been

spent and just 1% of projects completed. This resulted in delays of over €20 billion in originally scheduled spending from 2020–2022. The Italian Court of Auditors, in its second report on the PNRR, identified the health mission as one of the least advanced in terms of expenditure, noting critical risks that could delay targets for the first half of 2023.

Even if deadlines are met, the EHDS regulation will only become applicable 12 months after its formal entry into force. Given the lack of a coherent and uniform national health system, full implementation in Italy remains unlikely without structural reforms. Adding to this challenge are growing calls from some regions for greater autonomy over healthcare organization—an approach that may increase quality for non-essential services but risks undermining national governance mechanisms.

In this context, AGENAS (the National Agency for Regional Healthcare Services), acting as the operational arm of the Ministry of Health in charge of digital healthcare transformation, must enhance its guidance and oversight capacities. It must ensure that regional implementations align with national goals, while remaining attentive to the European dimension and the EHDS criteria and standards.

The PNRR could serve as a strategic compass, outlining objectives that reflect a vision of healthcare rooted in European integration. It represents a once-in-a-generation opportunity to transform Italy's healthcare system. However, this transformation will require strong political will, centralized leadership, and robust governance mechanisms to coordinate digital health initiatives across all levels.

6. The "Data Gap" and the Challenge of Measuring Health Phenomena

The collection of accurate and comprehensive health data is widely recognized as a fundamental prerequisite for advancing, for example, the understanding of health inequalities, informing the design of effective public policies, and evaluating the efficacy of health interventions. Nevertheless, a persistent challenge within the healthcare sector remains the inadequacy of sufficiently detailed data necessary to measure and analyze critical health phenomena. This deficiency not only impedes the progress of empirical research but also exerts profound consequences on the policymaking process, given that policymakers depend heavily on reliable data to identify and address disparities in health outcomes. The absence of robust and integrated health databases substantially limits the capacity to uncover causal mechanisms underlying health disparities, to monitor long-term epidemiological trends, and to formulate targeted interventions aimed at mitigating vulnerabilities within specific population groups. Inadequate data systems thus pose a significant barrier to the development of evidence-based policies designed to promote health equity. Drawing upon recent scholarly contributions, the following analysis explores the nature of the data gap in health research, assesses its impact on the comprehension of health disparities, and evaluates its implications for the advancement of data-driven, equitable policymaking.

6.1 – The Nature of the "Data Gap" in Health Research

The study of health outcomes inequalities relies on data drawn from administrative records, surveys, and longitudinal studies. Yet, as Case and

Kraftman (2024) highlight, many of the available datasets are incomplete or lack key variables needed for comprehensive analysis. One major issue is the fragmentation of data collection efforts. Many health surveys focus primarily on clinical indicators and collect only basic economic data, while economic surveys provide detailed income and wealth information but lack health variables. This division limits the ability to understand the interactions between socioeconomic and health factors.

Another significant challenge is the difficulty of tracking health trajectories over time. For instance, mortality data are often recorded long after the socioeconomic conditions that may have influenced outcomes, making it hard to link deaths to earlier life circumstances and limiting the ability to draw strong conclusions about long-term health determinants. Furthermore, studies focused on specific causes of death or rare conditions often operate with small samples, which undermines statistical significance and generalizability.

Linking diverse datasets could provide a more complete picture of health disparities, but such efforts remain limited. For example, Chetty et al. (2016) in the United States linked tax records with mortality data to study the relationship between income, geographic location, and life expectancy. Their findings revealed substantial life expectancy gaps between income groups and highlighted the importance of economic conditions as health determinants. However, even large-scale studies face limitations, as many administrative datasets lack fundamental variables like educational attainment or ethnicity—both strongly associated with health outcomes.

6.2 – Challenges in Linking Health and Socioeconomic Data

A core obstacle in health inequality research is the challenge of linking individual health data with long-term socioeconomic indicators. Ideally, this would involve merging census data with mortality records to track health trajectories over time (Case & Kraftman, 2024). However, this approach is rarely implemented systematically, and even when attempted, it often relies on small samples that limit analytical depth.

Another recurring problem is ecological fallacy, where researchers infer individual health outcomes from aggregate data. For instance, many studies use geographic units such as states or municipalities as the level of analysis. While this can reveal regional disparities, it often misses individual-level variation. Low-income individuals do not necessarily live in the poorest areas, and regions with high income inequality may contain pockets of poverty within generally affluent communities. This complicates the identification of causal mechanisms and highlights the limitations of relying solely on geographic data (Andrasfay & Goldman, 2021).

Moreover, demographic variables such as race and education are not consistently recorded in health databases, posing further challenges for research on health disparities. In the U.S., for example, educational attainment has been included on death certificates only since 1989, allowing researchers to explore growing mortality gaps by education level. Recent studies show that life expectancy has declined among Americans without a college degree, particularly due to suicide, substance abuse, and cardiovascular disease (Sasson & Hayward, 2019). However, such data practices are not widely adopted in other countries, limiting international comparisons and broader insights into education-health relationships.

6.3 – Implications for Policy and Decision-Making

The lack of comprehensive and integrated data has profound consequences for policymakers, restricting the ability to design targeted and effective health interventions. Without accurate measurements of health inequalities, it becomes difficult to identify vulnerable populations and implement policies addressing the structural causes of poor health outcomes. For example, if existing data fail to capture the long-term effects of childhood conditions on adult health, governments may underfund early-life interventions despite strong evidence of their long-term benefits.

Likewise, the absence of detailed demographic information in health databases creates blind spots in policy design. In many European countries, education level is not systematically recorded on death certificates, hampering evaluations of how education influences health disparities. Improving the quality and granularity of available data is therefore essential to ensure that policy decisions are grounded in robust evidence.

Additionally, the lack of demographic identifiers in mortality records—such as race and ethnicity—has historically limited the UK's ability to analyze health disparities among different population groups. Only recently has the Office for National Statistics (ONS) begun to address this gap (Case & Kraftman, 2024). Similarly, missing education data in many European countries prevents the identification of mortality trends by social class, further hindering the development of equity-focused health policies (Mackenbach, 2019).

6.4 – Potential Solutions and Future Prospects

Addressing the data gap in health research requires a coordinated effort to improve data collection, integration, and accessibility. A crucial step is expanding initiatives that link administrative data sources, such as tax records, census data, and health registries. This approach would allow researchers to conduct deeper analyses of health inequalities and assess the long-term effects of socioeconomic factors on health outcomes.

Another key strategy is investing in longitudinal studies that follow individuals over time. These studies provide valuable insights into the relationships between early-life conditions, socioeconomic status, and long-term health. Longitudinal cohort studies, such as those conducted in the UK, offer a detailed understanding of health trajectories and can help identify causal relationships that cross-sectional studies cannot capture (Hendi & Ho, 2021).

Policymakers should also prioritize enhancing the granularity of existing datasets by ensuring that critical demographic variables—such as education and ethnicity—are consistently recorded. This would support more nuanced research into health disparities and enable the design of interventions tailored to the needs of specific population groups. Finally, to avoid ecological fallacies, regional studies should be complemented with individual-level analyses wherever possible.

In conclusion, the data gap remains a significant barrier to advancing health research and tackling health inequalities. Incomplete datasets, fragmented collection efforts, and reliance on aggregate-level analysis highlight the urgent need to improve data integration and expand longitudinal research. Addressing these issues would empower policymakers to design more precise and impactful health interventions, ultimately reducing disparities and improving population health. Investing in more accurate data collection

and analysis would enable governments and research institutions to base their policies on solid, reliable evidence, contributing to the development of more equitable and efficient healthcare systems.

7. Best Practices in Europe: The Cases of Finland and Denmark

7.1 Accessing health registers in Finland: Findata

Access to individual health register data in Finland is provided by Findata, the Finnish data permit authority for the social and health care data, operating under the Ministry of Social Affairs and Health.[4] Findata issues permits to process: i) data maintained by several public social and health sector controllers, including those that transferred the right to issue permits to Findata itself; ii) register data of private social and health service providers; iii) data stored in Kanta services.[5] Findata is responsible to pre-process and combine data covered by a permit, which the pseudonymization and anonymization of registers.

Findata maintains an expanding list of ready-made registers, which are pre-compiled and pre-processed datasets ready to be quickly made accessible without the need for cost estimates or extraction fees from controllers. Currently ready-made registers at Findata fall under two groups: FinRegistry and COVID-19. FinRegistry consists of the registry data collected in

4 Findata activities are defined by the Act on the Secondary Use of Health and Social Data (Ministry of Social Affairs and Health, 2019).

5 Kanta services are a set of digital services that store and use citizens' social welfare and health care data.

the FinRegistry research project and the research data generated from them. The material includes data from Digital and Population Data Services Agency (DVV), Cancer Registry, Finnish Centre for Pensions (ETK), Kanta services, Kela, THL, and Statistics Finland, insofar as the data is covered by the Act on Secondary Use. Overall, Findata contains over 20 datasets and covers data from several decades.

On top of ready-made registers, Findata handles applications to access non-ready-made social and health care data maintained by the social and health controllers that fall under Findata permits.[6] Moreover, Findata can combine external data sources under the Secondary Use Act.[7] These include data collected by researchers or data accessed via another valid data permit. See section 7.3 for more information on linking external data sources.

7.2 Data permits

Findata and individual data controllers can issue and amend data permits. The first case applies whenever the application involves combining data from multiple controllers covered by the Act. Data requests are submitted to Findata via its online portal. Importantly, some public controllers have transferred the right to issue permits to Findata, so that Findata can issue permits on their behalf under the Act on Secondary Use. In these cases, Findata processes all permit applications related to these controllers' register data. A major controller that falls into this category is the Finnish Institute for Health and Welfare

6 See Findata' Data page.

7 Sensitive data, such as self-collected survey data or data generated via experiments, require an ethical approval from an institutional review board.

(THL), which provides several registers accessible via a Findata permit.[8] In practice, the system is highly centralized, with Findata acting as a central node when it comes to applications to access health data registers.

Of equal importance, and particularly relevant for linking external data sources, is the legal limitation that prevents Findata from receiving permit authority from all public controllers. In other words, Findata cannot issue permits for data from all controllers covered by the Secondary Use Act. A leading example of is Statistics Finland. In practice, researchers interested in linking Statistics Finland's registers to Findata's registers need to obtain a permit from Statistics Finland, not from Findata.[9] We will return to the dual nature of the Finnish environment in terms of accessing register data when discussing data linkage in Section 7.3.

A permit can be issued exclusively for the purposes laid down in law, which for individual-level data are scientific research, statistics, education, and planning and reporting duty of an authority. As a rule, the Secondary Use Act applies to register-based studies, that is, studies that use register data collected for other purposes or national registers.[10] Moreover, every data permit needs to apply the GDPR minimization principle, which requires to disclose only for data essential to answer to the question included in the proposal. While the application documents are confidential, decisions and permits granted by Findata are public. This is also to facilitate the exercise of the right to opt out on the part of project participants.

Data protection officers at Findata process the data application and evaluate it based exclusively on legal grounds. They can request additional infor-

8 THL reserves the right to issue data permits for internal administration and the THL Biobank data permits.

9 Other examples of public controllers that cannot transfer their permit authority to Findata are the Digital and Population Data Services Agency (DVV) and the Finnish Centre for Pensions (ETK).

10 Clinical and medical trials do not fall under the Secondary Use Act.

mation or modifications to the application or reject it altogether (to which decision the applicant has the right to appeal). When a permit is issued, then the data is extracted by the controllers and securely sent to Findata. As mentioned, Findata pre-processes, pseudonymize and links the data sources covered by the permit. This is done by removing all direct identifiers (e.g., name and surname, tax-authority personal identity numbers) and by creating a pseudo identifier. Pseudo identifiers uniquely identify individuals over time and across registers; they can be used to link information from several registers and to construct family networks within and across generations.

7.3 Linking data sources

Registers whose access is covered by Findata can be combined with external data sources that the applicant is in possess. These can be other registers. The researcher needs to have the right to process the external data sources via a separately issued data permit from the data controller that specifies the use of the data in relation to the Findata registers combined in the same application. Having such data permit from the data controller does not automatically guarantee access to the combined data, as this decision must be taken by Findata after making the data protection (and data minimization) considerations required to release a Findata permit.

Importantly, if the data controller is Statistics Finland, then the whole permit must be applied from Statistics Finland. Suppose for instance that for specific research question a researcher needs to access individual data on hospitalizations and drug purchases (covered by Findata) and link these to individual data on employer (covered by Statistics Finland). In this example,

it is not possible to have a permit issued by Findata that comprises the use of Statistics Finland's registers as external data source. Instead, the researcher needs to i) obtain a permit to use the health data from Findata, ii) apply for a data permit at Statistics Finland, asking Statistics Finland to pseudonymize and combine Findata's registers, which will be access from Statistics Finland's servers. In other words, a permit at Statistics Finland can cover the access to Findata registers (and those covered other controllers, such as DVV, ETK), but the opposite is not true.

Statistics Finland's data access process resembles that described here, but there are some notable differences.[11] For instance, Statistics Finland's interpretation of the GDPR is stricter than Findata's. Register data can only be accesses from within the EU and EEA in the case of Statistics Finland, whereas under specific conditions it can occur from outside of it in case of Findata permits (see next section). It is also worth stressing that registers at Statistics Finland can generally never leave Statistics Finland's secure environments. On the other hand, as explained below, Findata permits can in principle allow data access from local servers if the applicant can prove that the level of data protection meets the same protection existing via Findata's remote access system. While setting up local systems for projects covered by Findata permits is a rather complex, costly, and time-consuming process, it shows a fundamental difference between the rules covering the permits issued by Findata and Statistics Finland.

11 See also Lombardi (2026a) for more information on the rules and process to access register data at Statistics Finland, and Lombardi (2026b) for a parallel description of the Swedish system.

7.4 Accessing and processing the data

Individual-level data must always be accessed and analyzed in a secure environment. The primary way to access individual-level data is through Findata's secure processing environment, Kapseli. However, under the Act on the Openness of Government Activities, data can also be disclosed to other approved secure environments if necessary. In this case, the processing environment must follow Findata's regulation specifying the information security requirements used for secondary use of social and health data. In practice, the processing environment must be certified by a data security assessment body. The current regulation allows for alternative options, ranging from a secure space with an isolated computer to cloud-based solutions. Foreign researchers' processing environments must comply with these requirements and obtain internationally recognized security certifications, verified by an approved Finnish assessment body. As a rule, the processing environment should have the same level of information security as Findata's own operating environment.

By default, the processing of personal data from abroad is considered a transfer of personal data, even if the data is in a remote access environment. However, this assessment can vary depending on the affiliation of the data processor and of the data controller. If the *data processor* is employed by a *data controller* located within the EU and EEA (EU Member States, Norway, Liechtenstein, and Iceland), then processing from abroad is *not* considered a data transfer, and the processor may access the data from outside the EU/EEA.

Under the EU's General Data Protection Regulation (GDPR), data can be transferred within the EEA under the same conditions as within Finland. For

data transfers or processing outside the EEA (third countries), there must be a legal basis as outlined in Chapter V of the GDPR. Consider the following example:

- Findata has granted a data permit covering datasets from HUS, Pirha, and Varha.
- The permit states that the *data processors* are employees of HUS, Pirha, and Varha, whereas the *data controller* of the dataset is HUS.
- The data is processed within Findata's secure Kapseli environment.
- Then, if the data processors travel to the United States for a conference:
  - An employee of HUS can process the data remotely via Kapseli from the U.S., since they are employed by the data controller.
  - Employees of Pirha and Varha, however, are not employed by the data controller (HUS), meaning they cannot process the data in Kapseli from the U.S. without a legal basis under Chapter V of the GDPR.

When it comes to data processing and exporting, data must always be processed to preserve anonymity. and Findata must ensure that results are anonymous before exporting them from a secure environment. Researchers that want to export data from a secure environment must make sure that each cell in a table or underlying a graphical output is based on frequencies of at least 3 units. Moreover, results cannot identify any individuals, either directly or indirectly.

As such, the Finnish system offers a clear example of how data protection requirements can be fulfilled while granting access to register data. This balance is achieved in agreement with National and EU laws, while allowing researchers to access very detailed, individual-level information. As Finland,

Italy and the other EU member states must abide by the GDPR and could even take inspiration from the Finnish system when considering whether to open administrative data access for research purposes.

It is important to recall that the current status-quo was reached in a stepwise fashion, building trust on the institutions. Therefore, importing the Nordic model in other settings should likely be made in steps. Fortunately, the Finnish system itself embeds and suggests alternative ways to reach the end goal of granting access to administrative registers. First, data access can alternatively occur via the Kapseli system or by sending the data to a secure environment. If policy makers deem too impractical (or even risky) the latter option, then having a fully centralized data access system appears to be a viable alternative. Second, Finland offers an example of dual system, where different broad categories of registers can be accessed via either a Findata permit or via a Statistics Finland's one. There are pros and cons for having a dual system. For instance, from the perspective of a researcher it is not always practical to navigate a dual system. At the same time, data experts at Statistics Finland and at Findata can fully specialize on (and improve the offer of) specific data sources in ways that would not be achieved in a fully unified setting.

7.5 Accessing health registers in Denmark

Although the European Union's General Data Protection Regulation (GDPR) introduced stringent personal data protections, Denmark stands out as a leading model in the responsible and innovative use of individual health data for both scientific and clinical purposes. The Danish healthcare system is widely recognized for its successful digitalization and robust data governance,

enabled by long-standing investments, innovation, and strong public trust (Healthcare Denmark, 2024; OECD, 2019).

At the heart of Denmark's digital health ecosystem is the Civil Registration Number (CPR) system, introduced in 1968. This unique identifier links data across public sector databases—including healthcare, social services, and demographic registries—allowing healthcare providers to access comprehensive patient histories. This facilitates continuity of care across general practice, hospitals, and municipal services (Healthcare Denmark, 2024; Schmidt et al., 2019).

Citizen engagement is a key feature of the system. Sundhed.dk, the national e-health portal, offers individuals secure access to their health records, prescriptions, lab results, and appointment schedules. Users can also monitor who has accessed their health data, promoting transparency and reinforcing trust (Healthcare Denmark, 2024; Andreassen et al., 2020). The Shared Medication Record (FMK) supports safe prescribing practices by maintaining a unified, up-to-date medication profile for all patients, significantly reducing the risk of errors (Healthcare Denmark, 2024).

A core pillar of the Danish system is interoperability. MedCom, a government-owned non-profit, ensures compatibility across healthcare IT systems, enabling secure data exchange among general practitioners, hospitals, pharmacies, and municipalities (MedCom, 2022). The National Service Platform supports standardized, secure access to national health databases, allowing healthcare professionals and researchers to use integrated data while maintaining security (Healthcare Denmark, 2024).

In addition to supporting clinical care, Denmark excels in enabling the secondary use of health data for research and policy. The Danish Health Data Authority operates a national research platform that provides access to

de-identified data in secure environments. These systems meet GDPR requirements and are subject to oversight by ethics committees (Legido-Quigley et al., 2024). Denmark's approach aligns with FAIR (Findable, Accessible, Interoperable, Reusable) data principles (Wilkinson et al., 2016).

Denmark is also advancing decentralized clinical trials through initiatives like the Personalized and Decentralized Clinical Trials (PACT) project. By using telemedicine, wearables, and digital platforms, this model allows patients to participate in research from home, increasing inclusivity and diversity in clinical studies (Healthcare Denmark, 2024; Dorsey & Topol, 2020).

To support advanced analytics and real-time data access, Denmark connects local IT systems with national registries, such as the National Patient Registry, Cancer Registry, and Prescription Registry. Access to these data is governed by strict protocols, ensuring both comprehensive insights and robust privacy protections (Healthcare Denmark, 2024).

These advancements are part of Denmark's national vision for 2024–2027, which promotes a "digital and technological first" approach. This aligns national efforts with European initiatives like the European Health Data Space (EHDS), which aims to facilitate health data sharing across the EU while safeguarding privacy and interoperability (European Union, 2025). Denmark's Digital Health Strategy 2022–2026 targets key challenges such as workforce shortages and the rising burden of chronic illness by promoting telemedicine, artificial intelligence, and cross-sector integration (Danish Ministry of Health, 2022). The "Coherent Health Network for All" project focuses on streamlining patient care across hospitals, general practice, and local services. Meanwhile, the PACT initiative supports decentralized clinical trials by enabling data collection through remote tools, further democratizing research participation (Healthcare Denmark, 2024).

International benchmarks confirm Denmark's leadership. The OECD (2019) ranks Denmark among the world's top performers in electronic health record adoption, citizen access to digital services, and secondary data use. Yet, experts emphasize that sustaining public trust will require ongoing transparency, strong cybersecurity, and clear governance frameworks (van Panhuis et al., 2014).

In conclusion, Denmark's integrated approach—combining national policy, interoperable technologies, and citizen-centered governance—demonstrates how a digital health ecosystem can be both resilient and equitable. By strategically linking clinical and research data, Denmark continues to set a global example for data-driven healthcare innovation and evidence-based policymaking.

8. Conclusions

The COVID-19 pandemic highlighted the essential role of reliable, accessible, and high-quality public health data in shaping effective policies and managing crises. Studies by Ortiz-Prado et al. (2023) and Zhang et al. (2023) show that timely, robust data directly influences healthcare strategies, particularly during emergencies. Johannesson et al. (2023) emphasize the need for globally coordinated data systems that transcend national boundaries to improve responses to global health threats.

Health data sits at the crossroads of technological innovation, public health progress, and ethical governance. It holds transformative potential across areas such as early disease detection, personalized medicine, health equity, and

system resilience. Despite digital advancements, significant barriers remain—especially in contexts where privacy regulations limit data reuse. These challenges are pronounced in countries like Italy, where rigid interpretations of regulations often impede research.

The European Union's efforts to harmonize data governance—through instruments like the GDPR, the Data Governance Act, and the forthcoming European Health Data Space (EHDS)—are crucial steps forward. Yet national discrepancies and administrative fragmentation, as seen in Italy, demand further operational clarity, infrastructure investments, and institutional coordination to fully realize these frameworks' benefits.

Finland and Denmark provide successful models that show how robust privacy protection can coexist with data accessibility for research. Their centralized governance, secure data platforms, and interoperable systems enable responsible, evidence-based policymaking while maintaining public trust. Initiatives like Findata in Finland and Denmark's integrated digital health infrastructure exemplify this balance between data protection and utility.

Emerging technological solutions—such as synthetic data, federated learning, and secure processing environments—also offer promising paths to address legal and ethical constraints. These tools allow researchers to draw insights from real-world data while minimizing privacy risks, either by simulating realistic datasets or enabling analysis across decentralized sources without actual data transfer.

To unlock the full potential of health data, regulatory evolution must be accompanied by a cultural shift toward transparency, stewardship, and collaboration across sectors. With appropriate policy frameworks and technological infrastructures, health data can become the backbone of a resilient and adaptive healthcare system, ready to meet both current and future challenges.

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The One Health (OH) Approach and the Sustainability of Healthcare Systems

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Abstract

The One Health (OH) approach, based on the interdependence of animal, human, and environmental health, presents a fruitful framework for enhancing the economic sustainability of healthcare systems. At the same time, OH proposes a new epistemology of health, and reimagines it as an emerging attribute of complex adaptive systems, determined not only by disease-causing organisms or genes, but also by land cover, biodiversity, inequality, and interspecies relationships. In this paper, in addition to the OH evolving foundations as an epistemic paradigm, we discuss the ability of OH for meeting key global challenges such as emerging infectious diseases, antimicrobial resistance (AMR), and the burden of non-communicable diseases (NCDs) using integrated, intersectoral approaches. Leveraging case studies and tools of evaluation such as the Network for Evaluation of OH (NEOH), we evaluate the cost-effectiveness and preventive benefits of OH interventions. Drawing from evidence from programs implemented in Switzerland, England, Malta, and Serbia, we describe the capacity of OH in realizing public health savings, lessening healthcare burden, and improving system effectiveness. Despite its advantages, OH is still largely neglected in health economy modeling and policy integration. We evidence key gaps in the quantification of long-term financial benefits and harmonize OH approaches with healthcare financing policies and emphasize the need of more effective cross-sector governance, uniform metrics of evaluation, and fiscal frameworks inclusive of its preventive benefits of health policies. Integrating OH into healthcare systems can

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enhance resilience, maximize resource allocation, and enhance preparedness for future health emergencies—goals which are core for sustainable health economics and policy design.

Sintesi - L'approccio One Health (OH) e la sostenibilità dei sistemi sanitari

L'approccio One Health (OH), basato sull'interdipendenza tra salute animale, umana e ambientale, rappresenta un contesto proficuo per migliorare la sostenibilità economica dei sistemi sanitari. Allo stesso tempo, l'OH propone una nuova epistemologia della salute e la reimmagina come un attributo emergente di sistemi adattativi complessi, determinati non solo da organismi o geni che causano malattie, ma anche dalla copertura del suolo, dalla biodiversità, dalla disuguaglianza e dalle relazioni tra le specie. In questo articolo, oltre alle basi evolutive dell'OH come paradigma epistemico, discutiamo la capacità dell'OH di affrontare sfide globali chiave come le malattie infettive emergenti, la resistenza antimicrobica (AMR) e il peso delle malattie non trasmissibili (NCD) utilizzando approcci integrati e intersettoriali. Sfruttando casi di studio e strumenti di valutazione come il Network for Evaluation of OH (NEOH), valutiamo il rapporto costo-efficacia e i benefici preventivi degli interventi di OH. Attingendo ai dati dei programmi attuati in Svizzera, Inghilterra, Malta e Serbia, descriviamo la capacità dell'OH di realizzare risparmi per la salute pubblica, ridurre il carico sanitario e migliorare l'efficacia del sistema. Nonostante i suoi vantaggi, l'OH è ancora ampiamente trascurato nella modellazione dell'economia sanitaria e nell'integrazione delle politiche. L'articolo evidenzia le principali lacune nella quantificazione dei benefici economici e finanziari a lungo termine e nell'armonizzazione degli approcci all'OH con le politiche di finanziamento della sanità, sottolineando la necessità di una governance intersettoriale più efficace, di metriche di valutazione uniformi e di quadri fiscali che includano i benefici preventivi delle politiche sanitarie. L'integrazione dell'OH nei sistemi sanitari può aumentare la resilienza, massimizzare l'allocazione delle risorse e migliorare la preparazione alle future emergenze sanitarie, obiettivi fondamentali per l'economia sanitaria sostenibile e la progettazione delle politiche.

JEL Classification: I1, H12, H41, H44, H51

Parole chiave: *One Health; Economia sanitaria; Costo-efficacia; Resistenza antimicrobica; Malattie non trasmissibili; Sostenibilità sanitaria; Prevenzione.*

Keywords: One Health; Health economics; Cost-effectiveness; Antimicrobial resistance, Non-communicable diseases; Healthcare sustainability; Prevention

1. Introduction [1]

The global burden of infectious diseases has increased markedly in recent decades, driven by zoonotic spillovers, antimicrobial resistance (AMR), climate change, deforestation, urbanization, and globalization (Brüssow, 2023; Destoumieux-Garzón et al., 2018; Elnaiem et al., 2023; Mohamed and Wali, 2023). Crises such as the COVID-19 pandemic have laid bare the vulnerabilities of healthcare systems to emerging and re-emerging infectious diseases (EIDs), especially when societal changes and environmental disruptions fuel the spread of zoonotic pathogens and AMR (Brüssow, 2023; G-Science Academies, 2022; Mohamed and Wali, 2023). Simultaneously, demographic shifts—particularly aging populations—and the growing prevalence of non-communicable diseases (NCDs) such as diabetes and cancer are reshaping healthcare demands globally (Bygbjerg, 2012; Goswami, 2024). This convergence of infectious disease risks, NCD burdens, and demographic transition exerts significant pressure on both high- and low-income healthcare systems, calling for integrated, sustainable strategies to address overlapping public health challenges.

The intersection of infectious diseases and NCDs is particularly pronounced in low- and middle-income countries (LMICs), where infectious diseases like tuberculosis and HIV/AIDS elevate NCD risks, while NCDs increase vulnerability to infections (Bygbjerg, 2012; Goswami, 2024). These "double burdens" overwhelm health systems already struggling with fragmented programs, leading to inefficiencies and diminished sustainability

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(Bygbjerg, 2012). Even in high-income countries, aging populations with multiple chronic conditions experience elevated susceptibility to infections like pneumonia and influenza, further burdening healthcare services (Goswami, 2024; Osakunor et al., 2018). The COVID-19 pandemic further compounded these issues by disrupting chronic disease management across all income settings (Goswami, 2024).

The One Health (OH) framework offers an integrated, interdisciplinary approach to these intertwined challenges, addressing shared risks across human, animal, and environmental health (Brüssow, 2023; Destoumieux-Garzón et al., 2018; Heymann et al., 2017). OH emphasizes surveillance, zoonosis control, and environmental health protection, aiming to mitigate spillover risks, AMR, and vector shifts from climate change and land use (Destoumieux-Garzón et al., 2018; Mohamed and Wali, 2023). Despite growing recognition of its value in infectious disease control and AMR management, OH remains underutilized in broader healthcare discussions involving NCDs, aging, and system sustainability (Brüssow, 2023; Destoumieux-Garzón et al., 2018).

High-income nations, shaped by epidemiological transitions, often prioritize chronic disease care, sidelining infectious disease preparedness until crises strike (Atella and Scandizzo, 2023). However, the synergies between acute infections and chronic illness remain insufficiently addressed. For instance, individuals with cardiovascular disease or obesity are at higher risk during flu seasons or pandemics like COVID-19 (Bygbjerg, 2012; Goswami, 2024). Additionally, older populations face rising exposure to hospital-acquired infections and sepsis, conditions exacerbated by fragmented healthcare systems that fail to deliver coordinated care (Bygbjerg, 2012; Goswami, 2024). Incorporating OH into surveillance and elderly care infrastructure could enhance resilience and enable more strategic allocation of resources.

A persistent obstacle across settings is the fragmentation of healthcare delivery. Many systems remain divided between programs addressing either infectious or chronic conditions, with little coordination between them. Vertical programs for diseases like HIV have demonstrated disease-specific success, yet often ignore syndemic interactions that undermine holistic care (Brault, 2021). Integrated care models have proven more effective and resilient, particularly in resource-constrained environments. Nonetheless, even advanced systems in high-income countries struggle to deliver cohesive responses, often due to underdeveloped public health infrastructure (Goswami, 2024).

This article aims to synthesize research on the intersecting pressures of infectious diseases, aging populations, and NCDs, particularly through the lens of OH. Studies have clearly identified the ecological and societal drivers behind infectious disease emergence (Brüssow, 2023; Destoumieux-Garzón et al., 2018), while also emphasizing the need for broader OH adoption to manage cross-sectoral health risks (Heymann et al., 2017; Destoumieux-Garzón et al., 2018). Moreover, literature on integrated care models supports the need to bridge acute and chronic care paradigms to improve outcomes and efficiency (Brault et al., 2017; Bygbjerg, 2012; Goswami, 2024).

Despite these insights, important gaps remain in translating OH principles into operational frameworks, particularly in high-resource settings. The OH framework has yet to fully integrate with chronic disease care, aging services, or systemic reforms that address sustainability across health systems. Moreover, its deployment in high-income contexts remains limited, often focusing on disease surveillance rather than on broader structural reform (Destoumieux-Garzón et al., 2018).

In response, this paper is organized into six sections. Section 2 outlines the evolution and interdisciplinary basis of the OH concept. Section 3 presents

the methodological framework used in the study. Section 4 offers empirical findings, particularly on health trends, disparities, and public perception in Italy. Section 5 explores policy and implementation challenges, with a focus on economic feasibility and alignment with EU sustainability goals. Section 6 concludes by summarizing the findings and offering recommendations for advancing OH as a pillar of resilient and equitable healthcare systems.

2. The OH as an epistemic project

The concept of *One Health*—the recognition that human, animal, and environmental health are interconnected—has deep historical roots, but the term itself is relatively recent. Its intellectual foundations can be traced back to the 19th century, particularly to the German pathologist Rudolf Virchow, who famously asserted that "between animal and human medicine there are no dividing lines—nor should there be" (Schwabe, 1984). This integrative approach was later developed by veterinary epidemiologist Calvin Schwabe, who coined the term *"One Medicine"* in the 1960s, advocating for a unified approach to human and veterinary health.

The modern term OH began to gain traction in the early 2000s, particularly in response to emerging zoonotic diseases such as SARS, avian influenza, and Ebola. It was formally adopted in 2004 by the Wildlife Conservation Society (WCS) during a conference held in New York, where the "Manhattan Principles" were drafted—twelve recommendations calling for a holistic approach to preventing epidemic disease through interdisciplinary collaboration

(WCS, 2004).[2]

Since then, the term has been institutionalized by major global health organizations. The World Health Organization (WHO), the World Organisation for Animal Health (WOAH), the Food and Agriculture Organization (FAO), and the United Nations Environment Programme (UNEP) have all endorsed the OH approach. In 2021, these organizations launched the *One Health High-Level Expert Panel (OHHLEP)* to develop a shared framework and define OH as "an integrated, unifying approach to balance and optimize the health of people, animals and ecosystems" (OHHLEP, 2022).

Today we define as OH approach a holistic and collaborative framework emphasizing the interconnectedness of human, animal, and environmental health. By addressing shared health threats such as zoonotic diseases, antimicrobial resistance (AMR), and environmental impacts, OH seeks to tackle health challenges that cannot be resolved by siloed interventions. Its application is particularly relevant in Europe, where cross-sectoral and cross-border collaboration is integral to tackling both local and systemic health risks. The increasing recognition of economic implications—such as the costs of inaction or the need for cost-effective interventions—has positioned OH as an essential method for achieving sustainable healthcare systems, particularly in the context of European Union (EU) policies and strategies. The OH approach is thus currently understood to be a holistic, interdisciplinary framework that captures the interrelated nature of human, animal, and environ-

2 In 2004, the Wildlife Conservation Society (WCS) brought together stakeholders to discuss global health challenges at the nexus of human, animal, and ecosystem health. The symposium "Building Interdisciplinary Bridges to Health in a Globalized World" at The Rockefeller University gave birth to 12 recommendations for establishing a more holistic approach to preventing epidemic / epizootic disease and for maintaining ecosystem integrity for the benefit of humans, their domesticated animals, and the foundational biodiversity, which since then went under the name of the "Manhattan Principles" (http://www.oneworldonehealth.org/sept2004/owoh_sept04.html). These detailed a collaborative, trans-disciplinary approach, coined 'One World - One Health', or simply 'One Health'.

mental health. It confronts shared health hazards—such as zoonotic diseases, antimicrobial resistance (AMR), and environmental degradation—that leap across disciplinary and spatial boundaries and cannot effectively be addressed through silo-based interventions. Crucially, OH is interpreted not just as a policy tool or a technical framework, but a complex property that emerges from dynamic relationships and interdependency between biological, ecological, and societal networks, just like consciousness or ecosystem resilience. It is not a top-down imposed model in this vision, but a coordination and integration pattern of multiple sectors and stakeholders working toward a shared vision of well-being.

This frame of reference is especially pertinent to the European environment, where health management is increasingly depending on cross-border and cross-sectoral partnership to deal with local and system-level hazards. The realization of the cost of not acting—e.g., the cost of outbreaks or the untenable weight of disjointed healthcare interventions— has further boosted OH's status as a strategic instrument. Consequently, OH is not just crucial to enhance public and planetary health but also to enhance the resilience and sustainability of health systems, in accordance with overall European Union (EU) policies on sustainability, biosecurity, and health equity.

In sum, the OH framework has grown beyond being an intersectoral strategy between human, animal, and environmental health fields; it now reflects deeply an epistemological change in the very conception of health itself. This strategy is based on the realization that the health of any single component—human, animal, or environmental—cannot be properly addressed independently, but needs to be understood in the broader context of systemic interdependence and relationality.

The concept of a natural balance often invoked in discussions of OH may,

on closer inspection, be a problematic simplification. While the image of an ideal equilibrium across human, animal, and environmental domains is rhetorically powerful, it risks promoting a form of undifferentiated holism that obscures the nuanced, layered interdependencies that characterize real-world health systems. Such a notion may inadvertently flatten the complex and often asymmetrical relationships that structure these systems, where factors like biodiversity loss, zoonotic disease spillovers, and social inequalities intersect in dynamic and context-specific ways. Rather than envisioning health as the attainment of a static biological equilibrium, it is more accurate—and more useful—to understand it as a state of integrative co-functioning, where various systems sustain each other through flexible, resilient, and adaptive interactions.

By emphasizing that human, animal, and environmental health are intimately linked, the OH notion naturally focuses on multidisciplinary collaboration and shared resources to mitigate threats. Examples of key focus areas include:

- **Zoonotic Diseases**: Diseases passed from animals to humans, such as Q fever and brucellosis, account for substantial societal and financial burdens. Preventative measures under OH, such as livestock vaccination or environmental controls, often have significant cost-savings compared to reactive human health interventions (Babo Martins, Rushton & Stärk (2017); Buttigieg, Savic and Aragrande (2018)).
- **Antimicrobial Resistance (AMR)**: AMR is one of the most pressing global health threats. Integrated surveillance systems, as advocated by OH, combine data from human healthcare, veterinary medicine, and environmental monitoring to optimize the use of limited resources and provide shared benefits (Bennani et Al. (2021); Bronzwaer et Al.

(2021)).

- **Environmental and Climate Drivers**: Changes to ecosystems, such as deforestation, farming practices, or climate change, exacerbate zoonotic risks and drive healthcare costs. The OH strategies integrate these ecological factors into health planning (Mazzeo et Al. (2022); Bronzwaer et Al. (2021)).

In such an understanding, health comes not just in the form of the absence of disease, but as an expression of balance in an intricate system of living systems, each having the potential to impact and be influenced by the other.

More recent work formalizes this shift in emphasis by stating that applying the OH notion necessitates more than seeing the connections between things, and needs an acknowledgment of real interdependence, in which the health of each component depends on the integrity and health of the whole. Beever and Morar (2018) distinguish critically here, asserting that interconnection—simply relational adjacency—is inappropriately confounded with interdependence, implying mutual need and co-determination. Unless we recognize the distinction, OH will be notionally ambiguous or ethically incoherent, above all when dealing with multifaceted real-world issues (Beever & Morar, 2018).

The COVID-19 pandemic provided stark proof of such interdependence, exposing how anthropogenic disruption of ecosystems—through deforestation, wildlife trade, and urban encroachment—can instigate zoonotic spillovers, revealing the shortfalls of narrowly human-centered health systems. Goel et al. (2021) contend that the pandemic showed the shortfalls of traditional, mechanism-based health models based in Enlightenment-era academic silos. They support the application of a "relational paradigm," in which health is not viewed as an isolated biological state, but rather as an emergent state produced through dynamic interplay between organisms and environments.

Such a paradigm necessitates transdisciplinary education and epistemological humility, given that traditional educational institutions tend to replicate constituencies for fragmented, reductionistic forms of knowledge poorly suited for responding to complex global health challenges (Goel et al., 2021).

Here, the OH approach supports an integrative conception of health as dynamic equilibrium, able to resist and accommodate endogenous and exogenous shocks. Resilience is an integral property of this integrative conception of health, in which the interplay among the different areas enables systems to resist stress and reorganize while retaining their core function. Such systemic resilience is then in stark contrast with linear, monocausal approaches to health, such as those not well adapted to the fluid and multifaceted nature of modern threats such as climate change, antimicrobial resistance, or food insecurity. In addition, OH encourages us to understand the dialectical relationship between nature and nurture as anything but an opposing binary, but rather an ongoing negotiation—a process in which health is the ability to be affected, to be able to be harmed, and then recover and change. This conception has appeal in the argument presented in Agarwal (2024) for the incorporation of whole person healthcare into an ecocentric framework explicitly attuned to the embedment of individuals in socio-environmental systems. Agarwal pushes for health as a universal planetary value, with the belief that well-being arises out of ecologically aware, justice-oriented interactions rather than discretely medicalized intervention (Agarwal, 2024).

The vision has specific ramifications in indigenous health paradigms, such as those detailed by Hueffer et al. (2019) in the Circumpolar North. Indigenous societies have traditionally approached health from holistic perspectives that echo OH paradigms, in their stress on relationality, communal resilience, and the sacredness of balance in ecosystems. Such traditions yield rich epis-

temological resources for the building of more inclusive and adaptive paradigms for health, for example, as climate uncertainty and environmental deterioration amplify health inequities (Hueffer et al., 2019).

Then, Romizi et al. (2024) propose the next direction for OH is to further incorporate it into the larger "Planetary Health" approach, centered on ecological justice and sustainability. They believe to realize the potential for the paradigm, health professionals and decision-makers need to support interdisciplinary approaches, systemic transformation, and environmental stewardship. For them, well-being is inextricably linked with the integrity of the biosphere—a norm that should be the foundation for both public health as well as policy in the Anthropocene (Romizi et al., 2024). Together, these views reinforce the fact that the OH approach is not merely a science, or policy advance, but rather an epistemological shift—a new manner of thinking about life, about health, and about the shared, interdependent destiny of all living things.

In conclusion, the OH concept has gradually developed into a comprehensive epistemic and ethical framework for conceptualizing health beyond the confines of individual species. It frames health as a holistic, integrated system encompassing humans, animals, and the environment. Within this expanded paradigm, health is increasingly understood through two principal frameworks: firstly, as an anti-rival universal good that benefits all parties, and secondly, as an intrinsic component of a natural web of interconnected life forms. More broadly, health—understood as a state of interdependent well-being among humans, animals, and the natural world—can be regarded as a global common good. It is characterized by its non-rivalrous and non-exclusionary nature, relying on inclusive comprehensiveness and collective responsibility for its maintenance. Extending this perspective further, OH

invokes the notion of a planetary commons: a shared ecological and ethical space where living and non-living entities exist in a dynamic state of interdependence, at times harmonious and at others in tension. Effective stewardship of this commons requires vigilant attention to the complex interdependencies involved and the universal values at stake, alongside morally informed behavioral, institutional, and policy approaches that can uphold both equity and ecological integrity.

2.1. Health as a social merit good

Health is a public good of anti-rival nature, i.e., a good whose use, access, or improvement of a health resource by one individual or group enhances, rather than reduces, its value or benefit for others. Thus, it can also be conceptualized as a social merit good that benefits society at large, is not reduced by greater inclusion, and indeed gets stronger with greater access and collective consumption.[3] Like other public goods of merit such as culture and trust, the value of health is not created by individual fruition alone, but by the web of direct and indirect relationships among members of a community.

In this context, a living being is not an isolated recipient of health but rather a constituent of a system in which the health of each individual is intricately intertwined with that of others. To fulfill a range of different and heterogeneous requirements, a subject is thus induced to conceive health in ways that are compatible and synergistic and see that his own health require-

3 A merit good is a product or service that is considered socially desirable by the government, and which tends to be under-consumed if left to the private market because individuals may underestimate its personal or social benefits (Mankiw, 2021). Examples include education, healthcare, and vaccinations. Governments often support merit goods through subsidies or direct provision to ensure broader access and consumption.

ments are not separate from those of others. This results in a collective perception of a single condition of need and a realization that health is a shared concern. Consequently, health is not simply enjoyed by the individual, but is collectively produced through intersubjectivity, where everyone identifies and attends to the others' needs within a shared system. The resultant mutuality of recognition of collective health needs produces a communion of concern based in the direct, system-based interdependence of the participants. It is through this connectedness that health becomes a social good of public and moral concern.

Within the OH context, health is not excludable and "anti-rival" in essential areas: disease control, ecosystem homeostasis, and antibiotic efficacy are best when supported by the greatest possible participation. Consequently, as Capps and Lederman (2014) persuasively argue, the paradigm of the OH requires that we reconceptualize biobanking and other public health assets not simply in public goods terms as a benefit to humans, but as "universal goods" that are of benefit to human, animal, and environmental stakeholders equally.

Alog similar lines, Degeling et al. (2016) stress that OH recasts the very idea of "health" itself: no longer a commodity that is controlled within species lines, but a value shared across multiple life realms and optimized through interspecies alliances and ethical deliberation that bridges life domains. That conception is most receptive to the general policy imperatives of universal health coverage, particularly in resource-poor countries, where legal and moral architecture that posits health as a universal right is increasingly required to stem mortality and enhance overall well-being globally (Ngwaba, 2019).

2.2. Health as a natural network among living things

As an epistemic project, the OH approach provides a new perspective by problematizing the anthropocentric and mechanistic conception of health through its network characteristics. From this point of view, OH proposes to go beyond the concept of health as a bounded entity confined to a single organism or species, to consider it a much more general, emerging property of the network of relations across biological, ecological, and social systems. Goel, Barbosa Mendes, and Snick (2021) illustrate this concept by addressing systemic health abnormalities like zoonotic pandemics, which occur through breakdowns of some of these interconnections. They advocate a relational paradigm that goes across disciplinary siloes and entails novel transdisciplinary education, research, and policy-making that acknowledges health to be a by-product of intricate relations.

More generally, and even beyond its network characteristics, this perspective suggests that health can be characterized as an emergent property of complex systems of life that result not from any organ, gene, or environmental factor but from the dynamic interaction of biological, psychological, social, and ecological subsystems. Like consciousness, health resists reduction to simple, linear models and cannot be comprehended by isolating its elements. Instead, it results from the integration and coordination of multiple levels of activity within and between systems. In living organisms, therefore, health is not mere absence of disease or malfunction, but a condition of adaptive coherence—the organism's capacity to preserve internal stability (homeostasis) yet adjust flexibly to environmental change (allostasis). On a larger scale of organization, including communities or ecosystems, health likewise represents the system's ability to achieve resilience, regulate itself, and co-evolve relative to context.

This system's perspective reflects how consciousness is now conceptualized in neuroscience—that is, not a feature of any brain area or neuronal activity pattern, but a global integration of information within distributed systems. As consciousness "arises" when brain activity gets synchronized to give rise to integrated awareness, health arises when physiology, behavior, social circumstances, and environment come into harmony with one another in mutually supporting ways.

Both consciousness and health therefore exhibit central characteristics of emergent phenomena:

- **Non-linearity**: Small changes in a part of the system may have large, unforeseen effects elsewhere.
- **Context-dependent influence**: The value and meaning of elements (e.g., stress, inflammation) are a function of where they fit within the system.
- **Self-organization**: Patterns of order (such as immune regulation or psychological well-being) can emerge spontaneously out of complex interactions.
- **Multi-scale dynamics**: They occur across scales—from cells and organs to social systems and ecosystems.

According to this perspective, health is not just the aggregate of what can be measured (e.g., laboratory results or symptoms), but a qualitative, emergent description of system integrity. A person's or group's health reflects how intact the system is, how it adapts to stress, and how it maintains purposeful function over time.

This view is corroborated by recent discourse around planetary health, in the Gaia tradition, which makes a case for the application of ecosystemic thinking to conceptualize how some fruits of human behaviors like deforestation, industrial agriculture, and urban development destabilize natural health

networks and initiate global crises.[4] These disturbances influence microbial ecologies, species habitats, and even climate cycles—and end up as powerful components of human health impacts. The OH model does not just pursue balance in a static sense, but embodies resilience through networked stability, where each node in the network supports and is supported by others.

The OH notion, viewed through the multifaceted prism of health as a public merit good, a network form of interdependence, and an emergent property of nature, thus presents a powerfully integrative epistemic view of life. It resists reductionism in favor of inclusive, ethically sound, and ecologically sensitive solutions that can inform policy and practice. By reformulating the very notion of health as a form of collective strength to be nurtured through stewardship and systems thinking, the OH paradigm brings us to a more just and sustainable concept of wellness.

On the practical side, and as a policy program that goes beyond pure epistemics, by assuming that human, environmental, and animal health are inherently connected, OH requires multi-disciplinary and multi-geographical co-governance. With increasing globalization, growth dynamics and preferential attachment influence how health may develop its complex structure as a merit social good and a network system.

With the expanding perception of connected health hazards fueled by zoonotic pandemics like COVID-19, antimicrobial resistance, and climate-related health shocks, fresh nodes in the OH defined health and health care networks emerge continuously. These could range from local public health organizations to wildlife disease surveillance units, indigenous systems of knowledge, NGOs, biotechnology companies, and policy institutions that

4 We refer to the Gaia hypothesis, originally proposed by James Lovelock in the 1970s, which conceptualizes Earth as a self-regulating, complex system where living organisms interact with their inorganic surroundings to maintain conditions conducive to life.

are transnational. These entry nodes are incentivized by the allure that an OH system of health care would display as a deliverer of global public goods: disease avoidance, ecological resilience, and public confidence in science.

This trajectory of development aligns with the observations of Goel et al. (2021), who characterize the current health care framework as an epistemic space that attracts diverse stakeholders due to its comprehensive foundations and its tangible integrative potential. As the network expands, new actors are drawn to established, highly connected institutions such as the WHO, FAO, WOAH (formerly OIE), leading research centers, and funding bodies like the Gates Foundation and the World Bank. These central nodes possess institutional legitimacy, extensive knowledge capital, and significant financial resources, resulting in a hierarchical network structure. Within this structure, a minority of influential actors shape the framing of norms, research priorities, and funding allocations, while peripheral nodes tend to remain dependent or marginal.

According to Capps and Lederman (2014) however, current health governance systems cannot effectively serve the interests of humans, non-human species, and the environment in an equitable manner without deliberate restructuring around the principle of universal goods. In practice, node centrality produces a structural imbalance, concentrating influence unevenly in accordance with the power-law distribution described by network theory. Therefore, while OH promotes interdependence and collaboration, the prevailing network architecture of health governance and healthcare systems remains predominantly hierarchical and fragmented. Leadership tends to be unevenly distributed, exacerbating inequalities across the network. Dominant hubs—such as major global research collaborations or funding organizations—control agenda-setting, while smaller or local actors are often confined

to roles as data providers or implementers.

These observations echo several critiques of global health governance, including those of Degeling et al. (2016), who contend that a true OH strategy must have ethical frameworks that are sensitive to and correct these imbalances. OH, embedding in globalization's network logic thus must anticipate a system that is more fluid and less predictable than earlier models of global health development. Instead of a single central system (e.g., WHO-based), the OH network must be polycentric, with multiple points of innovation, surveillance, and intervention—but bound together by several highly connected nodes. This implies, inter alia, multipolar development, with knowledge and interventions no longer originating from the Global North but also from regional nodes in Asia, Latin America, and Africa. Like global commerce among intermediate products, global health must also entail global flows of knowledge, samples, protocols, and personnel that produce distributed value chains of surveillance and response. Finally, locally based systems of health knowledges (e.g., indigenous ecological knowledges) must be incorporated into global systems by prevailing protocols of science and realize and represent a new form of epistemic exchange.

2.3. The OH Framework and the Exposome: An Integrated Systems Approach

While the OH approach offers a broad and systemic framework for understanding health as shaped by interspecies and ecosystem interactions, it frequently lacks the methodological tools necessary to comprehensively capture the full spectrum of environmental exposures experienced by individuals over time. This limitation arises from its traditional emphasis on population-level

determinants and ecological interactions, rather than on the continuous, cumulative, and individualized exposures—such as chemical pollutants, dietary factors, psychosocial stressors, and lifestyle behaviors—that critically influence health trajectories throughout the human lifespan. Recently, this gap has been partially addressed by the Exposome framework, which provides a comprehensive methodology for measuring and analyzing lifelong individual exposures, making it a natural and necessary complement to the OH perspective.

In 2005, Christopher Wild coined the term "exposome" as the result of cumulative environmental exposures over the course of life from the prenatal period onwards. Since then, this definition has been extended and refined by enumerating the constituent components of the exposome and suggesting metrics and measurement methodologies. In general terms, the exposome is an attempt to define in a more meaningful and documentative way the environmental variable in the equation phenotype = genotype + environment. It is semantically characterized by a parallelism with the genome and has been interpreted as an index of "nurture", as opposed to the genome as an index of "nature". The concept captures the essence of a person's formation, as the sum and integration of external forces that act on our genome throughout our lifespan. The exposome also recalls the notion of human capital, a somewhat ambiguous term, which however can be interpreted as the embodiment of the genome and the exposome, both interacting to produce the unique quality of a life.

The idea behind the exposome is germane to the OH paradigm in more than one way. First, it captures the key notion of space-time interdependence, in that it considers that the state of health of an organism, and in general its physiognomy at any one time, reflect the cumulative effect of its histor-

ical exposure to a variety of events. Second, this is not only true for human beings, but for all living organisms, such as individuals (animals and plants) and as collective clusters, such as cities, farms and other aggregates whose exposome is the recapitulation of the organisms' history through the traces left by their interaction with their environment. Third, both individual and collective exposomes mirror ecological, social, and historic factors that create systemic vulnerabilities and resilience. Individuals as much as cities, farms, and institutions are metabolic organisms, each embodying a built-up history of exposures. This allows for systemic risk appraisal and holistic health planning across human, animal, and environmental levels. Through tracking and reconfiguring aggregate exposomes, we can design improved, health-supportive environments.

Integrating the OH network interpretation to exposomic theory gives us a compelling systems-level explanation of how health inequalities and environmental exposures are built into structural arrangements of global health networks. The exposome, as a record of long-term exposures to the environment, shows how structural inequities (e.g., pollution, infrastructure deficiencies, green space limitations, and occupational exposures) are unequally distributed geographically and by populations. When we look beyond just considering OH as a health paradigm, but rather as an evolving global network based upon preferential attachment, we can observe that it reflects much of the same inequitable drivers of exposomic burdens.

While global networks centralize power and visibility in dominant nodes (e.g., wealthy institutions, wealthier countries), burdens of exposure also centralize historically disadvantaged regions and communities—inflating biological inequality via the environment. The OH network's susceptibility to centralization thereby reflects the susceptibility of bodies and ecosystems to

imbalanced exposures.

In sum, as a science and justice framework, the exposome can be interpreted as an integral part of the OH's paradigm as an equitable and ecologically consistent health system. This interpretation has important practical implications and involves, inter alia, *i)* promoting epistemic justice by recognizing diverse methods of knowledge acquisition, including local knowledge systems and experiential understanding of the environment; *ii)* decentralizing agenda-setting such that exposure science and interventions based on OH are responsive to local exposure conditions and not just dominant institutions' priorities; *iii)* making investments in local systems to minimize structural disparities of exposures and to ensure that all global network nodes, not just central ones, are enabled to actively contribute to and benefit from OH knowledge and policy.

Within such an integrated conception, the exposome is both an indicator of environmental health risk and a diagnostic index of systemic injustice within the global architecture of OH. It measures the extent to which a genuinely resilient, equitable, and life-sustaining commons can be created by reorganizing both systems of exposure and knowledge systems.

3. The role of institutions in supporting and adopting the OH approach

The One Health (OH) approach, by emphasizing the interconnectedness between human, animal, and environmental health, provides a vital framework for managing complex health challenges. In Europe, mounting pressures from pandemics, antimicrobial resistance (AMR), and climate change

have spurred interest in OH to bolster resilience and sustainability. A critical, though underexplored, aspect of OH lies in its economic and financial implications—specifically, how cost-effectiveness, resource allocation, and risk evaluations influence its scalability and integration into healthcare systems.

The economic value of OH has been examined in areas like disease prevention, AMR surveillance, and zoonotic outbreak control. Studies highlight the efficiency of preventive OH strategies over reactive, sector-specific interventions. In Switzerland, Campylobacter surveillance shows that integrating human and animal health data yields stronger risk assessments and cost savings, despite increased operational costs (Babo Martins, Rushton & Stärk, 2017). In England, integrated AMR surveillance has improved resource use and outcome efficiency (Bennani et al., 2021). Global models also underscore OH's potential, suggesting savings of $6 billion annually from better outbreak responses and $30 billion from pandemic prevention (Grace, 2014; Machalaba et al., 2017). However, these benefits are often demonstrated outside Europe or in isolated national contexts, limiting their broader relevance for European systems.

A key advancement in OH evaluation is the "Network for Evaluation of One Health" (NEOH), which introduced standardized, systems-based methodologies for assessing OH programs. Using tools like the OH-index and OH-ratio, NEOH enables cross-sector comparisons and quantifies added value across healthcare, agriculture, and veterinary domains (Haxton & Rivière-Cinnamond, 2015; Rüegg et al., 2018). For example, evaluations of brucellosis control in Malta and Serbia revealed cost-saving opportunities through preventive integration (Buttigieg, Savic & Aragrande, 2018). Despite its utility, the NEOH framework remains largely project-focused and seldom addresses long-term economic viability or healthcare system-level sus-

tainability.

OH strategies also align with several EU policy initiatives, including the Farm-to-Fork strategy, the AMR Action Plan, and the European Green Deal. These connections reflect OH's capacity to address interconnected goals in public health, food safety, and sustainability (Bronzwaer et al., 2021; Mazzeo et al., 2022; Taylor et al., 2024). Integrated zoonosis management, for instance, advances both emission reductions and public health objectives (Mazzeo et al., 2022). AMR policies informed by OH principles further demonstrate cross-sector collaboration, as seen in EU Joint Actions (Bronzwaer et al., 2021; Jestin et al., 2021). Nonetheless, while policy coherence is frequently highlighted, few studies incorporate detailed financial modeling or long-term cost-effectiveness analysis linking OH to broader system sustainability (Taylor et al., 2024).

European case studies reinforce both the promise and the limitations of OH's economic case. While AMR surveillance in England and zoonotic monitoring in Switzerland offer strong examples, their lessons are not often translated into systemic or regional healthcare policies (Babo Martins, Rushton & Stärk, 2017; Bennani et al., 2021). Evaluations of OH-informed programs in Malta and Serbia support its utility in disease prevention but highlight difficulties in scaling due to financial and infrastructural disparities (Buttigieg, Savic & Aragrande, 2018; Jestin et al., 2021).

A persistent challenge in OH evaluation is measuring its long-term and indirect economic benefits. Intangible outcomes—such as improved resilience, better risk mitigation, and ecosystem health—are difficult to monetize and often excluded from cost-benefit calculations (Babo Martins, Rushton & Stärk, 2017; Buttigieg, Savic & Aragrande, 2018). This limits the appeal of OH investments, especially in lower-resourced European regions, where

financial constraints complicate adoption. Without models accounting for these regional disparities, scaling OH across the EU may reinforce healthcare inequities (Mazzeo et al., 2022).

In sum, while the OH approach has laid solid conceptual and empirical foundations for multi-sectoral collaboration in health, its integration into sustainable European healthcare systems remains limited. Financial assessments largely remain project-based, rarely addressing broader healthcare infrastructure or systemic resilience. Future research should focus on developing Europe-specific economic models that link OH programs to long-term health outcomes and systemic sustainability metrics.

4. The Role of OH in Supporting the Economic and Financial Sustainability of Healthcare Systems

The OH approach offers a critical framework to support the economic and financial sustainability of healthcare systems by addressing root causes of health challenges, promoting preventive strategies, and fostering cross-sectoral collaboration that optimizes resource use. Healthcare systems in Europe face rising costs and systemic vulnerabilities due to emerging zoonotic diseases, antimicrobial resistance (AMR), pandemics, and climate-related health crises. OH's integrated focus on human, animal, and environmental health not only enables a more holistic response to these challenges but also creates economic opportunities by improving cost-effectiveness, reducing the financial risks of inaction, and supporting sustainable resource allocation.

4.1 Cost-Effectiveness and Public Health Savings

Preventive policies under OH frameworks have consistently been shown to offer significant cost savings compared to reactive approaches. One of the key economic arguments in favor of OH is that investments in prevention at the source, particularly in animal and environmental health sectors, result in a more than proportionally larger reduction in healthcare costs down the line. For example, zoonotic disease control programs that implement preventive interventions, such as livestock vaccinations and hygienic farm practices, reduce the risks of spillover to human populations, thereby limiting the costs of managing zoonotic outbreaks in healthcare systems. Studies such as the evaluation of Campylobacter surveillance in Switzerland highlight these dynamics, finding that integrated OH approaches—while requiring higher up-front investment in surveillance and data sharing—result in more effective risk assessments and better mitigation strategies than siloed interventions, ultimately benefiting both public health and long-term financial sustainability (Babo Martins, Rushton & Stärk, 2017).

Additionally, reducing the prevalence of zoonoses and AMR under OH frameworks help alleviate a significant economic burden on healthcare systems. In Europe, AMR alone costs an estimated €1.5 billion annually in healthcare expenses and productivity losses. OH interventions such as antibiotic stewardship programs in human, veterinary, and agricultural settings not only reduce the spread of AMR but also improve the cost-efficiency of healthcare by limiting the use of expensive, last-line antibiotics and preventing extended hospital stays due to resistant infections (Taylor et Al., 2024). Cost-benefit analyses of specific programs further underscore the advantages of aligning animal and human health strategies; for instance, brucellosis vac-

cination programs in livestock not only protect animal health but also reduce costly healthcare interventions for humans exposed to the disease, as seen in Malta and Serbia (Buttigieg, Savic and Aragrande, 2018).

In the context of large-scale public health crises, OH approaches can prevent outbreaks that cause significant economic disruption. Global economic models cited in OH literature estimate that a $25 billion investment in OH initiatives over a decade could yield approximately $125 billion in benefits by preventing zoonotic pandemics, such as those caused by SARS, Q fever, or Ebola (Grace (2014); Machalaba et Al. (2017)). In Europe, this macroeconomic principle can be applied to develop targeted, regionally focused prevention efforts, potentially averting the economic losses experienced during recent crises like the COVID-19 pandemic.

4.2. Mitigating Financial Risks of Inaction

The OH interventions also serve as a buffer against financial threats and systemic instability generated from lack of action with respect to health problems, resulting from lack of knowledge and the increasing complexity of health causes and effects. Escalating healthcare costs as well as serious economic loss stem from zoonotic outbreaks, antimicrobial resistance, and environmental degradation in the absence of coordinated, preventive measures. Direct healthcare spending as well as indirect productivity loss, loss in trade, loss in tourism, loss in agricultural production, are some economic implications of zoonotic outbreaks. Zoonotic crises, for example, can cause billions of euros in terms of loss in GDP if left unchecked, in addition to requiring emergency injections into healthcare systems not adequately equipped to meet the spikes

in demand.

The OH framework offers financial advantages by shifting from reactive, short-term responses—which are often more expensive—to preventive, long-term solutions that create economic stability. For example, managed zoonotic disease outbreaks have been shown to cost significantly less than uncontrolled ones. In the case of the Netherlands' Q fever epidemic, late human health responses created far greater healthcare costs than if livestock vaccination and control measures had been initiated earlier (Machalaba et Al. (2017); Mazzeo et Al. (2022)). The OH strategies focused on reducing deforestation, urbanization of animal habitats, and intensification of livestock farming also have economic benefits that go beyond healthcare savings by reducing environmental damages and enhancing ecosystem resilience.

In the context of AMR, continued inaction could result in staggering costs to healthcare systems. If AMR rates are left unchecked, projections indicate healthcare systems will face exponentially rising costs from failing antibiotics, with an estimated reduction of €2.5 trillion in global GDP by 2050. The implementation of integrated surveillance and antibiotic stewardship across health, agricultural, and environmental sectors under OH principles mitigate this financial risk by reducing the likelihood of resistant strains emerging and spreading (Bronzwaer et Al. (2021); Jestin et Al. (2021); Mazzeo et Al. (2022)). For European healthcare systems, the proactive implementation of OH measures ensures that resources are targeted at reducing long-term financial burdens, preventing excessive reliance on emergency response funding when systems are overwhelmed.

4.3. Optimizing Resource Allocation and System Resilience

The OH approach inherently supports more efficient and equitable resource allocation across sectors, which is vital for maintaining sustainable and resilient healthcare systems. By coordinating efforts across human, animal, and environmental health domains, OH prevents resource duplication while allowing investments in one sector to generate shared economic benefits across others. For instance, integrated surveillance of antimicrobial usage (AMU) and resistance (AMR)—such as the system implemented in England—illustrates how combining data from human healthcare, veterinary medicine, and agricultural settings improves decision-making, increases cost-efficiency, and enhances operational efficiency for all sectors involved (Bennani et Al., 2021). The pooling of resources across traditionally siloed disciplines maximizes returns on investments and reduces the financial inefficiencies of unilateral action.

The OH approaches also link public health outcomes to broader EU sustainability goals, such as those outlined in the European Green Deal and the Farm-to-Fork strategy. By integrating health, agricultural, and environmental objectives, OH aligns with Europe's larger sustainability agenda. For example, reductions in air and water pollution via sustainable agricultural practices not only contribute to environmental targets but also decrease the burden of pollution-related diseases (e.g., chronic respiratory illnesses), reducing long-term healthcare costs. Programs such as zoonotic disease management under the EU-supported OH European Joint Programme demonstrate the potential for combining cross-sector goals while ensuring that investments in health and sustainability generate compounding benefits (Jestin et Al. (2021); Taylor et Al. (2024)).

From a structural perspective, improved resilience is an additional key economic advantage of OH. By addressing systemic vulnerabilities before they

escalate into crises, OH reduces healthcare system fragility. The COVID-19 pandemic revealed that healthcare systems actively integrating preventive measures are better equipped to handle surges in demand and adapt to sudden changes. The OH approaches focusing on resilience, such as diversified antibiotic stewardship programs and comprehensive disease surveillance systems, ensure that healthcare systems can absorb shocks from zoonotic spillovers or AMR surges without suffering catastrophic economic consequences. Operational efficiencies derived from OH interventions add financial flexibility to healthcare systems, enabling them to direct resources to where they are most needed during emergencies (Babo Martins, Rushton & Stärk (2017); Bennani et Al. (2021)).

4.4. Economic Models and Return on Investment (ROI) for OH

Economic models applied to OH demonstrate the potential for substantial returns on investment (ROI). For example, cost-benefit analyses of integrated AMR strategies routinely illustrate the downstream cost savings generated by early investment in surveillance, education, and regulation targeting antibiotic misuse across human, veterinary, and agricultural sectors (Babo Martins, Rushton & Stärk (2017); Machalaba et Al. (2017); Mazzeo et Al. (2022)). Public health savings are accompanied by societal benefits, such as increased productivity due to fewer workdays lost from zoonotic infections or AMR-associated illnesses, as well as broader benefits to food security, trade, and tourism when animal health improves.

While conceptual economic frameworks propose ROI measurements for OH, there remains a need for locally specific financial models in Europe. Ex-

isting evidence primarily highlights disease-specific returns (e.g., brucellosis prevention (Buttigieg, Savic and Aragrande, 2018)) or global-level projections (Grace (2014); Machalaba et Al. (2017)). Future research must incorporate region-specific regulations, scaled policy impacts, and healthcare system priorities within Europe to better describe the economic contribution of OH to healthcare sustainability.

5. Open Questions and Gaps in Research on the Role that OH Approach can have on Healthcare Systems

The current literature presents worthwhile information regarding economic costs and finance in the OH strategy, centered mainly on cost-effective precautions, prevention measures, and policy consistency. Nonetheless, OH ideas and practices still lack a rigorous theoretical framework, and many crucial questions have not yet been resolved, with significant areas needing a more systematic research agenda to be implemented. What follows is an overview of what are deemed most significant research gaps and future research, as they are grouped under principal unresolved matters.

5.1. Systematically Quantifying the Economic Impact of OH in Healthcare Systems

The economic potential of OH interventions is increasingly recognized in the literature, particularly in areas such as cost savings from zoonotic disease prevention and improved resource allocation for antimicrobial resistance (AMR) surveillance. Studies such as those by Babo Martins, Rushton & Stärk

(2017), Grace (2014), Machalaba et Al. (2017), Mazzeo et Al. (2022), and provide evidence of the value of OH strategies in these domains. However, despite these contributions, there remains a notable lack of systematic and comprehensive financial models that explicitly quantify the economic returns of OH interventions, particularly within the context of European healthcare systems. Much of the existing research is conceptual or based on global case studies, leaving European-specific and healthcare system–focused evaluations relatively underdeveloped.

In addition to measurable economic outcomes, OH interventions are often associated with intangible benefits such as increased system resilience, improved intersectoral collaboration, and enhanced risk mitigation. These aspects are acknowledged in the literature (e.g., Babo Martins, Rushton & Stärk (2017); Rüegg et al., 2018) but are seldom integrated into quantitative analyses. As a result, the full value of OH approaches is likely underestimated in current evaluations.

One major gap in the literature concerns the limited development of detailed economic models tailored to European healthcare systems. While the Swiss case study on Campylobacter surveillance (Babo Martins, Rushton & Stärk, 2017) provides a cost-benefit appraisal, its findings are context-specific and do not generalize to systemic healthcare outcomes at the European level. Similarly, studies such as those by Machalaba et Al. (2017) and Mazzeo et Al. (2022) primarily offer conceptual frameworks without embedding real-world healthcare data into their analyses.

Another underexplored area relates to the range of health threats considered in economic assessments of OH. While zoonoses and AMR remain the dominant focus, there is limited attention to the economic implications of OH initiatives targeting climate-related health conditions, pollution-induced

diseases, and other emerging syndromic threats, particularly within Europe.

To address these limitations, future research should focus on the development of comprehensive economic and financial models that assess both direct healthcare savings and broader systemic benefits from OH interventions. These models should be tailored to the diversity of European healthcare systems and incorporate different regulatory and funding scenarios. Furthermore, methodological innovations are needed to quantify the intangible and long-term benefits of OH, such as using multi-criteria decision analysis or system dynamics modeling. Expanding the scope of economic evaluations to include non-infectious, environmentally driven health threats will also be essential for capturing the full value of OH strategies in an era of global ecological and epidemiological change.

5.2. Barriers to Scaling and Implementing OH Initiatives in an Economically Equitable Manner

The expansion and institutionalization of OH strategies across European healthcare systems encounter significant barriers, particularly concerning economic equity and operational feasibility. Although the literature acknowledges financial and resource disparities among European Union Member States, there is a lack of systematic investigation into how these disparities affect the feasibility and effectiveness of OH implementation at national and subnational levels. For instance, while some contributions (e.g., Buttigieg, Savic, & Aragrande (2018); Mazzeo et Al. (2022)) highlight the risk that wealthier countries may more readily adopt resource-intensive OH interventions, such as advanced antimicrobial resistance (AMR) surveillance, the consequences

for less-resourced countries remain insufficiently explored. This uneven capacity risks reinforcing pre-existing health and infrastructural inequalities within the EU.

Operational challenges also arise in fostering intersectoral collaboration, which is a cornerstone of OH approaches. Studies by Bennani et al. (2021), Haxton and Rivière-Cinnamond (2015), and Rüegg et al. (2018) underscore the necessity of cross-sectoral integration—including cooperation between human health, animal health, and environmental agencies—but typically stop short of offering concrete strategies for overcoming financial fragmentation or misaligned incentives. Issues such as cost-sharing mechanisms, institutional accountability, and governance frameworks remain underdeveloped both conceptually and empirically.

Among the key evidence gaps is the inequity in OH implementation due to resource asymmetries. Wealthier Member States may deploy comprehensive OH initiatives, while lower-income countries are limited to more rudimentary forms of surveillance or intervention, often lacking the infrastructure necessary for intersectoral data integration or coordinated response. This situation not only limits the scalability of OH at the European level but also compromises the efficacy of cross-border public health responses.

In addition, while funding models such as pooled financing and pay-for-performance mechanisms have been proposed (Grace (2014); Mazzeo et Al. (2022)), empirical evaluations of their implementation and effectiveness in real-world European healthcare contexts are virtually absent. Without such assessments, it remains unclear whether these models can guarantee equitable allocation of resources or incentivize meaningful collaboration across sectors and jurisdictions.

Governance also represents a major challenge. Current OH literature of-

fers limited insights into how institutions can align priorities, ensure procedural transparency, and resolve accountability disputes when responsibilities and costs are shared across multiple sectors. The absence of robust governance frameworks weakens the institutional capacity to sustain OH initiatives over time and across diverse political and regulatory environments.

In summary, OH presents a redefined concept of health and envisions a planetary network of individual and shared exposomes, yet it embodies a dual and problematic nature. While it holds potential to advance interspecies equity and ecological resilience, it also risks reinforcing systemic hierarchies akin to those in global markets and digital platforms. To realize its transformative potential, deliberate efforts must address its tendency toward inequality by:

- Promoting epistemic justice and equitable resource distribution.
- Democratizing agenda-setting to reflect diverse priorities.
- Empowering local and regional health systems as autonomous contributors to global health knowledge.

Such intentional recalibration is essential for OH to evolve from a fragmented system into an inclusive, resilient commons that supports the shared future of all life.

Future research should prioritize comparative analyses of regional disparities in OH scalability, particularly between economically divergent Member States or between urban and rural areas within countries. Testing innovative funding mechanisms—such as shared financing pools for zoonotic surveillance or performance-based incentives for AMR reduction—in real-world settings would provide crucial empirical grounding for policy recommendations. Finally, further work is needed to identify and refine governance models that can facilitate the equitable and efficient adoption of OH across Europe, drawing on both successful and unsuccessful implementation cases to inform best practices.

5.3. Strengthening the Alignment of OH with Policy and Sustainability Goals

While the conceptual compatibility between OH and major European policy frameworks—such as the European Green Deal and the Farm-to-Fork Strategy—is frequently acknowledged in the literature (Bronzwaer et Al. (2021); Mazzeo et Al. (2022)), the integration of OH into concrete policy implementation remains underdeveloped. Most existing contributions focus on theoretical synergies, without offering detailed analytical frameworks that link OH interventions to existing EU strategies in terms of cost-effectiveness, implementation logistics, or financial implications for healthcare systems.

Moreover, regulatory misalignments between sectors, such as agriculture, veterinary services, and healthcare, are only superficially addressed. For instance, although Mazzeo et Al. (2022) briefly highlight potential regulatory frictions, a systematic analysis of how intersectoral policy conflicts may impede the adoption or scalability of OH strategies is lacking. This is particularly problematic in contexts where divergent incentives or mandates across sectors hinder coordinated responses to zoonotic risks, antimicrobial resistance (AMR), or environmental health threats.

The current evidence base reveals several significant gaps. First, there is limited operationalization of OH's alignment with EU policy goals; much of the discourse remains at an abstract level, offering little guidance on how OH approaches can be embedded within existing institutional frameworks. Second, no comprehensive evaluations exist that examine the ways in which sector-specific regulations may constrain or facilitate the integration of OH principles. Third, although EU strategies are often referenced in OH discussions, few studies quantify the economic impact of policy-aligned OH interventions—such as estimating healthcare cost savings from preventive mea-

sures inspired by the Farm-to-Fork Strategy.

Addressing these gaps requires the development of robust analytical models capable of demonstrating how OH contributes to EU policy targets—such as greenhouse gas reduction, AMR containment, or biodiversity protection—while concurrently reducing healthcare expenditures and societal costs. These models should assess not only ecological and health outcomes but also the fiscal and administrative feasibility of implementation.

Additionally, empirical case studies examining policy coordination, or lack thereof, between relevant sectors are essential. Such analyses should identify both the enabling conditions and the institutional barriers that shape OH implementation in different regulatory environments. These case studies would offer actionable insights for policy harmonization and intersectoral governance reform.

Finally, targeted pilot programs explicitly linking OH interventions to EU policy instruments—such as subsidies for sustainable farming or Horizon Europe health research funds—could serve as testbeds for evaluating policy alignment in practice. By conducting cost-benefit analyses of these programs, researchers and policymakers could generate the empirical evidence needed to justify broader integration of OH into the European policy landscape and to design mechanisms that promote both public health and environmental sustainability in a fiscally responsible manner.

5.4. Enhancing Evidence-Based Decision-Making Tools and Frameworks for Funding OH Initiatives

Recent years have witnessed considerable progress in the development

of evaluation frameworks for OH, with initiatives such as the Network for Evaluation of One Health (NEOH) contributing to a more structured understanding of OH's systemic value. However, most existing frameworks prioritize qualitative or semi-quantitative assessments of interdisciplinary integration, institutional cooperation, and health system benefits (Haxton & Rivière-Cinnamond, 2015). These approaches, while valuable in articulating the holistic rationale for OH, often lack sufficient integration of financial indicators such as return on investment (ROI), long-term cost projections, or budgetary trade-offs. As a result, their utility in informing resource allocation decisions within healthcare budgeting processes remains limited.

Moreover, current tools offer few capabilities for systematically prioritizing OH interventions based on economic efficiency or comparative cost-benefit analyses. Policymakers operating under fiscal constraints are therefore left with insufficient guidance when evaluating the relative value of competing health, agricultural, and environmental interventions. Tools that facilitate decision-making across sectors—using standardized financial metrics such as cost-effectiveness ratios or ROI estimates—are either underdeveloped or entirely absent in the context of OH evaluation.

This lack of financial integration presents a critical evidence gap. Most existing frameworks, including NEOH, emphasize system-level outcomes and governance quality, but do not align well with the financial criteria typically used in healthcare planning and investment decisions. Furthermore, there is a lack of comparative tools that allow policymakers to evaluate the relative benefits of OH initiatives within broader public policy portfolios, which often involve competing priorities and limited resources.

To address these shortcomings, future development of OH evaluation frameworks should incorporate tools capable of capturing both qualitative

and quantitative dimensions of value. One avenue would be to expand existing frameworks, such as NEOH, to include explicit cost-effectiveness and ROI assessment modules. Such integration would enhance the relevance of these frameworks for budgetary decision-makers and increase their practical applicability in funding allocation processes.

In parallel, the creation of prioritization tools—such as interactive models or simulations—based on real-world European healthcare and environmental data would allow for the comparison of financial viability and trade-offs among various OH interventions. These tools should be designed to operate across policy domains and to reflect the complexity of resource allocation in integrated systems.

Finally, there is a pressing need to establish a standardized evidence base of economic metrics applicable across OH initiatives. The use of consistent financial indicators would facilitate cross-country comparisons, improve transparency in decision-making, and enable the broader scaling of OH strategies within the European Union. By aligning OH evaluation tools more closely with the requirements of evidence-based public finance, it will be possible to advance both the legitimacy and the sustainability of OH investments.

5.5. Measuring and Achieving Long-Term Resilience in Healthcare Systems through OH

The enhancement of health system resilience is often cited as a central justification for the implementation of OH strategies. Several studies (e.g., Babo Martins, Rushton & Stärk (2017); Grace (2014); Rüegg et Al. (2018)) highlight the potential of OH approaches to strengthen healthcare systems'

ability to anticipate, absorb, and adapt to complex health threats, particularly those at the human–animal–environment interface. Nevertheless, the current body of literature falls short of offering robust methodological frameworks for measuring resilience or assessing its evolution following OH integration. Most existing contributions focus on narrow outcomes—such as the cost savings associated with specific surveillance programs—while neglecting broader system-level capacities, such as adaptability to future zoonotic outbreaks or overall reduction in system fragility.

The conceptual link between resilience and financial sustainability, although widely acknowledged, remains underexplored in quantitative terms. Few studies investigate how improvements in resilience resulting from OH interventions may contribute to long-term cost containment, operational efficiency, or resource optimization within healthcare systems. This limits the ability of policymakers to evaluate the strategic return on investment of OH approaches beyond their immediate epidemiological effects.

A critical gap in the literature lies in the absence of well-defined and operationalized resilience indicators within the OH context. Currently, there is no standardized framework for capturing multi-dimensional aspects of resilience—including financial, organizational, and systemic outcomes—that result from OH implementation. Furthermore, while several studies examine disease- or program-specific benefits, such as in the case of Campylobacter surveillance (Babo Martins, Rushton & Stärk, 2017), they do not assess whether such interventions translate into broader improvements in healthcare system sustainability.

Additionally, the interaction between resilience gains and fiscal outcomes remains insufficiently theorized and empirically validated. Without this connection, it is difficult to make a compelling economic case for investing in

OH strategies as a tool for long-term system stability.

Future research should aim to fill these gaps by developing and validating resilience metrics tailored to the OH framework. These indicators should capture both immediate capacities (e.g., response to acute outbreaks) and long-term systemic robustness (e.g., reduced dependence on emergency interventions, improved continuity of care). Longitudinal studies evaluating the system-wide impacts of OH strategies—across domains such as affordability, infrastructure resilience, and care integration—would provide a more comprehensive understanding of their contribution to healthcare sustainability.

Moreover, modeling efforts should be directed toward quantifying how resilience-enhancing OH interventions influence long-term fiscal trajectories in healthcare systems. By linking operational resilience to macroeconomic planning, such analyses would offer critical insights into how OH can serve not only as a health strategy but also as a fiscally prudent investment in the structural stability of European health systems.

6. Concluding Remarks

The OH approach is a new paradigm that promises to be transformative on both the epistemic and the policy making front. As a theory of health as a social merit good emerging from a commons of interdependences and deeper structure of nature and nurture, OH proposes an entirely new way to look at the relationship between humans and the environment, as well as to the whole meaning of life on the planet. As a practical guide to health policies, OH presents great opportunities for fostering economic and financial health

system sustainability through cost savings, financial risk mitigation, resource optimization, and systemic resilience. Integrated, cross-sectoral interventions applied by OH promise to yield large cost savings from prevention of diseases, decrease healthcare and society burdens from threats such as AMR and zoonotic diseases, and bring public health outcomes into alignment with more general sustainable goals. Greater, more holistic economic and financial modeling suited specifically to European health systems, as well as policy and funding mechanisms ensuring fair availability and scalability across all geographical areas, are necessary for more complete realization of OH's economic potential.

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Recensioni

Pippo Ranci (a cura di), *Economia dell'energia. Transizione ecologica e sostenibilità*, Il Mulino, 2025, pp.363, euro 34.

Negli ultimi dieci anni, a partire dagli Accordi di Parigi sul clima del 2015, la questione energetica ha assunto una centralità crescente nelle agende economiche e politiche globali, non solo per il suo peso nelle emissioni climalteranti ma anche come variabile strutturale e abilitante dei modelli di sviluppo economico. La crisi energetica del 2021–22, innescata dalla ripresa post-pandemica ed esacerbata dall'invasione russa dell'Ucraina, ha evidenziato quanto la sicurezza energetica, la sostenibilità ambientale e la competitività industriale siano profondamente interconnesse.

In questo contesto, il volume, a cura di Pippo Ranci, offre un quadro teorico dettagliato delle molteplici dimensioni della questione energetica. L'opera, corale nella struttura e scientificamente rigorosa, raccoglie contributi di economisti, ingegneri, fisici, con competenze multidisciplinari. Il volume si articola in quindici capitoli, organizzati in quattro sezioni, secondo una logica che segue il ciclo dell'energia dalle sue basi teoriche fino alle politiche pubbliche. Le sezioni sono così distribuite:

- la prima sezione (capitoli 1-3) inquadra il contesto: chiarisce perché l'energia è una variabile strutturale dell'economia contemporanea, ricostruisce l'evoluzione storica del

settore, analizza le trasformazioni istituzionali e l'affermazione delle politiche europee;
- la seconda sezione (capitoli 4-8) è dedicata alle fonti di energia, fossili e rinnovabili: descrive le tecnologie, i costi, l'evoluzione del mix energetico e le sfide ambientali;
- la terza sezione (capitoli 9-11) tratta i servizi energetici, ossia l'utilizzo finale, le reti, i mercati, la regolazione e l'evoluzione della domanda;
- la quarta sezione (capitoli 12-15) affronta le politiche pubbliche: dalla fiscalità ambientale alla governance multilivello, dall'industria alla giustizia climatica.

Uno dei principali pregi del volume è il modo in cui l'energia viene trattata, non come un comparto settoriale, ma come cerniera tra economia e ambiente.

Le dinamiche di produzione e consumo di energia sono oggi ampiamente riconosciute come motore – o freno – delle strategie climatiche globali, influenzando crescita e occupazione. La struttura stessa del libro consente di osservare come le scelte energetiche influiscano su differenti aspetti del benessere collettivo: l'efficienza delle risorse, l'equità intergenerazionale e la competitività industriale. In tal senso, l'impianto concettuale sottostante è riconducibile all'identità di Kaya (Y. Kaya, (1990). "Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios"), che scompone le emissioni climalteranti in quattro variabili: popolazione, PIL pro capite, intensità energetica e intensità carbonica. Si tratta di una visione che consente di comprendere come le dinamiche energetiche plasmino simultaneamente i costi economici e quelli ambientali, determinando gli esiti della transizione energetica. A questa impostazione si collega anche la nozione di decoupling, ovvero la possibilità di disaccoppiare la crescita economica dal consumo di risorse naturali.

La prima sezione del volume (capitoli 1–3) fornisce le fondamenta concettuali per comprendere la centralità dell'energia nell'economia contemporanea. La sezione si apre con la descrizione del bilancio energetico dell'Italia, dalla produzione ed importazione di energia primaria alla trasformazione in energia per uso finale. Viene poi ripercorsa con rigore l'evoluzione dell'energia come fattore di produzione, evidenziando come ogni fase dello sviluppo capitalistico sia stata accompagnata da un diverso paradigma industriale: dal carbone della rivoluzione industriale, al petrolio del XX secolo, fino alle rinnovabili come prospettiva per il XXI. Accanto all'analisi storica, la sezione approfondisce il tema dell'integrazione europea. Uno dei maggiori meriti di questa parte risiede proprio nel chiarire il ruolo delle politiche comunitarie nella costruzione di un mercato integrato dell'energia. Il volume illustra come le politiche energetiche europee, nate inizialmente per esigenze di mercato interno e concorrenza (in particolare nel settore elettrico e del gas), abbiano progressivamente assunto una funzione climatica e ambientale, evolvendo in una cornice normativa orientata alla decarbonizzazione. Importante è anche l'attenzione rivolta alle trasformazioni regolatorie a livello nazionale. Viene ben illustrato il passaggio dalla monopolizzazione pubblica dei servizi energetici a una struttura liberalizzata e regolata, a partire dagli anni Novanta in Italia. La sezione chiarisce, inoltre, come l'energia non possa essere compresa se non all'interno di una riflessione sulle interdipendenze globali: flussi commerciali, catene del valore, asimmetrie geopolitiche.

La seconda sezione del volume (capitoli 4–8) è dedicata alle fonti di energia. Vengono analizzate tutte le fonti fossili (gas naturale, carbone, petrolio), le rinnovabili (solare, eolico, idroelettrico, geotermico, bioenergie) e, con attenzione mirata, il nucleare. Per ciascuna fonte vengono

fornite indicazioni precise sui livelli di produzione attuali e le dinamiche di costo (con riferimento al LCOE, *Levelized Cost Of Energy,* costo medio per unità di energia prodotta da un impianto nel corso del suo ciclo di vita utile). Il volume approfondisce anche il ruolo delle rinnovabili intermittenti e la conseguente importanza delle tecnologie di accumulo energetico e di gestione della flessibilità. Le diverse opzioni di stoccaggio sono spiegate in dettaglio, e viene evidenziato come la loro evoluzione costituisca un fattore abilitante per l'integrazione delle fonti non programmabili nella rete elettrica. L'esposizione si avvale di dati tecnici (come le ore equivalenti di funzionamento e i costi marginali) e include anche una lettura della variabilità giornaliera e stagionale della domanda elettrica, mediante l'analisi di curve reali di carico in Italia. Questo consente di comprendere con precisione il problema del bilanciamento e le sfide operative che la transizione impone al sistema elettrico. Di particolare interesse è l'attenzione posta al tema del carico residuo, analizzato tramite la cosiddetta "curva dell'anatra". Attraverso serie storiche recenti (2019-2023) si mostra la crescente penetrazione delle rinnovabili nelle ore centrali della giornata e l'effetto depressivo sui prezzi di mercato, fino a casi di prezzi negativi. Questa evidenza empirica è letta in relazione ai meccanismi del mercato elettrico (ordine di merito, costi marginali, mercati infragiornalieri).

La terza sezione del volume (capitoli 9–11) tratta i servizi energetici, ovvero l'utilizzo finale dell'energia, la gestione delle reti infrastrutturali, la regolazione dei mercati. Si tratta di una parte cruciale del sistema energetico, in cui si realizzano – o si incagliano – le ambizioni di efficienza, equità e sostenibilità della transizione. Il valore aggiunto di questa sezione è la capacità di articolare una lettura tecnica e istituzionale delle infrastrutture energetiche, riuscendo a garantire una piena comprensibilità per un

pubblico anche non specialistico. Le curve temporali di domanda, le variazioni stagionali e orarie, l'evoluzione della domanda elettrica dei settori civili e industriali e l'importanza della domanda flessibile sono analizzate in rapporto alla crescente incidenza delle fonti rinnovabili e alle nuove esigenze di bilanciamento. Vengono descritte in dettaglio le modalità con cui l'elettricità è gestita nel tempo reale attraverso i diversi mercati: mercato del giorno prima, infragiornaliero, di bilanciamento, nonché le funzioni del dispacciamento e dei servizi ancillari. Le logiche dell'ordine di merito e della formazione dei prezzi marginali sono spiegate con chiarezza, così come il ruolo di attori pubblici (sia regolatori che gestori), o il funzionamento del *capacity market* per assicurare la stabilità del sistema nei momenti critici. Particolare rilievo è dato all'importanza delle infrastrutture, che non sono solo "supporti" fisici, ma veri e propri nodi strategici nella transizione: la sezione mette in luce come la disponibilità di rete, la qualità della distribuzione locale, la digitalizzazione dei sistemi di monitoraggio e la capacità di accumulo siano tutti fattori che incidono direttamente sull'efficienza, la resilienza e l'equità del sistema. Una novità di grande interesse è rappresentata dalla trattazione delle Comunità energetiche rinnovabili (CER), illustrandone vantaggi, limiti e sostenibilità nel tempo. Si tratta di un campo emergente, ma cruciale per l'inclusione delle comunità locali e per il rafforzamento della coesione territoriale.

La quarta e ultima sezione (capitoli 12–15) si concentra sulla transizione dei sistemi energetici e le politiche di supporto. Viene dapprima posta l'attenzione sull'efficientamento energetico e la traslazione del sistema energia verso l'elettrico, con le sue implicazioni industriali, residenziali e modale. Gli ultimi capitoli guardano al futuro. Dalle visioni prospettiche dello IEA (International Energy Agency) e dell'IPCC (International

Panel On Climate Change), si passa ad analizzare le recenti politiche industriali a supporto della transizione: vengono discusse le strategie di riconversione delle filiere produttive e il sostegno all'innovazione tecnologica. Non mancano i riferimenti alla *green finance* e al gap di investimenti per raggiungere gli obiettivi al 2050 Net Zero. Infine, viene affrontato in modo esplicito e approfondito il tema della giustizia climatica e sociale, che attraversa trasversalmente tutta la sezione. Le politiche pubbliche sono qui lette non come strumenti neutri, ma come scelte conflittuali, che implicano un trade-off tra territori, classi sociali e generazioni future. La transizione, per essere equa, richiede politiche redistributive, meccanismi di compensazione per le fasce vulnerabili, partecipazione democratica e una forte attenzione ai costi sociali della decarbonizzazione.

Il volume "Economia dell'energia" merita di essere assunto come manuale di riferimento nei corsi di economia dell'energia, *green economics*, scenari e politiche energetiche, che oggigiorno trovano sempre più interesse e diffusione nell'offerta universitaria nazionale.

Massimiliano Parco

Mariano Bella (a cura di) *Sense of Italy - Esportazioni, servizi, turismo, prosperità*, Il Mulino, Bologna, 2025, pagg.296, Euro 29,00

Nell'illustrazione economica dell'Italia si avverte in modo sempre più marcato l'insufficienza di un parametro di riferimento generalistico, quale il "Made in Italy", ai fini di una rappresentazione adeguata del mondo dei servizi. Una carenza decisamente grave, considerata anche la vocazione operativa del nostro Paese in certi settori di attività economica, uno fra tutti il turismo.

Questo aspetto problematico viene affrontato in modo metodologico e costruttivo nel libro curato da Mariano Bella, Direttore dell'Ufficio Studi di Confcommercio, nel tentativo, a mio avviso, riuscito di rispondere a quell'esigenza con un'adeguata sistematizzazione concettuale, suffragata da coerenti riscontri empirici e statistici.

È ormai tempo, come sottolinea nella Prefazione il Presidente di Confcommercio Imprese per l'Italia, Carlo Sangalli, che si passi dal "Made in Italy" al "Sense of Italy" – SofI; un concetto ben più ampio, che certifica lo spostamento del focus di attenzione "dalla limitata suggestione di fruizione di un prodotto alla valorizzazione del mondo culturale che esso veicola". Un'operazione concettuale, che non può essere banalizzata dall'uso di slogan o di un semplice marchio che appare su un'etichetta, ma che, invece, tende a fotografare in modo puntuale la nostra identità culturale nelle sue molteplici implicazioni.

Un'operazione culturale, che, come ribadito dal curatore del libro nelle pagine dell'Introduzione, superando l'ormai sterile discussione frutto della contrapposizione tra settori economici (manifattura vs servizi), punta con decisione a rendere più produttivi i servizi di mercato, nell'ambito di un processo di terziarizzazione, che investe tutte le

economie del mondo avanzato e non avanzato.

L'articolazione del volume riflette fedelmente questa impostazione concettuale nei contributi scritti dal curatore, oltreché dagli altri firmati da qualificati esperti, che qui si ricordano (in ordine alfabetico): Federico D'Amario, PhD Intern presso la Bank of England e collaboratore esterno dell'Ufficio Studi di Confcommercio; Silvio Di Sanzo, Senior Economist presso l'Ufficio Studi di Confcommercio; Riccardo Grassi, sociologo Head of Research di SWG; Alberto Hidalgo, Visiting Professor di Economia presso l'Università delle Isole Baleari; Mara Manente, Consigliere del Touring Club Italiano; Luciano Mauro, Economista Senior dell'Ufficio Studi di Confcommnercio; Pasquale Mirante, Analista economico presso l'Ufficio Studi di Confcommercio; Massimo Riccaboni, docente di Economia applicata presso la Scuola IMT di Lucca; Alessandro Rinaldi, Vice Direttore Generale e Direttore Studi e Statistiche del Centro Studi delle Camere di Commercio, Guglielmo Tagliacarne; Francesco J. Velazquez docente presso il Dipartimento di Economia Applicata e strutturale presso l'Università Complutense di Madrid.

Nei primi tre capitoli, pertanto, ci si sofferma ad illustrare il significato di SofI e a misurarne la dimensione con una contestualizzazione nella nostra realtà nazionale, valutata nei suoi aspetti di positività e criticità. Viene, così, delineato un percorso concettuale nel quale ampio spazio è riservato alla descrizione delle strutture produttive del SofI, mettendone in evidenza le peculiari caratteristiche di creazione di valore aggiunto e di internazionalizzazione del marchio Italia, in una sinergia tra beni e servizi, in cui la seconda componente si rivela "fondamentale per il posizionamento strategico e competitivo del Made in Italy".

Nel capitolo successivo, conseguenza naturale di questa impostazio-

ne concettuale è l'attenzione riservata al tema del turismo e alle sue evidenze statistiche per meglio comprendere la complessità di questo fenomeno, così importante per il nostro Paese, il suo impatto sul sistema economico e la connessa difficoltà di una sua rappresentazione fedele all'effettiva realtà fattuale.

Legata al tema del turismo è, poi, nel capitolo quinto, la trattazione dell'overtourism, un fenomeno sempre più presente e diffuso, come testimoniato dalle numerose cronache giornalistiche e che peraltro non può essere banalizzato e liquidato con analisi superficiali e considerazioni "coloristiche"; ma merita di essere affrontato in modo scientifico, avvalendosi di adeguati supporti statistici e di significativi raffronti nazionali (il panel di riferimento è inclusivo di 120 città italiane, oltre a un focus su 114 quartieri di Roma) ed internazionali. Infatti, nel libro viene fatto uno specifico riferimento alla situazione di Madrid, destinazione particolarmente coinvolta nei flussi di turismo, capitale di un Paese che si colloca al secondo posto a livello globale per numero di turisti internazionali.

A completare gli elementi di valutazione nel capitolo sesto sono offerte al lettore annotazioni, particolarmente, interessanti sulle propensioni, le scelte, e la spesa dei viaggiatori, così come risultano dalle rilevazioni periodiche dell'Osservatorio Confcommercio - SWG.

Le pagine finali di questo libro tornano ad affrontare alcune delle questioni cruciali emerse lungo il suo percorso intellettuale e metodologico: dal ruolo delle imprese che operano nel settore dei servizi di mercato e non sono considerate esportatrici; alle modalità per favorire la crescita delle imprese del terziario, ovviando al pericolo di un temibile nanismo imprenditoriale; alla opinabile ragionevolezza di effettuare raffronti delle variazioni nel tempo della produttività del lavoro tra settori interessati da variazioni radicalmente differenti

nell'input di lavoro.

Questioni e relativi interrogativi sui quali, già da oggi e nel prossimo futuro, bisognerà fare i conti nella prospettiva di approfondire ed ulteriormente affinare quanto emerso meritoriamente dal percorso tracciato da questo libro per una rappresentazione più significativamente reale e fedele del terziario in Italia. E per porsi in modo coerente in questo nuovo scenario occorrerà, in definitiva, un cambio di passo ideologico, utile certamente a soddisfare le esigenze concettuali in precedenza illustrate ed anche ad indicare la via più adeguata per adottare le best practises, indispensabili a favorire e gestire il salto di qualità socio - economico del Paese.

Filippo Cucuccio

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ECONOMIA ITALIANA 2025/2

Le sfide per il Sistema Sanitario Nazionale

Questo numero, **editor il prof. Vincenzo Atella** (Università di Roma Tor Vergata), analizza le sfide cui si trova davanti il sistema sanitario italiano. Negli ultimi quattro decenni, i sistemi sanitari nazionali sono stati investiti da trasformazioni di portata storica che ne hanno profondamente modificato il ruolo, le funzioni e le modalità operative. **Il Servizio Sanitario Nazionale (SSN) italiano si trova in una fase critica, alle prese con l'impellente necessità di riformarsi in risposta alle sfide poste dal cambiamento, sinora trascurate:** invecchiamento della popolazione, innovazione tecnologica, carenza di risorse, cambiamenti di paradigmi clinici ed organizzativi e disuguaglianze socioeconomiche.

Decenni di innovazione medica hanno cambiato rapidamente il panorama, ma il quadro organizzativo del SSN è rimasto indietro, con conseguenti inefficienze e disparità nell'assistenza. Per garantire un'assistenza sanitaria di alta qualità, equa e sostenibile per le generazioni future, gli autori sostengono che il SSN debba essere sottoposto a riforme complete. Questi cambiamenti dovrebbero allineare il finanziamento dell'assistenza sanitaria, l'erogazione dei servizi e la pianificazione del personale alle moderne capacità mediche e alle esigenze di salute della popolazione. È essenziale un approccio lungimirante, che riconosca l'evoluzione congiunta della politica sanitaria e della scienza medica e garantisca che l'adattamento istituzionale sia in linea con le realtà della medicina contemporanea. Affrontando queste sfide, il Servizio sanitario nazionale può trasformare i suoi meccanismi di erogazione dei servizi e mantenere il suo impegno a fornire un'assistenza sanitaria equa per tutti.

I saggi contenti nel numero affrontano svariate questioni. Nel primo saggio l'editor spiega **le ragioni che rendono urgente una riforma del SSN:** *"The Urgent Need for an NHS Reform: Adapting to Overlooked Years of Transformation in Healthcare"* (Atella). Si prosegue poi per temi: **l'innovazione tecnologica,** *"Digital Disruption in Healthcare: What It Means for the NHS"* (Atella e Chiari); **il finanziamento della sanità pubblica** (Atella, Cincotti, d'Angela, Polistena e Spandonaro); **le disuguaglianze sanitarie** *"L'evoluzione delle disuguaglianze di salute in Italia (1984-2023)"* (Atella, De Luca, d'Angela, Maresch, Polistena e Spandonaro); **l'utilizzo dei dati sanitari e le regole della privacy,** *"Optimizing Population Health Through Strategic Use of Health Data"* (Atella, Ganna, Lombardi); **rafforzare la resilienza del sistema sanitario** *"The One Health (OH) Approach and the Sustainability of Healthcare Systems"* (Atella e Scandizzo).

ECONOMIA ITALIANA nasce nel 1979 per approfondire e allargare il dibattito sui nodi strutturali e i problemi dell'economia italiana, anche al fine di elaborare adeguate proposte strategiche e di *policy*. L'Editrice Minerva Bancaria è impegnata a portare avanti questa sfida e a fare di Economia Italiana il più vivace e aperto strumento di dialogo e riflessione tra accademici, *policy makers* ed esponenti di rilievo dei diversi settori produttivi del Paese.

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