UNIVERZA V LJUBLJANI, SLOVENIJA
UNIVERSITY OF WARWICK, UNITED KINGDOM

HATIDŽA SERDAREVIĆ
ABDULLAH ACHKAR
SAKINA LOKHANDWALA
LEON GORŠE
WILLIAM BEVAN
EVA SOLWAY

EUTOPIA 2035: YOUTH PERSPECTIVES ON THE FUTURE OF EUROPEAN HEALTHCARE

Ljubljana, 2025

This work stems from the EUTOPIA TeamWork 2025 programme, part of the EUTOPIA Alliance's Erasmus+ EUTOPIA MORE project, which is a European Universities initiative. The Alliance is a learning and research community made up of ten European universities. It was founded to actively engage in the development and renewal of the common European Higher Education Area. A particular emphasis is placed on actively involving stakeholders at various levels – local, regional, national, and international. This approach ensures a wide-ranging and inclusive method for both education and involvement within the community.

ACKNOWLEDGMENT

The completion of this research paper would not have been possible without the support and guidance of prof. dr. Igor Švab, dr. med., the Dean of the Faculty of Medicine at the University in Ljubljana. Special thanks also to Jelena Ličanin, the Head of Career Centres at the University of Ljubljana and the student's mentors in alphabetical order: Aljaž Prevolšek, Janez Bernik, Janko Burgar, Jure Brankovič and Žana Voh.

Authors:

Hatidža Serdarević, University of Ljubljana, Slovenia

Abdullah Achkar, University of Warwick, United Kingdom

Sakina Lokhandwala, University of Warwick, United Kingdom

Leon Gorše, University of Ljubljana, Slovenia

William Bevan, University of Warwick, United Kingdom

Eva Solway, University of Warwick, United Kingdom

Index

Abbreviations

AI - Artificial Intelligence

AMR - Antimicrobial Resistance

DGM - Deep Generative Models

EIP on AHA - European Innovation Partnership on Active and Healthy Ageing

EHDS - European Health Data Space

EU - European Union

EUTOPIA - European Universities Transforming to an Open Inclusive Academy

FFS - Fee-for-Service

GDP - Gross Domestic Product

GDPR - General Data Protection Regulation

MTI - Multimodal Training Intervention

NCD - Non-Communicable Diseases

NGS - Next-Generation Sequencing

NHS - National Health Service

OECD - Organisation for Economic Co-operation and Development

PPPs - Public-Private Partnerships

PROMs - Patient-Reported Outcome Measures

SDGs - Sustainable Development Goals

WHO - World Health Organization

WSD - Whole System Demonstrator

1 Summary

The study presents a forward-looking vision for a reimagined European healthcare system shaped by the values and expectations of younger generations. It begins by critically examining existing structural shortcomings within EU healthcare, particularly issues of fragmentation, unequal access, and inconsistencies in healthcare quality across member states. The need for a harmonized and resilient system is positioned as an urgent priority in the context of both recent global health crises and long-term demographic and environmental shifts.

Central to the study is the articulation of guiding principles for the transformation of healthcare by the year 2035. These principles include equity, sustainability, digital advancement, and a holistic, patient-centered approach. The study highlights the importance of moving beyond reactive models of care toward systems that actively promote physical, mental, and social well-being. A substantial portion of the discussion is dedicated to digital innovation, including the integration of telemedicine, artificial intelligence, and interoperable electronic health records. These tools are identified as essential to improving care efficiency and accessibility, while the study also acknowledges the risks associated with digital exclusion and emphasizes the importance of data protection and digital literacy.

Public health and preventive care are presented as foundational elements of the envisioned future. The study advocates for a shift in policy focus toward addressing social determinants of health, promoting healthy behaviors from an early age, and embedding prevention into routine care structures. Interdisciplinary collaboration—linking healthcare providers, educators, policymakers, as well as researchers and industry workers—is emphasized as vital to the success of these reforms.

Mental health is another key area of focus. The study underscores the need for mental health services to be normalized, destigmatized, and fully integrated into general healthcare frameworks. In parallel, environmental sustainability is discussed as a critical concern, with

recommendations for the adoption of climate-conscious policies and infrastructure within the healthcare sector.

The study concludes by emphasizing the essential role of youth as active stakeholders in the development of healthcare policy and systems. Rather than being passive recipients of care, young people are portrayed as co-creators of the healthcare landscape of the future. Through this perspective, the study offers a hopeful and strategic outlook, envisioning a 2035 healthcare system that is equitable, technologically advanced, environmentally responsible, and responsive to the evolving needs of all EU citizens.

2 Introduction

The European healthcare system has reached a pivotal juncture. Shaped by demographic shifts, technological advancements, and ever-evolving geopolitical and economic challenges, it demands a bold reimagination. "Europia 2035: Youth Perspectives on the Future of EU Healthcare" presents a visionary yet actionable blueprint for a sustainable, equitable, and innovative healthcare system by 2035. This report, crafted through the lens of Europe's youth, addresses critical themes—governance, digitalisation, technological innovation, prevention, equity, and financing—proposing transformative steps to shift from reactive care to proactive well-being. By illustrating our vision for healthcare in Europe in 2035 and analysing current trends pointing to what we believe are the most prominent issues, we have crafted a set of forward-looking steps to achieve this. We call on policymakers and healthcare leaders to transform the existing healthcare system to be more resilient and prioritise patient-centred outcomes, universal access, and climate-conscious practices by leveraging AI, genomic medicine, and cross-sectoral as well as cross-border collaboration. Our solutions craft our vision for the future, where healthcare is not just a service but a cornerstone of societal vitality.

3 Methodology

This report, titled Youth perspectives on the future of European healthcare, aims to present a comprehensive and forward-looking view of what healthcare in Europe could and should look like in the near future - particularly from the standpoint of younger generations. To achieve this, our team undertook a collaborative, qualitative research process centered around independent exploration, online literature review, and future scenario building.

The report was developed through a multi - phase approach, beginning with the identification of six key areas we believed to be essential for understanding the challenges and opportunities facing European healthcare in the coming years: 1) Governance in Healthcare & Health Policies in Europe, 2) Digitalization in Healthcare, 3) Technological Innovations in Healthcare, 4) Health Promotion and Disease Prevention, 5) Equity and Access to Healthcare, and 6) Healthcare Financing and Economics. Each group member took responsibility for one of these topics, ensuring a more focused and in-depth exploration of each subfield.

The research was conducted entirely online, utilizing a range of secondary sources. These included academic articles, health policy documents, governmental and intergovernmental reports (from bodies such as the European Commission, WHO, and OECD), white papers, publications from think tanks, and news articles from credible media outlets. The selection criteria for sources prioritized their credibility, recency (with most sources dating from 2018 onward), and relevance to the healthcare topics being examined. We also considered the diversity of perspectives - incorporating viewpoints from policymakers, researchers, healthcare professionals, and patient advocacy groups.

In parallel with gathering current data and policy analyses, we also studied emerging trends and innovations in the healthcare sector, including AI, digital twins, and personalized medicine. This helped inform our visioning process and allowed us to propose realistic, yet ambitious ideas for the future. Scenario thinking and backcasting were used as tools to imagine how specific innovations or systemic changes might evolve by 2035, and to reflect on the steps necessary to make those visions possible. While our ideas are future - oriented and occasionally speculative, they are grounded in current developments and technological capabilities already in progress.

Throughout the research and writing process, collaboration played a key role. Regular team meetings were held every week to align on tone, structure, and content. We gave each other feedback, discussed how our topics intersected, and looked for overlapping themes, such as the role of data in both technological innovation and health equity. During the week we also communicated through different online platforms to make sure we're on the right path and to resolve any issues that would come up. This helped us create a more unified final product with natural connections between sections.

Given the scope of the report, we acknowledge several limitations. Our work relied exclusively on publicly accessible materials and did not include any primary research, such as interviews, focus groups, or surveys. The visions for 2035 are necessarily speculative, though they are based on factual groundwork and expert discussions in the fields we covered. Furthermore, due to the collaborative nature of the report and differing research styles among group members, there may be some variation in the depth and detail across sections. Nonetheless, we believe that this diversity of perspectives enriches the report and mirrors the complexity of real - world healthcare systems.

In summary, the methodology behind this report involved exploratory desk research, collaborative topic division, and forward - thinking scenario creation. It reflects not only our interpretation of current health system dynamics but also our collective hopes and expectations for a more accessible, technologically advanced, and equitable European healthcare system in the future.

4 Healthcare Themes

Healthcare is a multifaceted and ever-evolving field, and breaking it down into six key themes provides us with a clear framework for understanding the most critical areas for improvement.

G*overnance in Healthcare & Health Policies in Europe* highlights the importance of effective governance and well-structured policies that ensure the healthcare systems remain efficient, equitable, and adaptable to emerging challenges across Europe.

Digitalization in Healthcare focuses on the integration of digital tools, such as electronic health records and AI-driven diagnostics, which would enhance efficiency, accuracy, and coordination in healthcare delivery.

Technological Innovations in Healthcare deals with advancements like precision medicine, wearable devices, and robotic-assisted procedures that are transforming treatment outcomes and empowering patients to take control of their health.

Health Promotion and Disease Prevention centers around how genome sequencing could improve the quality of our lives and reduce the burden of chronic diseases and healthcare costs.

Equity and Access to Healthcare concerns itself with equal access to quality care that requires addressing financial, geographic, and systemic barriers that disproportionately affect marginalized and rural populations.

Healthcare Financing and Economics explores sustainable healthcare financing models, such as value-based care and balanced public-private investments, which are essential for long-term affordability and system resilience.

While all of the themes bring unique insights, together they provide a comprehensive blueprint for a reimagined healthcare system. The overlap between them underscores the interconnectedness of the healthcare reform that we propose.

4.1 Governance in Healthcare & Health Policies in Europe

4.1.1 Current Trends

European healthcare governance is at a critical turning point, facing demanding challenges from demographic shifts, post-COVID-19 constraints, and geopolitical trade-offs (e.g., defence spending vs. healthcare budgets [1,2]). European health policies respond through 20 guiding principles focused on reliance, equity, and digital transformations [1]. Key initiatives include the One Health approach, commitment to achieving the Sustainable Development Goals (SDGs), or negotiating a legally binding pandemic agreement to ensure better response coordination in the future [1]. There are also significant efforts to battle non-communicable diseases, which represent an astounding 90% of EU deaths (and 68% of premature deaths), such as the Beating Cancer Plan [1]. While appreciating these are already in place, there is still much more to be done to address critical challenges emerging.

Governance/Systemic Challenges

European healthcare spending is increasing in most countries, with a spike in COVID-19, but the percentage of GDP allocated to healthcare has stabilised or even fallen in some countries, causing a trade-off between healthcare and other critical sectors such as defence spending [1,2]. NATO's 2% GDP defence target competes with health budgets [2], while energy crises and inflation threaten universal systems [3]. Europe's sluggish economic growth, high public debt levels, and global competitiveness challenges further strain healthcare budgets and bring challenges for policymakers and healthcare organisations [4] as they need to reassess priorities.

Furthermore, climate change is threatening future quality of life, bringing more frequent and violent tropical storms, heat waves, droughts, and floods and adding an expected 250,000 annual deaths from malnutrition, malaria, diarrhoea, and heat stress globally between 2030 and 2050 [5]; the European Commission has a Green Deal that begins to address this [6].

The debate between private and public healthcare systems in Europe reflects border challenges in governance, funding, and equity. With public and private systems having their pitfalls, many countries, such as Spain and Italy, have introduced public-private partnerships (PPPs) to improve efficiency and expand capacity, aiming to leverage private sector innovation and investment while maintaining public oversight to ensure equitable access [7].

Affordability Challenges

High out-of-pocket costs disproportionately affect low-income households despite universal healthcare efforts, only exacerbated by cost-of-living crises. Within countries, there is a noticeable pattern of households in higher income brackets investing more money in improving their own health, while those in lower income brackets will have persisting unhealthy lifestyles, have fewer resources for improving their well-being, and more so lack healthcare literacy. Moreover, these households are also more vulnerable to lifestyle risk factors, including smoking, alcohol use, and obesity. 18% of adults still smoke daily, and 20% engage in heavy drinking, highlighting the magnitude of this issue [1,8].

Furthermore, rising healthcare costs and supply chain disruptions from geopolitical pressures threaten healthcare affordability. The EU is working on greater self-sufficiency in pharmaceutical and medical supply chains to reduce reliance on international markets [2,3].

Accessibility Barriers

A severe and building workforce shortage threatens access to care, with 20 EU countries reporting shortages of doctors in 2022 and 2023. Over one-third of doctors and one-quarter of nurses in the EU are over 55 years old and nearing retirement [1]. While countries increasingly rely on foreign-trained professionals (e.g., Germany had around 14,000 foreign-trained physicians waiting to get their medical credentials recognised when the pandemic broke out), representing an unsustainable pattern [1,9].

There persists significant inequality between European countries, with an 8-year life expectancy gap due to differences in access to quality healthcare; for example, cardiovascular diseases and cancer cause 7 times higher mortality rates in some Eastern European nations compared to Western nations [1,5].

Rising mental health concerns, obesity, and unhealthy lifestyle impacts across Europe call for better mental health services and lifestyle interventions, particularly for young people. Psychological distress increased due to social media exposure and post-pandemic effects, yet mental health services remain underfunded.

War, particularly in Ukraine, has the power to significantly impact health policies in Europe. With large-scale migrations as well as the displacement of over 6 million Ukrainians, pre-existing health system challenges have been exacerbated in refugee-receiving countries, necessitating adaptable health responses. With the demographic of refugees primarily women, children, and elderly, migration has created more complex health needs, including noncommunicable diseases, infectious diseases, mental health issues, and sexual/reproductive health concerns. With language differences and workforce shortages, host countries struggle to integrate these populations into their health systems (legislation modification giving access to national healthcare is facilitated by the EU's Temporary Protection Directive) [5].

Availability Constraints

With healthy life expectancy growing slower than life expectancy itself in most EU countries, we have a new threat of increasing frailty in Europe, harming the welfare of citizens [9] and increasing demand for healthcare. Europeans over 65 is expected to reach 29% by 2050, and many older adults are living with chronic conditions requiring long-term care, representing a growing structural issue in most developed countries [1]. While AI and telemedicine are expanding healthcare services, rural and lower-income regions struggle with limited digital infrastructure and broadband access, hindering availability and adoption [1,7]. Additionally, cybersecurity risks and privacy concerns pose significant challenges to digital health tools. The European Health Data Space (EHDS) aims to improve cross-border access to medical records, enhancing patient mobility and continuity of care. However, these benefits may be limited by disparities in digital infrastructure and cybersecurity threats, particularly in underserved areas.

European health policy is beginning to bring focus to antimicrobial resistance (AMR), as it causes 35,000 deaths. Stronger disease surveillance and emergency response are needed to prepare for this growing crisis [1,10].

4.1.2 2035 Vision

Some current trends we see do not give the most promising indicators, and there is a clear trade-off between advancing healthcare and other government spending pathways such as defence, as previously discussed. While keeping this in mind, a new healthcare approach is needed that is sustainable and cost-effective to ensure Europe sustains its health, well-being, and productivity. With inflation and cost of living crises increasing out-of-pocket costs, the transition to a more sustainable healthcare model is only becoming more vital.

Preventive care

There will be a greater focus on preventative care than the current reactive-treatment model, as in 2018, preventive care only accounted for 2.8% of total health expenditure [13]. With challenges in aging populations, climate change, and the rising burden of non-communicable diseases, there is a growing strain on healthcare systems, rendering the reactive-care model unsustainable. In 2035, we will see earlier diagnosis as a result of a proactive, preventive care model with a focus on early diagnosis, health promotion, and disease prevention. As a result, the burden from an aging population will be lessened, with people educated on how to age in a way that reduces their likelihood of requiring long-term care. AMR will also have a reduced burden with preventive care with a more healthcare-literate population.

Rising defence spending due to geopolitical tensions (e.g., Russia-Ukraine war) and economic pressures (e.g., inflation, high public debt) are diverting resources from healthcare, as mentioned earlier. Preventive care, reducing costs of healthcare systems, will allow for more flexibility when it comes to migrationary shocks, for example, or others.

There is a call to address the rise of non-communicable diseases (NDCs), given they account for a staggering 90% of EU deaths [14]. Intervening early rather than focusing on treatment is more cost-effective and would provide better outcomes for individuals in Europe suffering from cardiovascular disease, cancer, kidney diseases, mental health conditions, and other NDCs [15]. ‘Active Aging’, for example, is becoming a heavily discussed topic in politics and will be important to encourage to extend independent living as much as possible to maximise the welfare of a population with an increasing prevalence of frailty [15].

Looking into the future, climate destabilisation will create new threats related to more extreme heat, the spread of infectious diseases, and air pollution, adding to the complexity of predicting the future of healthcare systems [12]. These patterns only reinforce the need for a preventive rather than reactive structure, particularly given the cost savings this would create. Every €1 spent on health promotion and disease prevention yielded a €14 return to the economy, according to a 2017 review [13]. A renewed emphasis on green healthcare practices in hospitals would help the healthcare industry reduce its contribution to the climate crisis.

As discussed, disparities in healthcare accessibility persist across Europe, exacerbated by income inequality, digital divides, and workforce shortages. With increasing strain on healthcare resources in the future pushing them towards exhaustion, alongside digital divides, and issues with workforce shortages exacerbating the issue. By 2035, Europe will be closer to health equity through preventive care alongside working back to pre-pandemic growth rates of healthcare spending. Funding disparities for healthcare as a percentage of GDP are still likely to persist between European countries but be narrower.

Digital Transformation

The EU is investing in digital health and workforce planning to close service gaps, but this is threatened by inequalities in digital infrastructure in terms of trying to achieve universal adoption. In 2035, Europe can become a leader in digital health innovation to reduce costs and improve patient outcomes. For example, telemedicine platforms, AI-driven diagnostics, and wearable technologies are already transforming healthcare delivery, while initiatives like the European Health Data Space (EHDS) aim to enable seamless health data sharing across borders [11]. Particularly regarding the EHDS, this data access can form the basis for further transformation to develop simpler and better solutions to make Europe a leading region in healthcare, as well as giving patients greater control over their data [14]. Digital transformation and AI adoption will allow for some skills of current healthcare workers to change in a way that reduces the required workforce and eases the strain from both the numbers and ageing fronts.

With 80% of European citizens expected to have at least basic digital skills by 2030 [11], this will make the transition to digital healthcare much easier, particularly for the growing ageing population. It would ease the implementation of the EHDS in data sharing. Therefore, European citizens will have greater control over their own health data, and this data can be easier to use for innovations and policymaking in the healthcare field.

Digitally literate young people

Mental health issues are on the rise among young people, exacerbated by social media exposure and post-pandemic effects, yet mental health services remain underfunded. [16] Adult mental health also deserves greater focus, but with the root lying in education, perhaps this should be a priority for now. By 2035, Europe will have a comprehensive, youth-focused mental health strategy integrating digital literacy and mental health education into schools and communities to benefit safely from the digital world and build resilience against mental health challenges.

4.1.3 Steps to get there

To assess how to achieve this vision in a digestible manner, we can set short-term goals within the next 3 years and medium-term goals within the next 7 years to make this goal a reality by 2035.

Short-term goals (3 years)

Improved health promotion and disease prevention are able to mitigate non-communicable diseases by as much as 70% [17,18]. For example, population identification of the prevalence of non-communicable diseases and how this will likely cause their death, creating targeted regulatory health checks for particularly high-risk individuals. The creation of a personalised “death risk” profile could be created using the digital tool of a “cause of death” simulator. When citizens input their age, gender, lifestyle, etc, into an AI-powered EU mortality calculator, it can generate this “death risk” profile, giving statements such as, "Based on your BMI and smoking, you have a 63% chance of dying from heart disease, but quitting now cuts it down to 31%”. Mandatory integration into national health portals and promotion through social media through easily clickable links to the calculators or filters showing accelerated ageing from non-communicable diseases.

An impactful “This Will Kill You” food labelling campaign could be used as a preventative measure to promote healthy lifestyles. Reinforced by fines based on a percentage of revenue, it will become mandatory, for example, on processed foods with a red skill icon if it contains over 5 grams of sugar per 100g, or “this drink increases your liver cancer risk by 12%” on products containing alcohol [20].

A “prevention lottery” can address the issue of low public engagement in preventive care [19], where tickets to national lotteries may be earned through completing health screenings or vaccinations. For example, if a citizen completes an NHS health check, they get a lottery ticket; if they get their annual flu vaccination, they get 2 tickets; and if they complete a smoking cessation program, they get 4 tickets. Furthermore, this can have anonymised data linkage via EHDS and a limit of 10 tickets per month to safeguard gambling addicts. This program, coupled with campaigns promoting the effects of sustained physical inactivity or social reclusion as well as the unpleasant sides of unhealthy diets or tobacco use, is a step towards a preventive care system.

With late diagnosis coming from the current reactive mode, particularly in rural areas, installation of AI mirrors on pharmacies, post offices, public toilets, parks, and other public areas. The results may produce a 10-second anaemia/diabetes scan, promoting early detection in ‘medical deserts’ and assisting mitigation of healthcare inequalities.

Medium-term goals (7 years)

Staff shortages require some workforce planning, given that it takes many years for workers to be trained in the medical field. A goal of reducing workforce shortages by 40% can be worked towards through introducing “preventive care professional” as a new profession and training and distributing 500,000 equally across Europe by 2050 in pharmacies, schools, or factories. Training and salaries of newly trained unemployed youth/new migrants on basic diagnostics, lifestyle coaching, and AI tool navigation can be paid for through NCD reduction savings [22].

Building comfortability in a digitalising world will bring forward our vision and should also be a priority through education to promote implementation. Building from the ground up on community-level education of parents and primary school teachers will switch culture from social media being something to be kept from youth as it is terrible for their development to something that can help their learning, and they should be knowledgeable about how to use their resources wisely [23]. This can be achieved through mandatory teacher “digital mentor” training that earns a free certification on healthy screen-time strategies, identifying harmful content, and leveraging educational apps. Parent workshops co-led by child psychologists, incentivised by tax credits or continuing education credits for participation, can root childhood digital education in their parents, which creates an environment of positive digital attitudes and practices among young people. may also encourage participation. Moreover, an EU-wide digital literacy curriculum adjusted for different age ranges, teaching AI literacy, critical thinking, and mindful usage of technology from primary school onwards. These initiatives empower future generations to navigate the digital world more effectively, turning systematic risks into opportunities. It will protect children from adverse psychological effects of negative exposure.

New initiatives within hospitals and healthcare clinics can mitigate climate change risk. Hospitals can be transformed through zero-waste clinical pathways, which make the transition from waste generators to closed-loop resource hubs. For this initiative, more efficient plasma gas sterilisation units processing 3,000 surgical instruments per day with less energy should be more widely installed [21], as well as returning unused medications via drone collection, which can be reformulated into other drugs to cut waste. Green healthcare has much progress to be made still, so innovation incentives can be created by rewarding Europe's lowest 5% of carbon emitters, for example, with priority access to grants to scale their innovations accompanied by debt financing perks and regulatory fast-tracking.

Conclusion

Europe's healthcare systems are at a crossroads. Ageing populations, post-pandemic strains, and tightening budgets. With defence spending now competing for funds, we are pushing our systems to the brink. While current policies promote equity and digital transformation, we need bold, concrete actions to avoid collapse.

Here's how we fix this:

1. Prevention Over Treatment – Let's stop just treating disease and start preventing it. AI-powered "death risk" calculators and stark "This Will Kill You" food labels could jolt people into healthier habits.
2. Workforce Revolution – Train 500,000 new "preventive care professionals" by 2050 to fill staffing gaps before it's too late.
3. Digital Leap Forward – The EHDS is a start, but we need AI diagnostics in pharmacies and schools to catch diseases early.
4. Climate-Smart Healthcare – Zero-waste hospitals and drone-delivered medicines must become the norm, not the exception.

The clock is ticking. If we act now, Europe can build a healthcare system that's not just surviving – but thriving – by 2035.

4.2 Digitalization in Healthcare

4.2.1 Current Trends

Digitalization in healthcare: current trends and developments in Europe

The digital transformation of healthcare in Europe is accelerating, driven by advancements in data management, artificial intelligence, and digital tools that improve patient care and research efficiency. Several key initiatives and technological breakthroughs are shaping the future of healthcare across the European Union and with this moving away from the old methods; for example, transporting patient files from one doctor to the other, physical paperwork that gets lost easily, and patients bringing along medical reports every time.

While digitalization offers numerous advantages, it also presents significant challenges. Data privacy concerns remain a primary issue, as the increased digital exchange of sensitive medical information necessitates robust cybersecurity measures. Policymakers are working to establish secure frameworks that balance innovation with patient rights.

Another challenge is ensuring equitable access to digital healthcare solutions. Not all regions in Europe have the same level of technological infrastructure, which could result in disparities in healthcare quality. Investments in digital literacy programs for healthcare professionals and patients will be crucial to bridging this gap.

The European Health Data Space (EHDS): a cornerstone of digital healthcare

On the 24th of April 2024, the European Parliament adopted the provisional agreement on the European Health Data Space (EHDS) Regulation. That was an official start to adopting the new Regulation and a very big milestone towards digitizing the healthcare sector. It is also an important breakthrough in the EU’s efforts to build a secure and efficient digital health ecosystem as part of the European data strategy [24].

One of the most significant developments in European healthcare digitalization is the establishment of the European Health Data Space (EHDS). This initiative aims to create a unified framework for the secure and efficient sharing of health data across EU member states. The EHDS will allow patients to have greater control over their personal health data while enabling healthcare professionals to access critical information more seamlessly. It is expected to enhance the efficiency of medical treatments and facilitate cross-border healthcare services [25].

According to the European Commission, the EHDS is designed to support both primary and secondary use of health data. Primary use refers to direct patient care, where medical professionals can access electronic health records across borders, ensuring continuity of care. Secondary use involves utilizing aggregated and anonymized data for research, innovation, and policymaking. The European Parliament highlights that this will significantly improve the quality and availability of medical research, paving the way for breakthroughs in treatment methodologies [26].

The European Health Data Space (EHDS) regulation has now been published in the EU Official Journal and will enter into force in a short time, paving the way for better health data sharing, enhanced patient care, and stronger research & innovation across the EU. The law is becoming applicable from 26 March 2027 [27].

The most significant milestone will happen in four years, on 26 March 2029, when data exchanges for the first group of priority categories (including patient summaries) under primary use will go live. At the same time, the rules on secondary use will begin to apply to most data categories. Two years later, on 26 March 2031, the EHDS will expand to additional data categories [28].

Digital twins: a game-changer in healthcare

Digital twin technology is emerging as a transformative force in healthcare digitization. This concept involves creating virtual replicas of biological systems, organs, or even entire patients using real-time data. Digital twins facilitate personalized treatment planning, disease simulation, and enhanced clinical decision-making.

One of the key applications of digital twins in healthcare is in precision medicine. By leveraging real-time patient data, healthcare providers can simulate different treatment outcomes before applying them to real-world patients. This approach is particularly useful in complex medical procedures such as organ transplants, cancer treatments, and chronic disease management. Additionally, digital twins can help medical researchers develop more effective drugs by simulating their effects on a virtual human model before conducting clinical trials [29].

The role of artificial intelligence in healthcare digitization

Artificial intelligence (AI) plays a pivotal role in the digital transformation of European healthcare. AI-powered tools are increasingly being integrated into diagnostic procedures, hospital workflows, and personalized treatment plans.

For instance, AI-driven imaging technologies are enhancing the accuracy of medical diagnostics by identifying anomalies in radiology scans with greater precision than human specialists. Machine learning algorithms are also being used to predict disease outbreaks and assess patient risk factors, leading to improved preventive care strategies.

The European Parliament supports the adoption of AI in healthcare, particularly in the context of the EHDS, as AI-driven analysis of vast health datasets can lead to groundbreaking discoveries in medicine. However, regulatory frameworks are being developed to ensure the ethical use of AI and prevent biases in healthcare algorithms [30].

Challenges and prospects of digitalization in healthcare

In conclusion, digitalization is fundamentally reshaping healthcare in Europe through initiatives like the EHDS, digital twin technology, and AI-driven innovations. These advancements promise to improve patient outcomes, streamline medical research, and enhance healthcare efficiency. However, careful regulatory oversight and investment in digital infrastructure will be essential to maximizing the benefits of this transformation while addressing its challenges.

4.2.2 2035 Vision

As a World, as people who are constantly developing, constantly striving for greatness, and being better every day, it's extremely important that we do that in as many areas of our lives as we can. Healthcare overall and especially digitalization of healthcare is an area into which we should put a lot of efforts. We should always begin with the ideas, and that's what we are doing here; generating ideas - some futuristic, but most of them very realistic and with the intention of making our future better.

Again, we are dividing our ideas on three main topics of digitalization in healthcare; EHDS (European Health Data Space), Digital twins, and AI (Artificial intelligence).

4.2.2.1 EHDS: Unlocking the power of data for smarter healthcare

Virtual health assistants powered by EHDS

By 2030, virtual health assistants could become widespread, driven by the massive data repositories provided by EHDS. These assistants, available through phones, smart devices, or even augmented reality (AR) glasses, could engage patients in real time. They would help patients monitor vital signs, guide them through their medical treatments, remind them of medications, and even perform health checks based on data integrated from wearable devices. These virtual assistants could act as an intermediary between patients and doctors, helping patients understand their treatment plans and track their progress.

Predictive analytics for public health

Using AI and big data, predictive analytics could revolutionize how public health initiatives are planned. By analyzing trends in data from the EHDS, wearable devices, and other health sources, AI systems could predict outbreaks of diseases, assess the overall health of a population, and recommend targeted interventions. Governments could use these insights to create more effective public health strategies, preventing diseases before they spread widely.

Blockchain-based health data security

Given the importance of data privacy in the digitalization of healthcare, blockchain technology could play a crucial role in securing sensitive medical information. As patients and healthcare providers exchange data more frequently, blockchain could ensure that every transaction is encrypted and transparent. This would empower patients to have full control over who accesses their health data and ensure that only authorized individuals can use or view their information. Blockchain would also enhance trust in platforms like EHDS, reinforcing the importance of data security.

4.2.2.2 Digital twins: The next frontier in healthcare innovation

Digital twins are set to revolutionize the future of healthcare, bringing significant advancements in several key areas, particularly in personalized drug testing, robotic-assisted surgeries, and predictive healthcare.

Accelerating and improving clinical trials with digital twins

Digital twins can revolutionize clinical research by making trials faster, safer, and more representative. Instead of relying solely on human participants, AI-powered digital twins could simulate thousands of patient responses to new treatments based on real-world data. This would speed up drug development by identifying ineffective treatments earlier, reducing the number of failed clinical trials. It would ensure better representation by including diverse virtual patient models, balancing gender, race, age, and genetics in clinical simulations before human trials. Also, ethical concerns would be reduced by minimizing the number of human participants needed, making trials safer and less risky.

AI-enhanced personalized medicine with digital twins

Currently, precision medicine uses genetic profiling to customize treatments, but digital twins could take this even further. In the future, each patient might have a real-time AI-powered digital twin that continuously updates based on their lifestyle, medical history, and genetics. These digital twins would predict diseases before symptoms appear, allowing for preventive treatments tailored to an individual's future health risks. They would recommend the most effective treatments, by simulating how different medications or procedures would work for a specific patient before application. Optimized rehabilitation plans would come into play for injuries and chronic illnesses by tracking how a digital twin responds to therapy, adjusting exercises or medication in real time.

Digital twin-assisted robotic surgeries (The future of surgery)

Another groundbreaking application of digital twins lies in robotic-assisted surgeries. In the future, surgeons could perform every complex operation on a patient's digital twin before conducting the real procedure, allowing them to identify potential complications in advance and refine their techniques. During live surgeries, AI-powered digital twin models could provide real-time feedback, helping surgeons make immediate adjustments for greater precision and safety. In the long term, robotic surgical systems could be guided by digital twins, enabling highly standardized and automated procedures, as well as remote surgeries performed by specialists in different locations. This would improve access to high-quality surgical care, particularly in regions with a shortage of experienced professionals, and significantly reduce the risk of human error in operations.

Digital twins in predictive and preventive healthcare

Beyond personalized treatments and surgical advancements, digital twins could also play a crucial role in predictive healthcare and preventive medicine. By continuously analyzing real-time patient data, digital twins could detect early warning signs of serious conditions such as strokes or heart attacks and alert both patients and healthcare professionals before symptoms escalate. In emergency medicine, real-time digital twin simulations could provide immediate guidance on the best course of action for paramedics and doctors, ensuring faster and more effective responses. Additionally, digital twins could be integrated into everyday health monitoring systems, acting as virtual health coaches that analyze an individual's diet, exercise habits, sleep patterns, and other lifestyle factors to provide personalized recommendations for maintaining long-term health. Patients in hospitals and elderly care homes could have their health records linked to digital twin models, allowing AI systems to continuously track their conditions and automatically alert doctors if any concerning changes are detected.

Conclusion

These innovations would enhance clinical research, improve patient treatment, and revolutionize surgery. With continued advancements in AI and data collection, digital twins could become a core part of healthcare digitalization, bridging the gap between virtual simulations and real-world medicine.

4.2.2.3 AI: Automating and enhancing the future of medical care

Automated, home-based diagnostics

Similar to the ideas for robotized MRI, ultrasound, and RTG machines in private homes or buildings, future healthcare may involve autonomous diagnostic stations that use AI to perform diagnostic scans at home. These stations could be linked to digital platforms, ensuring that a healthcare professional can access results remotely, even providing real-time consultations. This system could potentially alleviate strain on healthcare facilities by decentralizing diagnostics, making it more convenient and cost-effective for people, especially those with chronic illnesses who need regular checkups. Still, this solution would probably be available only to the upper layer of the population.

Smart clinics: AI-enhanced autonomous consultations

A cheaper and more accessible version of the previous idea with home-based diagnostics. This one could potentially be available to people from the public sector. In the future, people might be able to visit fully digitalized "smart clinics" that offer autonomous consultations. These clinics would be equipped with sensors and AI that can analyze symptoms and recommend treatments. Patients would simply walk into the clinic, provide their medical history via their EHDS profile, and the system would use AI to diagnose the issue and suggest treatment options. The AI system would cross-check against a vast database of medical records and research to ensure that the diagnosis is accurate. It could even initiate teleconsultations with specialists if needed.

Healthcare robots as caregivers

This one is an upgrade from the first idea about automated, home-based diagnostics. As it is even more futuristic, it is even harder to expect it to be implemented until 2035. With the population aging, healthcare robots may become more prevalent in elderly care facilities or private homes. These robots could perform tasks such as assisting with mobility, reminding patients to take their medications, and monitoring patients' vital signs. Through integration with EHDS, healthcare robots could also alert doctors and caregivers if something unusual happens, such as a sudden drop in blood pressure or a fall. These robots could be especially beneficial for elderly people, who may be more susceptible to health conditions and may not be able to visit healthcare facilities regularly.

AI-generated reports (AI listening to the medical treatment)

There would be some kind of hardware connected to the AI software that would allow it to understand, transcribe, and summon the communication between the doctor and the patient. With the previous knowledge about the patient from EHDS (previous treatments) the AI alone would be able to write the report, set the diagnosis, and prescribe the medications.

Conclusion

The healthcare system of the future will be more digital, more personalized, and increasingly autonomous. With the continued growth of the EHDS, the digital tools mentioned, and emerging technologies like AI, blockchain, and wearable devices, the healthcare system will move toward a more efficient, accessible, and preventative model. Patients will have more control over their health data, enabling them to make informed decisions about their care. Doctors will work alongside AI systems to make more accurate diagnoses and treatment plans. While the future presents challenges, particularly in terms of data security and access, the digitalization of healthcare promises a more integrated and patient-centered approach to health management.

4.2.3 Steps to get there

EHDS: Building the foundations of a digital health revolution

To make EHDS a reality, governments, policymakers, and healthcare institutions need to work together to ensure that this system is not only functional but also secure and accessible to all EU citizens. One of the first and most important steps is finalizing the legal framework that guarantees data privacy and security while allowing health data to be shared efficiently. People need to trust the system, so regulations must clearly define how patient data can be used and who has access to it.

At the same time, significant investments in infrastructure are necessary. Hospitals, clinics, and medical centers across Europe need to transition from outdated systems to fully digitalized platforms that are compatible with EHDS. This includes modernizing electronic health record systems and ensuring that medical professionals have the tools they need to work with shared data. Since this system is meant to function across the entire EU, countries must also agree on a common approach to sharing health data so that every citizen, no matter where they are, can benefit from the EHDS.

Public awareness is another crucial aspect. Patients and doctors alike need to be educated on how to use the system, what their rights are, and how to keep their data secure. Without proper training, the system could end up being underused or misused. Additionally, technology companies will play a key role in developing secure platforms for EHDS, including blockchain-based solutions that ensure only authorized individuals can access sensitive medical data. If all these elements come together - strong policies, modern infrastructure, proper education, and advanced technology - EHDS can truly transform healthcare in Europe.

Digital twins: From science fiction to everyday medicine

For digital twins to become an essential part of healthcare, hospitals, universities, and tech companies need to work together to integrate this technology into daily medical practice. Right now, digital twin technology is still in development, but with proper investment and research, it could soon become a common tool for doctors and researchers. Governments and private investors should support scientific studies and AI model development, ensuring that digital twins can provide accurate and reliable simulations.

Regulations will also need to evolve. Since digital twins involve complex simulations of human health, there must be clear ethical guidelines to ensure they are used responsibly. This means deciding who is allowed to create and access digital twins and how patient data is used in these models. Without proper regulations, there could be risks of misuse or bias in how treatments are tested.

On a practical level, hospitals and medical schools need to start integrating digital twin technology into their systems and training programs. Future doctors and surgeons should be comfortable working with digital models, using them for diagnostics, treatment planning, and even surgery. Additionally, AI must be improved to make digital twins as accurate as possible. This means using big data and real-time patient monitoring to keep the digital twin updated and reflective of a person's actual health condition. If these steps are taken, digital twins could significantly enhance patient care and medical research in the coming years.

AI: Preparing for an AI - driven healthcare revolution

For AI to reach its full potential in healthcare, several changes must take place at the policy, infrastructure, and educational levels. The most immediate need is creating clear rules for AI in medicine. Policymakers must ensure that AI systems are developed and used ethically, avoiding biased algorithms and ensuring patient safety. Without proper regulations, there is a risk that AI could make incorrect diagnoses or be misused in decision-making.

AI in healthcare also depends on having access to large, high-quality datasets. The more data AI can analyze, the better it can identify patterns and provide accurate predictions. To achieve this, medical institutions need to standardize how they collect and store health data, making it easier for AI systems to learn and improve over time. At the same time, AI should not only be used in private, expensive healthcare systems but should also be available in public hospitals and clinics*, ensuring that it benefits as many people as possible.

If these steps are followed - creating strong regulations, improving data access, investing in AI-friendly infrastructure, and training professionals - AI has the potential to revolutionize healthcare by making diagnostics faster, treatments more accurate, and medical services more accessible.

Turning innovation into reality

The digital transformation of healthcare in Europe is well underway, but to fully realize the vision of a smart, AI-powered, data-driven healthcare system by 2035, action needs to be taken today. Governments must ensure *strong policies and funding*, hospitals and medical institutions must *adopt and integrate new technologies*, and *citizens and medical professionals must be educated* on how to navigate this new system. If all of these elements align, Europe will have *a healthcare system that is more efficient, personalized, and accessible* than ever before.

4.3 Technological Innovations in Healthcare

4.3.1 Current Trends

The growing demand for care of an ageing population coupled with an ageing healthcare workforce is placing immense pressure on the healthcare system. This demographic shift, known as the double demographic phenomenon [31], along with many gaps in the system are projected to continue to increase the pressure on the healthcare system. A technological transformation offers significant promise of increased efficiency while alleviating the workload of medical professionals. Rather than replacing personnel, AI and other digital tools are being integrated to enhance workflows and boost productivity. A recent umbrella review indicated that novel tools currently being deployed in high-income countries have been found to generally improve healthcare providers' performance, and a second study indicated a 30% decrease in administrative workload [31]. Fundamentally, these advancements are transforming how healthcare services are delivered and experienced. This transformation extends beyond healthcare delivery, reshaping the mechanisms behind health plan management and patient engagement, ultimately paving the way for a more efficient and patient-centred system.

Artificial Intelligence in Healthcare

Generative AI is a class of AI models that possess the ability to generate original/new outputs, mimicking human creativity based on inputs from deep learning tools [32]. In a medical and pharmaceutical context GenAI has the potential to reduce costs, improve patient access to care and improve the quality of care provided [33]. Currently we are seeing GenAI integrated into the healthcare system to leverage efficacy, accuracy, personalisation and innovation withing the administrative and care facets of the industry.

On the administrative front, AI is being used to automate tasks such as drafting, organising and filing documents, processing insurance claims, and collecting patient histories. Newly, AI has been used for automated transcription of doctor-patient interactions [34] and automate any communications or reminders from clinicians. Therefore, helping tackle the overwhelming administrative tasks faced by healthcare offices, allowing more time for healthcare professionals to focus on improved patient care.

In the field of diagnostics, GenAI has been used in the field of medical imaging. AI-driven algorithms are being used to analyse medical images, like CT-scans, X-rays and MRI's [35], to identify any anomalies and provide information to aid in early diagnosis and disease progression. AI use increases analytic efficiency, ensuring timely results and bypassing human error, which are crucial for early intervention.

Lastly, and more recently, AI and deep generative models are being used to revolutionize drug discovery and development. Deep generative models are neural networks trained to analyse layer of data samples, in order to approximate high-dimensional probability distributions [36]. In the pharmaceutical field, drug discovery is becoming increasingly industrialized, allowing the generation of large datasets. AI's ability to synthesise and analyse this data has triggered deep generative models ability to optimize and synthesise small macromolecules and molecules [37]. The pace with which AI is advancing shows potential to further optimize drug synthesis to be quicker and more efficient.

Telehealth and remote patient monitoring

As of 2021, an IQVIA report suggests, there are 150 commercially available Digital care products, including mobile/web applications and games. That aid from mental health issues like PTSD to aiding in rehabilitation, Obesity control and chronic condition monitoring. Healthcare apps such as these are working to address the growing need for more personalised patient engagement platforms along with increased accessibility and reliability of care through telemedicine services.

A second subset of telehealth is remote patient monitoring. Remote monitoring is seen as an effective method of allowing care providers increase patient engagement and monitoring while effectively reducing healthcare costs and mortality rates. The main method of remote care is the use of wearable health technology, like wearable sensors. This technology is equipped to continuously monitor a patient's physiological state and biochemical signals. It is highly attractive as it allows for lower medical costs, quick access to patients current and recent history of health data collected, mass production value and non-invasive admission.

A study conducted by The Whole System Demonstrator (WSD) program identified the use of electronic sensors to reduced emergency admissions by 20% and a reduced mortality rate by 45%, indicating its effectiveness [38].

Regulatory frame works surrounding AI

All existing **regulatory frameworks** are not designed to allows the use of AI as a diagnostic, treatment or management tool. This framework is designed to support practices that produce the same output per data input presented, hence approving the traditional static software. The approval process relies on the software's static and reproducible nature. However, AI software has an intrinsic ability to learn from each use becoming more intelligent, thus increasing its functionality and accuracy of outputs [39]. Current regulations prevent AI from adjusting its outputs according to the most up-to-date information, possibly leading to misdiagnosis, hence introducing scepticism around the reliability of AI among patients and other stakeholders.

Conclusion

A transition toward digitally enabled and personalized care is well underway, even as adoption rates vary. In Deloittes 2025 Global Healthcare Outlook Survey More than 40% of respondents said their organizations have already experienced a significant-to-moderate return on their investments in gen AI. This is further supported by a Research conducted in 2021 showing that Healthcare providers that don’t adopt digital and technological transformations are likely to lose younger patients to competitors who have done the same.

4.3.2 2035 Vision

The current wave of technological innovation has already begun to reshape the healthcare landscape. From AI-assisted diagnostics to the widespread adoption of wearable health tech, we are witnessing the early stages of a system-wide digital transformation. However, these advancements are just the beginning. Looking ahead to 2035, the vision is not only to scale up these innovations but to fundamentally reimagine healthcare. Shifting from a reactive, one-size-fits-all model to proactive, data-driven, and highly personalised systems. This section explores what a futuristic healthcare ecosystem could look like if technology, regulation, and society evolve in tandem.

Optimising the use of technology while maintaining regulatory control

To fully harness the potential of AI and technology in healthcare by 2035, regulatory frameworks must be redefined. An ideal system would implement continuous learning, allowing AI to refine its outputs based on the most up-to-date data. Accuracy of each output provided would be ensured through continuous verification and regulation, with periodic human intervention to assess efficiency and reliability.

To build use and stakeholder trust within these systems, rigid ethical guidelines should be established, ensuring fairness and responsible AI use. Extreme transparency of these laws and the use of any data collected will be key in gaining public trust. These principles would be embedded in public education initiatives, promoting technological literacy and allowing individuals feel in control of their healthcare decisions.

Leveraging AI to Improve Sustainability

A communication gap between healthcare providers often leads to redundant diagnostic testing, resulting in an estimated 20% of health spending in Europe being deemed wasteful [40]. Additionally, a fragmented healthcare information system increases the risk of misdiagnosis and inappropriate treatment further escalating wasteful expenditure. Implementing an AI-driven universal electronic health data space for each patient will enable seamless data sharing across healthcare providers, ensuring that up-to-date medical records are accessible at all points of care, reducing the chance of repetitive testing. Furthermore, these databases could be equipped with generative AI that analyses this data in real-time to provide physicians with evidence-based treatment recommendations and specialist referrals when necessary. Ultimately, this approach minimizes waste, improves communication, and optimizes patient care.

The pharmaceutical development process is a second outlet that adds to departmental waste as it is slow, expensive, and heavily reliant on trial and error during the pre-clinical and clinical testing phases. The concept of AI-driven Lab-in-Loop systems that automate experimentation by analyzing real-time data will accelerate drug development.

A Lab-in-the-Loop system combines machine learning with automated lab testing, allowing AI to continuously analyze experimental data, refine hypotheses, and adjust test parameters without human intervention [41]. It can interpret biological responses, chemical interactions, and genetic data, optimizing conditions to reduce redundant trials, minimize human error, and improve accuracy in both preclinical research and clinical trials.

By making primary research and patient care faster, more efficient, and data-driven, the adoption of AI reduces the financial and labour-intensive pressures off the pharmaceutical industry, leading to safer, more effective treatments reaching patients sooner.

Personalised medicine

Deep generative models (DGM) have already begun to harness AI's potential by enabling scientists to synthesize new effective drug molecules, optimizing their binding affinity, bioavailability, and metabolic stability [37]. Essentially already revolutionising and cutting costs in the field of drug discovery. Yet it is recognised that technology is evolving at a rapid pace, such that this technology can be improved further as a drug discovery tool in the future. An optimal approach would combine drug discovery via DGMs with patient-specific genetic maps and medical histories to produce personalized medicine that improves treatment efficacy while minimizing adverse effects. Theoretically, AI could be used to analyze and generate patient-specific, disease-specific biomarkers, which would serve as inputs for DGMs. This would facilitate the creation of molecular structures precisely tailored to a patient's unique biomolecular profile. This concept is currently in the early trial stages, attempting to transform cancer treatment. If succesful this technology can be extrapolated to general medicine, marking a significant step toward truly individualized therapeutics.

A shift from Sickcare to Healthcare: Preventative medicine

Currently, AI is focused on diagnostics, treatment and monitoring, yet the medical field is shifting focus onto preventative care. The population of older adults (65>) is projected to grow rapidly increasing by 24% by 2100 [42], and with 70% of healthcare spending already allocated to chronic multimorbidity, this cost is set to increase by 2035. As a result, preventative care will become essential in reducing healthcare expenditures.

AI-enhanced wearable sensors can be modified for the use of disease prevention and early intervention. Small, AI-driven wearables can continuously monitor vital signs, blood sugar, and stress levels, analyzing real-time data to detect early warning signs of potential health crises. These systems could then alert physicians for treatment adjustments or, in emergencies, automatically notify emergency services, significantly improving medical response time and care accuracy.

Similarly, personalized medicine, already used for custom drug development, could be adapted to create personalized geroprotectors aimed at reversing biological ageing, reducing the onset of chronic conditions and improving quality of life. As AI-driven prevention strategies advance, healthcare will shift from reactive treatment to proactive intervention, ensuring longer, healthier lives for patients while selfishly keeping more people out of hospitals thereby releiving the pressure on the system.

Conclusion

The future of healthcare lies in a system that is intelligent, personalised, and preventative. This vision for 2035 outlines a healthcare landscape where AI doesn’t just assist, it actively drives improvements in diagnostics, drug discovery, and disease prevention. Regulatory frameworks will evolve to accommodate continuous learning systems, while strict ethical guidelines and transparency will foster trust and responsible use. A universal health data space powered by generative AI will reduce redundancy and waste, while wearable technologies and personalised therapeutics will shift the focus from reactive treatment to proactive care. Ultimately, this vision reflects a system that is not only more efficient and sustainable but one that is centred around the needs of each individual patient—making care more human through the use of technology.

4.3.3 Steps to get there

At the rate technology has been advancing over the past few years, it is clear that technological growth and the discovery of the tools we require to reach our 2035 is inevitable. The question that is worrying, and that needs action is weather society and the industry will be ready to accept the technological advancement. The real hurdle is creating the infrastructure, ethical frameworks, and mindset required for this transformation to take root meaningfully. To navigate this shift, the following steps focus on building regulatory readiness, fostering AI literacy, strengthening digital infrastructure, and encouraging global collaboration.

Regulatory frameworks, ethical guidelines and Transparency

As discussed the current regulatory frameworks are not built to allow AI to continue to learn and become more intelligent while in use, thus limiting its accuracy of outputs. A collaboration between AI experts and healthcare professionals is essential to draft an adaptive regulatory standard, that may mould to each technology being introduced in the industry. Further, to allow the continuous growth, a dynamic monitoring system including human-in-loops verification would ensure safety and accuracy of AI models being used in field.

Intergovernmental corporation would be required to set both regulatory frameworks and ethical guidelines to allow the most efficient use of any system. Mandatory transparency of all ethical guidelines being followed for the production of said technology and handling of patient data must be compulsory in order to build user trust. Furthermore, the incorporation of some sort of an ongoing public education campaign to increase digital literacy through all generations will be pivotal in gaining user trust, acceptance and excitement.

Digital infrastructure

To ensure that technological transformations erupting in the industry are actually accepted and put to use, it is essential for there to be a third party factor that ensure and monitors the effective use of these systems within the industry. One option is to incentivise pharmaceutical companies to use AI tools such as AI powered Lab-in-Loop systems or AI-driven deep generative models to speed up drug discovery while advancing in personalised and precision therapeutics. These technologies not only cut down the time and cost of development but also improve the accuracy and relevance of treatments. In parallel, establishing strong public-private partnerships can help accelerate innovation in areas often overlooked, such as treatments for rare and chronic conditions. It's equally important to fund projects that integrate AI-driven wearable health technologies into everyday care, enabling real-time monitoring of vital signs and early intervention.

Conclusion

While the path to full integration of GenAI in healthcare is complex, it's not out of reach. With the right mindset, proactive policy-making, and a genuine commitment to collaboration and education, we can create a space where technology doesn't just exist but actually thrives in a way that benefits everyone. The goal isn't just to keep up with innovation, but to meet it with readiness, structure, and intention.

4.4 Health Promotion and Disease Prevention

4.4.1 Current Trends

Life expectancy in the European Union is rising due to improvements in healthcare and living conditions. While life is getting longer, ensuring that those years are lived in good health remains a significant challenge. Women, on average, live longer than men but not all of those years are lived in good health. Furthermore, socio-economic factors also determine health status; hence, robust health promotion and disease prevention policies are needed [43].

The Burden of Chronic Conditions

Chronic illnesses like Alzheimer's, arthritis, diabetes, and heart disease, along with mental health issues such as depression and anxiety, are common among older adults [44]. These illnesses significantly contribute to the strain on healthcare and long-term care systems, making prevention essential. Preventive strategies include organizing social events to combat isolation and encouraging physical activity and healthy eating to minimize obesity. To be able to offer diverse and affordable solutions, policy-makers, healthcare providers, and social services should all work tightly.

The Role of Prevention in Reducing Disability Rates

Good health in later life allows individuals to remain employed and productive longer, which relieves pressure on the health and retirement systems. Increasing disability rates, however, place additional pressure on health facilities and the workforce. Alzheimer's disease is perhaps the most concerning condition, as there is currently no cure for it. Despite a lot of research, treatments only delay disease progression and sometimes cause side effects. This shows the importance of prevention, as noted in the 2024 Lancet Commission on dementia [45]. Evidence from France, Sweden, and the UK suggests that age-specific rates of dementia have fallen in recent decades, thereby highlighting the potential of preventive approaches [46]. Dementia prevention is also complex. The 2024 Lancet Commission estimates that 14 modifiable risk factors are responsible for nearly 45% of dementia cases, and this demands targeted interventions [45].

The Impact of Lifestyle on Health

Environmental and lifestyle factors have a significant impact on health at any age, and one major concern is that most people aren't getting enough exercise. In the EU, about 73% of young adults aged 18 to 24 and nearly 80% of those aged 25 to 34 don't meet the recommended activity levels. As people get older, this trend worsens, and by the time they reach 65, over 90% do not achieve the WHO's recommended activity levels, highlighting a growing challenge as people age [47]. According to data from 2022, the proportion of overweight individuals increases with age, starting from 20.3% among those aged 16 to 24 years and peaking at 63.6% in the 65 to 74-year age bracket [48]. This trend underscores a critical public health concern, as excess weight is associated with numerous non-communicable diseases, including cardiovascular conditions and type 2 diabetes. The observed age-related increase in overweight prevalence may be attributed to factors such as metabolic changes, decreased physical activity, and dietary patterns. Addressing this issue necessitates targeted interventions that promote healthy lifestyles across all age groups, with particular emphasis on older populations who are disproportionately affected. The majority of diseases associated with old age can be prevented or delayed with a healthier lifestyle and supportive environment. Physical activity is particularly beneficial because it reduces the risk of cardiovascular disease, certain cancers, and cognitive decline. OECD and WHO research estimates that meeting WHO physical activity guidelines can prevent over 10,000 premature deaths annually in the EU and add 7.5 months to life expectancy for inactive individuals [49].

Initiatives Addressing Health Risks

Several EU member states started programs intended to promote physical activity levels among the elderly. The Multimodal Training Intervention (MTI) represents one effective programme that originated in Iceland but was later adopted in both Spain and Lithuania. MTI targets those over 65 years of age. The 'intervention' consists of endurance and resistance training sessions with educational components about nutrition, physical activity, and sleep [50].

Beyond physical activity, the European Union has also implemented measures to combat additional health risks through programs such as Europe's Beating Cancer Plan. This programme acknowledges the connection between inadequate nutrition and insufficient physical activity with increased cancer risk. However, the action has been stalled by a lack of consensus among member states on uniform nutrition labeling [51].

Mental Health Support and Social Engagement

A healthy society needs both social welfare programmes as well as mental health support. The European Commission introduced a mental health strategy in 2023 that includes 20 major priority actions, funded by €1.23 billion [52]. While it primarily targets younger people, the strategy recognizes the importance of helping older individuals maintain their mental well-being and social connections. As older adults experience major life changes like losing their spouses, they often become more susceptible to loneliness. A 2022 study conducted by Nurminen et al. discovered that the majority of EU programmes fighting loneliness were concentrated on older adults, mainly through community-based activities [53]. Yet, with little evaluation of such programs, it is difficult to determine their effectiveness.

Lastly, in order to tackle the existing health challenges, there has to be an integrated approach promoting physical activity, improved nutrition, enhanced social engagement, and strengthened preventive healthcare interventions. Implementing these measures not only improves overall public health but also helps to alleviate pressures on healthcare systems and social care institutions, ensuring a more sustainable and efficient use of resources.

4.4.2 2035 Vision

We all know that in order to live healthier, we need to eat healthier, have an active lifestyle, and avoid stress. Those are all things that we have an effect on. But what about the factors beyond our control—those encoded in our DNA—that we could anticipate and act on in advance? That is where genome sequencing comes into play. It gives us insight into the future of our health and allows for an even earlier prevention.

Not so long ago, people would get a disease, develop symptoms, and most of the time – die. Then, we got better at treating symptoms. Recently, we got better at recognizing symptoms early on. What if we could actually prevent them before either the disease or the symptoms develop? A powerful tool that could help us achieve this is genome sequencing. By unlocking our genetic code, we can ease the healthcare load.

Understanding the Genome

A genome is the complete set of an organism's DNA. Almost all living cells in our body contain the information needed to build the entire human body. It is the different signals that decide which genes would be transcribed and in which direction the cell would differentiate. Each of the estimated 20,000 to 25,000 genes in the human genome codes for an average of three proteins [54]. The entire DNA is made of only four nitrogenous bases: adenine (A), thymine (T), cytosine (C), and guanine (G). These bases are linked together and form a long chain, the DNA molecule. Our body reads them in sets of threes and transcribes them onto mRNA molecules, where the sets are now called codons. Every codon, a different combination of nitrogenous bases, translates into one amino acid. However, as one can easily see, there are more possible combinations than there are non-essential amino acids, which is why some amino acids can be encoded by more than one codon. It is important to note that some codons don't code for amino acids but rather signal to the enzymes when to start and when to stop the transcription process. It is precisely this level, the level of nitrogenous bases, that genome sequencing focuses on. The new techniques of genome sequencing termed Next-Generation Sequencing (NGS) have dramatically reduced the cost of genome sequencing and are also much faster compared to the classical genome sequencing because of their ability to sequence millions of DNA fragments simultaneously, which makes NGS a better option for large-scale genomic studies.

The Economic Perspective of Genome Sequencing

The total cost of cancer in Europe in 2018 was estimated at €199 billion [55]. My vision for 2035 would be to at least match this number in the funding for NGS. Having an insight into the entire genome would not only help us find and protect those at higher risk of developing cancer, but it would also give us the opportunity to identify individuals with a genetic predisposition for other issues, such as Alzheimer's disease, rheumatoid arthritis, monogenic diabetes, cardiovascular issues, etc.

As seen above, cancer alone is a great burden to the healthcare system, and that number is without even factoring in the cost of chronic diseases. If we added the figure of an estimated €700 billion, plus the cost of disease-related absenteeism, which costs the EU an estimated 2.5% of GDP annually [56], we would see that there is a lot of room for improvement in the field of prevention. The genome sequencing of the majority of the population is neither an easy nor an inexpensive feat, which is why the economic aspect should not be the only factor in the decision-making process to begin such a project. We must also account for the years of healthy life lost due to disability and the emotional consequences of both living with a chronic disease, as well as living with someone with a chronic disease. The contentment and well-being of its citizens should be of utmost importance to every country.

Advancing Scientific Research with Genome Databases

Besides the utilitarian aspects of genome sequencing for an average human, having a large and diverse genome database could help scientists identify the common and rare genetic variants that are associated with some diseases, as well as help with the profiling of disease-relevant genes and pathways by transcriptional profiling and epigenome mapping techniques. With the help of a vast amount of sequenced genomes, we would be able to predict the population-based disease epidemiology and, therefore, allocate funds accordingly, identify the novel candidate genes, and identify the functional role of genes in disease etiology and pathogenesis.

The Importance of Early Diagnosis and Preventive Medicine

Since nearly all of the cells contain the complete set of our DNA, the process of retrieving the samples needed for NGS can be minimally invasive. Compared to the aggressive treatment options offered at a later stage and the life spent with the disability before it is diagnosed (if one is to be diagnosed in a timely manner), the difference in well-being and quality of patients' lives is immense. This shows us once again the importance and benefits of preventive medicine compared to curative medicine.

Benefits of genome sequencing in the field of pharmacology

Another way how whole genome sequencing could at least partially pay for itself is in the field of pharmacology through identifying pharmacogenomic targets for drug discovery, as well as giving the doctor an immediate insight into the specific polymorphisms of his patient. Some active ingredients are metabolized through pathways that include polymorphic genes. Those different genes could be important factors leading to differences in the outcomes of desired effects, as well as play a role in the onset of side effects of the prescribed drugs. Were a doctor to have an entire genome of his patient in front of him before starting with the trial and error of different medications, he would be able to pick the right therapy with high confidence and less of a "hit-or-miss strategy". Prescribing the right choice from the first try would, in turn, save money on both the incorrect treatment as well as slow the onset of the disease and prevent the possible iatrogenic diseases, which would again need funds to be resolved. Previously mentioned drug discovery in itself could open the door to the treatment of diseases we hitherto considered incurable.

4.4.3 Steps to get there

Expanding and Integrating EU Genome Initiatives

While some of the initiatives are already underway in Europe, there is a long way ahead of us if we want to be able to offer NGS to every individual. Right now, we have an EU-wide programme called 1+ Million Genomes that is laying the groundwork for large-scale genomic data sharing. To help us facilitate that, we have the European Health Data Space that is working toward a unified legal and ethical framework regarding health data. Additionally, there are countries like the UK and France that are investing in national genome sequencing projects, namely Genomics England and France Genomic Medicine 2025, respectively [57]. The first step towards large-scale genome sequencing would be to expand and integrate existing EU genome initiatives. We could do this if we increase funding and participation across all EU member states by setting a specific, higher target of at least 100 million genomes to be sequenced by 2035. While the number seems modest, in order to yield the best results, we should prioritize the newborns, individuals at higher risk, and voluntary participants. If we were to continue with this trend, after a certain number of generations, the majority of the population would have their genome decoded in their early infancy. The only people not covered through this strategy would be those whose parents chose for them to opt out of the project, and they would be offered to participate voluntarily after they come of age. These patients would be offered NGS during routine medical check-ups, which would make it as accessible as blood tests. It is also of great importance to develop genomic counseling services across the primary health centres, which would ensure that the individuals understand their genetic predispositions and their options for how to proceed.

Secure Long-Term Funding & Incentives

The second step we should take is to establish long-term funding and incentives for our undertaking. Our key resource for establishing that would be to increase the Horizon Europe programme’s funding for genomics research. Horizon Europe is the EU’s key funding programme for research and innovation [58] and has already financed a similar €10 million project called European Advanced Infrastructure for Innovative Genomics [59]. The mission of the project was to provide researchers from academia and industry with free access to advanced DNA sequencing technologies as well as to address secure data management, ethical and legal issues. As we all know, economic resources drive global progress and development. We could facilitate that progress by increasing the funding for Horizon Europe, with a focus on personalized medicine and preventative care, as discussed in the previous chapter. Another way in which the economy could be utilized to the advantage of the project would be through tax incentives. The countries could offer pharmaceutical and biotech companies that invest in genome-driven drug discovery and diagnostics some tax deductions or tax exemptions. Lastly, as the project on a scale as large as this one would be an enormous challenge to begin, in order to cover the genome sequencing as part of preventative healthcare, EU-wide insurance reimbursement policies should be created.

Strengthen the Legal and Ethical Framework

The next step towards sequencing the entire European genome would be to reinforce the legal and ethical systems entrusted with bringing this project to fruition. As we are aware, there is a growing distrust of the people with the government institutions [60]. In a world where people are making decisions about their health based on multiple factors, and not just the recommendations of healthcare personnel, we must assure and reassure our fellow citizens of the safety of their data in our hands. For this purpose, we should draw inspiration from the Genomic Data Protection Act, which is a bill introduced by Congress of the United States that tackles the privacy and security of individuals' genomic data. The legislation addresses both the 'consumer' rights as well as the obligations of the company offering the services of genome sequencing [61]. Some of the rights include the subjects' ability to access, delete, and request the destruction of their genomic data and biological samples. The obligations of the provider mandate that the companies should offer clear notifications about their practices of data collection and obtain explicit consent from patients before collecting or using their genomic data. A good infrastructure to expedite this procedure is deeply rooted in the way Europeans care about their personal data – The General Data Protection Regulation (GDPR). GDPR pertains to the processing of sensitive personal data, with a specific focus on genetic data as a special category of personal data under Article 9 [62]. This would help ensure strict privacy laws regarding the genetic information, aligned with the GDPR that would prevent misuse of genetic information. Additional safety and trust could be gained from keeping the servers storing the genetic information of the Europeans within their country, which brings us to our next step.

Scale Up Genome Sequencing Infrastructure

At this point, we should consider scaling up the infrastructure required for the task. A great way to do this would be to expand existing genome sequencing centers such as those in Germany, Sweden, Belgium, etc., which would ensure their reach beyond just the major research hubs and democratize access to genomic technologies. To guarantee the existing genomic technologies are used to their full potential, we should strengthen the 1+MG genomic data platform, securing real-time access for authorized personnel, such as researchers (anonymized data) and physicians that treat those patients (unrestricted access to relevant aspects) with strict data protection measures that would make a record of every attempt at reading somebody's genome. Since we would be dealing with a colossal data pool, it would be smart to invest in quantum computing and AI-powered bioinformatics to be able to effectively handle genome data processing. This would drastically reduce the amount of time we would need to analyze a whole genome and make the whole project even possible. Another useful task that could be assigned to machine learning models would be predicting protein folding based on the mutated genes. It took humans a lengthy but unproductive effort to successfully predict the folding patterns of regular proteins that virtually all of us have in our genome. Then came Demis Hassabis and John Jumper with AlphaFold. A powerful AI model that managed to solve a 50-year-old problem: predicting proteins' complex structures, which granted them the 2024 Nobel Prize in the field of Chemistry. With its help, they have been able to predict the structure of 200 million proteins that researchers have identified [63]. Determining the 3D structure of a protein used to take many months or years, it now takes seconds [64]. Based on its pattern recognition of how different amino acids in polypeptide chains interact to form a 3D structure in a healthy protein, and with AlphaFold's growing database of experimentally confirmed protein structures, we would be able to predict the patterns in which faulty proteins fold, which would give us a deeper understanding of their activity. Based on this, we could store additional data such as which treatment we attempted and whether or not it was successful.

Discussion

Considering the arguments presented, it becomes clear that the future in which NGS is offered to all citizens and not only the ones that can afford it with the current out-of-pocket expenses is a bright one. We may not, however, be blinded by its brightness and naïve enough to think it would be able to solve all of our health problems. There are numerous issues that can benefit from whole human genome sequencing, such as:

- Rare genetic disorders (cystic fibrosis [65], Huntington's Disease [66])
- Increased risk of cancer (breast cancer [67], Lynch syndrome [68])

- Cardiovascular diseases (hypertrophic cardiomyopathy [69], familial hypercholesterolemia [70])
- Neurological and neurodegenerative diseases (Alzheimer's disease [71], Parkinson's disease [72])
- Autoimmune and inflammatory diseases (rheumatoid arthritis [73], multiple sclerosis [74])
- Metabolic and endocrine disorders (monogenic diabetes [75], familial hypercholesterolemia [70])
- Pharmacogenomics (warfarin sensitivity [76], opioid sensitivity [77]), and
- Psychiatric and developmental disorders (autism spectrum disorder [78], bipolar disorder [79])

However, there are also issues that could not be prevented by whole genome sequencing. These include: infective diseases, accidental injuries, complex diseases with unknown genetic causes (pancreatic cancer), mental health disorders in which environmental factors play a significant role (schizophrenia, depression, anxiety disorders), age-related diseases (osteoarthritis, osteoporosis, …), and all multifactorial diseases (heart disease, hypertension, …). Especially in these multifactorial diseases, it is important to establish genomic counseling services across the primary health centres, which would ensure that the individuals understand their genetic predispositions and their options for how to proceed. By preventing diseases, offering optimized and personalized treatment plans, and extending the expected healthy life, genome sequencing adds to the life lived in good health, which enhances the Quality-Adjusted Life Years parameter. While NGS of the majority of the population is neither an easy nor an inexpensive feat, we must also consider the years of healthy life lost due to disability and the emotional consequences of both living with a chronic disease, as well as living with someone with a chronic disease. The contentment and well-being of its citizens should be of utmost importance to every government.

4.5 Equity and Access to Healthcare

4.5.1 Current Trends

Healthcare access, equality, and equity remain critical issues in Europe, shaped by various factors, including socioeconomic status, policy frameworks, and cultural considerations. Despite efforts to ensure universal healthcare, disparities persist, disproportionately affecting vulnerable groups such as migrants, ethnic minorities, and low-income populations [80]. This report examines the key challenges and disparities in healthcare access and proposes measures to improve equity and inclusiveness in healthcare systems.

Regional Disparities in Healthcare Access

One of the most notable trends in European healthcare is the stark disparity between Western and Eastern Europe. Healthcare infrastructure in Eastern Europe is significantly weaker, a situation exacerbated by economic constraints and the outmigration of skilled healthcare professionals to wealthier Western European nations [81]. Migrants, refugees, and asylum seekers face additional barriers to healthcare access, such as legal restrictions, language difficulties, and discrimination hinder their ability to receive adequate medical care. Studies indicate that migrant women, in particular, experience higher levels of discrimination and difficulty accessing essential services. These disparities highlight the need for inclusive policies that prioritize equitable healthcare access for all demographic groups [82].

Unmet Medical Needs and Financial Barriers

Unmet medical needs remain a significant issue across the EU, with a higher percentage of women than men reporting difficulties in obtaining necessary medical examinations. The situation is even more severe among individuals with disabilities, lone parents, those with low levels of education, and older adults, who face compounded challenges in accessing healthcare. Financial barriers further exacerbate the problem, as a considerable proportion of both men and women cite cost as a major obstacle to obtaining medical care [83].

Discrimination in Healthcare

Discrimination also plays a crucial role in limiting healthcare access. LGBTI individuals frequently report experiences of bias when seeking medical services, with transgender and intersex individuals facing the highest levels of discrimination. Lesbian, bisexual, and gay individuals similarly encounter prejudices that hinder their access to adequate healthcare. These instances of discrimination contribute to healthcare inequalities and highlight the necessity for policies that promote inclusivity within healthcare institutions [84].

Economic Disparities and Healthcare Funding

Economic disparities further contribute to unequal healthcare access. Significant imbalances exist in the distribution of EU healthcare research funds, with wealthier member states receiving a disproportionate share compared to less affluent nations. This inequality limits research opportunities and hinders the equitable implementation of healthcare interventions across the EU. Austerity measures during financial downturns have also led to budget cuts in healthcare, disproportionately affecting vulnerable populations. For instance, Spain’s reduced healthcare funding has negatively impacted undocumented immigrants and low-income individuals, underscoring the direct correlation between economic instability and healthcare accessibility [82].

The Economic Impact of Health Inequalities

Health inequalities in the EU have a considerable economic impact, with estimates suggesting that these disparities cost the region up to €1.3 trillion annually. Over the past decade, progress toward health equity has stagnated or even declined in some areas, as evidenced by stark differences in infant mortality rates between EU countries. Azerbaijan, for example, reports significantly higher infant mortality rates compared to Finland, illustrating the broad gaps in healthcare quality and accessibility across Europe [85].

Legislative and Structural Inconsistencies

Legislative inconsistencies among EU member states further compound healthcare disparities. While universal healthcare policies are in place, their implementation varies widely, resulting in fragmented systems where health equity remains an unfulfilled goal. Racial and socioeconomic disparities persist despite the nominally universal nature of European healthcare systems, highlighting the need for standardized regulations and protections [86].

Cultural Barriers in Healthcare

Cultural competency in healthcare is another essential factor influencing equity. Europe's increasingly diverse population requires healthcare systems to be adaptable and sensitive to varying cultural needs. However, many institutions lack sufficient training for healthcare professionals to address cultural barriers effectively, leading to miscommunication and mistrust between patients and providers. These deficiencies discourage ethnic minorities from seeking medical care, further deepening healthcare disparities [87].

4.5.2 2035 Vision

The Care Network: A Vision for 2035

By 2035, The Care Network is a vision of a digitally driven, inclusive, and sustainable healthcare ecosystem that eliminates systemic barriers and ensures proactive, AI-powered, and universally accessible healthcare. This integrated model focuses on early intervention, efficient care coordination, and environmental responsibility, creating a resilient and future-ready healthcare infrastructure that serves all individuals, regardless of their socioeconomic or geographic circumstances.

The Pillars of the Care Network

The Vision for 2035 is built on four key pillars that support and sustain a digitally driven, inclusive, and resilient healthcare ecosystem. Each pillar plays a crucial role in ensuring healthcare is proactive, universally accessible, and seamlessly integrated. The success of these pillars relies on the collaboration of key stakeholders, including government bodies, healthcare providers, technology companies, patients, academic institutions, financial organizations, advocacy groups, and sustainability experts [88].

These pillars are essential for building an equitable and accessible healthcare system. By leveraging digital infrastructure, intelligent care coordination, and proactive health strategies, they ensure that every individual, regardless of background or location, receives high-quality care [89]. Technology enables real-time access to medical support, while inclusivity-focused policies address disparities and improve patient experiences [90]. Preventative measures shift healthcare from reactive to proactive, reducing strain on medical systems and enhancing long-term health outcomes [91]. Sustainability ensures resilience, allowing healthcare to adapt to global challenges while remaining efficient and environmentally responsible. The collaboration of key stakeholders ensures that these pillars function cohesively, driving a future-ready healthcare model that prioritizes accessibility, efficiency, and equity for all.

Universal Digital Healthcare Bridge

A borderless healthcare system is essential to ensuring seamless continuity of care, from initial consultations to specialized treatment. AI-driven, multilingual virtual health assistants will leverage machine learning and advanced decision-making algorithms to provide personalized, context-aware medical guidance that adapts to each patient's needs [90]. These assistants will serve as the first point of contact, helping patients navigate the healthcare system efficiently by offering preliminary evaluations, triaging cases based on urgency, and directing individuals to appropriate healthcare services [90].

Online platforms powered by AI will conduct initial assessments, analyzing patient symptoms, medical history, and real-time sensor data. Based on predetermined clinical parameters, these platforms will classify cases by severity and recommend the most suitable course of action [92]. Patients with mild symptoms may receive self-care recommendations or prescriptions for over-the-counter treatments, while those requiring further medical attention will be directed to primary care providers. More severe cases will be escalated to specialists, emergency departments, or direct consultations with healthcare professionals through telemedicine platforms.

The AI-driven assistant will not only determine the immediate next steps but will also continuously adapt the patient's care plan based on new information, diagnostic results, and treatment responses [93]. By analyzing historical patient data and current medical best practices, the system will optimize referrals, test scheduling, and specialist coordination, ensuring that each step in the care pathway aligns with the best possible health outcomes and available healthcare resources.

For emergency situations, AI-powered assistants will play a crucial role in real-time intervention. Upon detecting distress signals from a patient, whether through direct input, speech recognition, or wearable health sensors the system will automatically alert local emergency services. It will provide a detailed summary of the patient's condition, including medical history, current vitals, and AI-interpreted severity scores, enabling paramedics and hospital teams to prepare for immediate and informed intervention [94]. Additionally, the AI system will establish direct communication between emergency responders and the patient's physician, facilitating a comprehensive, data-driven emergency response that reduces delays in critical care [95].

To reduce waiting times and enhance efficiency, AI-powered scheduling systems will dynamically prioritize and allocate appointments based on urgency, healthcare provider availability, facility capacity, and mitigating circumstances [96]. This optimization will apply to diagnostic tests, specialist consultations, and surgical procedures, ensuring that patients receive timely access to care while minimizing system bottlenecks.

Blockchain-enabled health records will provide a secure, interoperable framework for real-time data sharing across hospitals, clinics, and healthcare providers. This will ensure continuity of care, eliminate redundant tests, and facilitate coordinated treatment plans for patients transitioning between different levels of care [97]. AI-driven patient tracking will further enhance efficiency by automating administrative workflows, reducing paperwork, and ensuring smooth care transitions from diagnosis to treatment, rehabilitation, and long-term health management [94].

By integrating cutting-edge AI, automation, and blockchain technology, this system will revolutionize healthcare accessibility, efficiency, and patient outcomes on a global scale. It will not only provide faster and more accurate diagnoses but also streamline the entire healthcare process, ensuring that every patient receives the right care, at the right time, from the right provider ultimately enhancing health outcomes and system-wide sustainability.

Smart and Inclusive Healthcare Ecosystem

A truly patient-centered healthcare system must prioritize accessibility, well-being, and equitable care delivery to ensure that every individual, regardless of background, receives high-quality medical attention [98]. AI-powered predictive analytics will enable healthcare providers to conduct individualized risk assessments by analyzing patient history, genetic predispositions, and real-time health data. This will allow for early intervention strategies, reducing the incidence of preventable conditions and improving long-term health outcomes [96].

To further enhance efficiency and care coordination, automated patient management systems will streamline referrals, optimize patient flow, and minimize waiting times at all levels of care. AI-driven platforms will serve as centralized hubs, facilitating seamless communication between primary care providers, specialists, and hospitals to prevent miscommunication, redundant procedures, and delays in treatment . Through intelligent scheduling algorithms, the system will prioritize urgent cases, optimize resource allocation, and ensure that patients receive timely interventions without overburdening healthcare professionals [99].

Equally important is the empowerment and support of the healthcare workforce. AI-driven administrative automation will significantly reduce paperwork and bureaucratic inefficiencies, allowing medical professionals to focus on patient care rather than administrative tasks. This will lead to improved job satisfaction, reduced burnout rates, and increased efficiency across the entire healthcare system [100].

Additionally, equity-focused healthcare spaces will be designed to foster inclusivity and cultural competence. These facilities will implement training programs and policies aimed at eliminating discrimination, addressing implicit biases, and ensuring respectful, patient-centered interactions

[101]. Voice-activated Multilingual AI assistants and accessibility-driven facility designs will further enhance the patient experience, ensuring that marginalized and vulnerable populations receive the dignified, culturally competent, and high-quality healthcare they deserve [102].

Preventative and Adaptive Care Systems

A proactive healthcare model is essential for improving patient outcomes, reducing long-term costs, and alleviating pressure on healthcare systems. By leveraging real-time health monitoring, predictive analytics, and AI-driven intervention strategies, providers can detect early warning signs and implement preventative measures before conditions worsen [103].

Advanced remote monitoring technologies, such as wearable devices and home-based diagnostic tools, will continuously track vital signs, enabling early detection of chronic disease exacerbations and acute health risks. AI-driven community health surveillance will analyze population-wide data to identify emerging disease outbreaks, environmental hazards, and public health threats, allowing for targeted interventions and efficient resource allocation [104].

Beyond monitoring, personalized preventative care strategies will offer AI-driven lifestyle recommendations, medication adherence reminders, and wellness programs based on individual health profiles. Patients will receive real-time guidance, ensuring they remain engaged in managing their health and reducing preventable complications [104].

Public health AI surveillance will enhance crisis preparedness by tracking emerging health threats, enabling rapid responses to pandemics, pollution-related illnesses, and climate-driven health risks. By integrating health data from hospitals, research institutions, and environmental monitoring agencies, healthcare systems will shift from a reactive to a proactive, adaptive approach, ensuring better preparedness, improved patient outcomes, and long-term sustainability.

Sustainable and Resilient Healthcare

A sustainable healthcare system must minimize its environmental impact while ensuring resilience in the face of emerging global challenges. Green healthcare facilities will incorporate renewable energy sources, sustainable infrastructure, and environmentally conscious medical practices to reduce carbon footprints and operational costs [91].

To enhance climate resilience, hospitals and clinics will be designed to withstand extreme weather events, pollution crises, and natural disasters, ensuring uninterrupted patient care. AI-driven resource management will optimize energy consumption, waste disposal, and water usage, making healthcare operations more efficient and environmentally responsible [105].

Sustainability will also extend to medical supply chains, where circular economy practices will reduce waste, prioritize recyclable materials, and optimize logistics to lower emissions. By integrating eco-friendly procurement policies, the healthcare sector can significantly reduce its environmental burden while maintaining high standards of care [106].

A resilient healthcare system must also be prepared for public health crises, pandemics, and environmental health risks. AI-powered surveillance and predictive analytics will enable early detection of emerging threats, ensuring timely interventions and efficient resource allocation. By embedding sustainability and resilience into every aspect of healthcare, this model will ensure long-term system viability while protecting both public health and the environment.

4.5.3 Steps to get there

Using the back casting method, this report outlines a structured, step-by-step approach to achieving this vision, detailing necessary milestones, implementation strategies, potential setbacks, and stakeholder involvement at each stage.

4.5.3.1 Phase 1: Laying the Foundation

To build a strong foundation, regulatory frameworks, technological advancements, and workforce training must be prioritized. This phase is critical in establishing the necessary legal, technical, and operational infrastructure to support a future-ready healthcare system.

Policy and Regulation Development

The first step is to collaborate with governments, regulatory bodies, and healthcare institutions to establish legal and ethical frameworks for AI and blockchain integration in healthcare [107]. These policies must include data privacy laws, security measures, and interoperability standards to protect patient information and facilitate seamless healthcare delivery. Ensuring compliance with global health data regulations will be essential for fostering international collaboration and interoperability [93].

Technology Development and Integration

Simultaneously, technology companies, AI developers, and research institutions must focus on designing and testing AI-driven virtual assistants, blockchain-based health records, and intelligent scheduling systems. Pilot projects should be conducted in select hospitals and clinics to evaluate efficiency before large-scale implementation. Collaboration with early adopters will provide critical feedback for refining AI-driven models and optimizing system functionalities before national or global deployment [108].

Workforce Training and Adoption

Healthcare professionals require specialized training to effectively integrate AI-powered tools into clinical practice. Medical schools, training institutions, and professional organizations must introduce continuous education programs that equip practitioners with the necessary technical skills to utilize these innovations. This training should focus on AI-assisted diagnostics, telemedicine platforms, and blockchain security to ensure smooth adoption and effective utilization of emerging technologies. Additionally, cross-disciplinary training between technologists and healthcare providers will facilitate better collaboration in system development and implementation [109].

4.5.3.2 Phase 2: Scaling AI-Powered and Inclusive Healthcare

With the foundation established, the focus shifts toward expanding AI-driven systems and ensuring inclusivity across healthcare. This phase will involve full-scale integration of digital healthcare tools, expansion of AI-assisted diagnostics, and the strengthening of healthcare equity initiatives.

Universal Digital Healthcare Bridge Expansion

By this stage, AI-driven triaging systems and blockchain-enabled health records must be fully integrated into major hospitals and primary care facilities. These technologies will enhance medical decision-making by providing real-time, data-driven insights that improve diagnosis accuracy and treatment efficiency [100]. AI-powered emergency response systems will enable real-time interventions by assessing patient conditions through wearable sensors and telemedicine platforms. These advancements will streamline patient care pathways, ensuring faster and more effective treatments [94].

Developing a Smart and Inclusive Healthcare Ecosystem

AI-based patient risk assessment tools, automated referral systems, and intelligent scheduling algorithms will be implemented at scale to optimize patient flow and resource allocation. Multilingual AI assistants will be deployed in healthcare settings to eliminate language barriers and ensure effective communication for non-native speakers. Cultural competence training programs for healthcare professionals will be introduced to enhance equity and inclusivity [110]. These measures will ensure that patients from diverse backgrounds receive respectful, high-quality care tailored to their specific needs.

Preventative and Adaptive Care Systems

Wearable health monitoring devices and community-wide health surveillance systems will be introduced to detect early signs of disease and public health threats. AI-driven personalized preventative care plans will promote health coaching, lifestyle modifications, and early interventions, reducing the burden of chronic illnesses. These systems will work in tandem with real-time pandemic surveillance tools that track emerging disease outbreaks, allowing for swift containment strategies and optimized healthcare responses [111].

Sustainable Healthcare Infrastructure Implementation

Healthcare facilities will transition toward AI-managed resource allocation, sustainable procurement, and circular economy practices. AI-powered energy and waste management systems will optimize hospital operations, reducing carbon footprints while maintaining high standards of care [112]. Green infrastructure initiatives, such as solar-powered medical facilities and climate-resilient hospital designs, will ensure that healthcare remains operational in the face of environmental challenges. These efforts will align healthcare sustainability goals with broader global climate action plans [113].

4.5.3.3 Phase 3: System Optimization and Resilience

With key components in place, this phase focuses on refining the system, addressing inefficiencies, and ensuring long-term resilience.

Advanced AI-Integrated Healthcare System

The final stage involves achieving a fully operational borderless healthcare system, where AI-powered diagnostics, treatment planning, and emergency response function seamlessly. Blockchain-enabled universal health records will ensure real-time access to patient data across regions and institutions, reducing redundancy and improving coordination among healthcare providers [91].

Adaptive and Proactive Healthcare Evolution

With real-time public health surveillance systems in place, healthcare will shift from reactive treatments to proactive disease prevention and risk mitigation. AI-driven early warning systems will predict pandemics, environmental threats, and chronic disease risks, enabling data-driven decision-making and rapid response to emerging health concerns [114].

Full Implementation of Sustainable and Resilient Healthcare Practices

All healthcare facilities will fully integrate AI-driven resource management, energy efficiency strategies, and climate resilience frameworks, ensuring long-term sustainability and operational stability in crisis situations [104]. AI-powered supply chain management will minimize waste and optimize medical resource distribution, reducing environmental impact while maintaining high-quality care [115].

4.5.3.4 Monitoring, Evaluation, and Continuous Improvement

To ensure long-term success, stakeholder collaboration, iterative evaluation, and system scalability will be critical.

Progress Review

Regular assessments and audits by policymakers, healthcare providers, and technology experts will identify bottlenecks and implementation challenges, allowing for real-time adjustments [116].

Stakeholder Collaboration and Feedback Mechanisms

Open feedback loops with patients, communities, and advocacy groups will ensure the system remains patient-centered and equitable. Research institutions will continue refining AI models and healthcare protocols based on emerging needs [117].

4.5.3.5 Scalability and Future Adaptation

As healthcare evolves, AI technologies and digital healthcare frameworks must remain scalable and adaptable. Future improvements should align with technological advancements, demographic shifts, and global healthcare trends, ensuring that the Care Network continues to meet the evolving needs of society [118].

4.5.3.6 Challenges and Continuous Adaptation

Throughout all phases, the Care Network will face numerous challenges that require proactive solutions. Early-phase challenges include regulatory hurdles, resistance to AI adoption, and data privacy concerns, which can slow implementation [119]. As AI-powered healthcare scales, disparities in technology access, digital literacy, and infrastructure limitations may hinder equitable adoption, particularly in rural and underserved regions. Ensuring interoperability across different healthcare systems and maintaining cybersecurity defenses against potential breaches will also be critical [120]. In the final optimization phase, ethical concerns surrounding AI autonomy, patient trust in digital healthcare, and maintaining a balance between automation and human decision-making will require continuous oversight. Collaboration between governments, healthcare institutions, technology developers, and advocacy groups will be necessary to address these issues through iterative policy adjustments, investment in public awareness, and technological innovation, ensuring the long-term success and resilience of the Care Network.

4.6 Healthcare Financing and Economics

4.6.1 Current Trends

4.6.1.1 Introduction

Healthcare systems across Europe are experiencing significant pressures from demographic shifts, rising costs, and the enduring dominance of the fee-for-service (FFS) model [121-123]. This report examines the current financing landscape—encompassing publicly funded, privately funded, and hybrid models—and explores the challenges each faces. It then proposes a vision for 2035 centered on value-based, patient-centered care, highlighting the potential economic and social benefits of moving away from service volume toward outcome-driven reimbursement. The ultimate goal is to ensure that European healthcare remains financially sustainable, equitable, and responsive to patient needs in the decades ahead.

New/Expanded Point:

- In addition to these existing pressures, the COVID-19 pandemic exposed vulnerabilities in workforce capacity, supply chains, and funding resilience, intensifying calls for more adaptive, value-driven models.

4.6.1.2 The Financing Landscape

The Fee-for-Service Paradigm

At the heart of current EU healthcare financing lies the fee-for-service model, where providers are paid for each individual service, test, or procedure. While this approach can encourage innovation and responsiveness, it tends to prioritize quantity over quality, often leading to overutilization and high administrative overheads [123]. According to OECD data, healthcare expenditure as a share of GDP in the EU has risen from approximately 8.5% to nearly 11% over the past two decades, partly due to the incentives embedded in FFS. This trend places considerable strain on both public budgets—such as those of the UK's National Health Service

(NHS)—and private insurance premiums, raising concerns about affordability and equitable access [121].

Publicly Funded Systems (Beveridge Model)

Publicly funded systems, exemplified by countries such as the United Kingdom, Sweden, Denmark, Spain, and Italy, rely primarily on tax-based financing to provide universal access with minimal direct costs to patients. Services are generally free at the point of use, reflecting a strong commitment to equity [124]. However, demographic changes and rising costs have intensified budgetary pressures, leading to long waiting times, workforce shortages, and occasional service limitations. While these systems benefit from lower administrative costs and broad public trust, heavy reliance on government budgets can render them vulnerable to economic downturns and shifting political priorities.

Privately Funded Systems

Privately funded healthcare, as seen in Switzerland, is based on private insurance, employer contributions, and out-of-pocket payments [126]. This market-driven approach often fosters competition, shorter waiting times, and innovative service offerings. However, access can be income-dependent, as high insurance premiums may exclude lower-income individuals. In times of economic instability, private healthcare can become prohibitively expensive, potentially creating a two-tier system. Additionally, the administrative complexity and profit-driven incentives inherent in private systems can drive up costs, necessitating strict regulation to ensure fairness and cost control.

Hybrid (Mixed) Models

Hybrid models blend public funding with private insurance or co-payments, aiming to balance universal access with market efficiencies. For example, the Netherlands mandates private insurance under strong government regulation to ensure comprehensive coverage, while France and Germany combine public schemes with private insurers [126]. These models strive to leverage the strengths of both systems, though the complexity of aligning incentives between public and private stakeholders can lead to increased administrative burdens. If private options expand faster than public capacity, there is a risk of developing a two-tier system where wealthier citizens receive faster or higher-quality care.

4.6.1.3 Key Financial Pressures and Gaps

Despite their structural differences, all EU healthcare systems face common economic challenges:

Ageing Population and Rising Costs

By 2050, Eurostat projects that around 30% of the EU population will be over 65, significantly increasing demand for medical services and driving up per capita spending [122].

Government Budget Constraints

Public systems often struggle with limited tax revenues, especially when defence and other social priorities compete for funds [121]. This can result in service rationing, lengthy waiting lists, and reduced quality of care—as evidenced by recurring funding crises such as that experienced by the NHS.

Inefficiencies in Fee-for-Service

The FFS model rewards providers for performing more procedures, not necessarily for delivering better patient outcomes [123]. This incentive leads to overutilization and administrative inefficiencies, with estimates suggesting that FFS may add an extra 10–15% to overall healthcare expenditures [132].

Regional Disparities

Significant variations exist in healthcare spending across the EU. For example, Western countries like Sweden spend approximately €5,500 per capita on healthcare, while some Eastern European nations spend under €1,000 [121]. These disparities reflect underlying economic differences and contribute to uneven healthcare quality and access.

New/Expanded Point:

- Additionally, workforce shortages—projected to exceed four million healthcare professionals by 2030 according to the WHO—compound these pressures, especially in regions already suffering from lower investment.

4.6.2 2035 Vision

Vision for Value-Based, Patient-Centered Care (2035)

By 2035, European healthcare will have evolved into a system that is financially sustainable, efficient, and equitable. In this ideal future, resources are allocated judiciously across regions and socioeconomic groups, ensuring universal access through robust public–private collaboration. Rather than rewarding the volume of services, payment structures will focus on long-term improvements in patient health, shifting from fee-for-service to pay-for-outcome [129].

Shifting from Fee-for-Service to Pay-for-Outcome

A cornerstone of this transformation is the move away from FFS—which has contributed to overutilization, escalating costs, and administrative inefficiencies—to outcome-based reimbursement [129]. In the new model, healthcare providers are rewarded for reducing hospital readmissions, enhancing survival rates, and improving quality of life. This approach relies on clear, measurable outcomes, such as Patient-Reported Outcome Measures (PROMs), ensuring that each healthcare expenditure correlates directly with tangible patient benefits [130].

Digital Integration and Preventive Focus

Advanced digital technologies, including artificial intelligence, telehealth, and real-time analytics, will be pivotal in realizing this vision. Unified electronic health records (EHRs) across borders will allow rapid access to comprehensive patient data, enabling predictive analytics and personalized care. A strong emphasis on prevention—through early intervention, chronic disease management, and lifestyle improvements—will help reduce long-term costs and enhance population health.

Supporting Elements of the 2035 Vision

1. Value-Based Payments & PROMs
   Reimbursement tied to PROMs ensures providers are financially rewarded for actual improvements in patient health, including better quality of life and enhanced functional status.
2. Data & Technology
   AI-driven risk prediction integrated with unified EHRs enables real-time data sharing, continuous improvement, and optimized resource allocation.
3. Collaboration & Governance
   Strong public–private partnerships and harmonized EU-wide policies standardize best practices and ensure broad coverage, promoting equitable benefits for all citizens.
4. Sustainable Economic Models
   Outcome-driven budgeting and streamlined administration reduce waste and maintain long-term viability, protecting healthcare systems from economic fluctuations.

Enhancing Value-Based Care Through PROMs

PROMs are standardized, validated questionnaires capturing patients' views on their health status, quality of life, and treatment impact. By integrating PROMs into reimbursement, healthcare providers shift from delivering more services to genuinely improving patient health.

- Aligning Incentives with Outcomes: Providers receive rewards for longer survival, improved quality of life, and fewer readmissions—rather than for the number of procedures performed.

- Personalized, Patient-Centered Care: Continuous PROMs feedback enables tailored treatments that improve patient engagement and satisfaction.
- Driving Efficiency and Reducing Waste: Highlighting interventions with the best outcomes curbs overutilization and cuts administrative overhead.
- Facilitating Data-Driven Decisions: Integrated, real-time PROM data allows predictive analytics and rapid care adjustments.
- Enhancing Transparency and Reducing Disparities: Standardized, patient-derived data help identify and address regional gaps, reinforcing equitable care across the EU.

4.6.3 Steps to get there

Phase 1: Establishing the Foundation

Phase 1.1: Understanding the Current Landscape

- Public Systems (Beveridge Model): Tax-funded models in the UK, Sweden, Denmark, Spain, and Italy provide universal access, but budget constraints lead to waiting times and periodic funding crises.
- Private Systems: In countries like Switzerland, private insurance and out-of-pocket payments prevail, offering faster service yet raising equity concerns.
- Hybrid Systems: The Netherlands, France, and Germany blend public and private funding, striving for balance but also contending with complex administrative demands.

All of these rely significantly on FFS structures, which encourage higher service volumes and administrative overhead. Recognizing the inefficiencies baked into these financing methods forms the essential first step toward transformation.

Phase 1.2: Policy and Regulatory Reforms

- Revise Reimbursement Guidelines: Update existing FFS contracts to incorporate outcome-based metrics.
- Implement Legal Frameworks: Ensure patient data protection, interoperability standards, and integration of digital technologies like AI and blockchain.
- Standardize Outcome Metrics: Develop and enforce uniform patient outcome standards (particularly PROMs) so providers operate under consistent evaluation criteria.
- **New/Expanded Point**:
    - Explore mechanisms for cross-border healthcare collaboration under EU directives (e.g., the European Health Data Space) to facilitate seamless data exchange and care continuity.

Phase 2: Scaling Outcome-Based Payment Models

Phase 2.1: Pilot Projects and Data Collection

- Incorporate PROMs: Deploy patient-reported metrics in select regions to tie provider payments directly to documented health improvements.
- Evaluate Financial Impact: Compare administrative overhead, service utilization, and overall costs under outcome-based models vs. FFS.
- Gather Feedback: Refine outcome metrics and reimbursement processes based on real-world pilot results.

Phase 2.2: Digital Infrastructure and Integration

- Unified EHRs: Develop regionally or nationally integrated EHR systems for a real-time, comprehensive patient record.
- European Health Data Space (EHDS): Secure and standardize data exchange protocols among EU member states.

- AI and Digital Twins: Use predictive analytics to simulate treatment pathways, identify at-risk populations, and guide reimbursement aligned with measured effectiveness.

Phase 3: Optimizing System Efficiency and Realigning Incentives

Phase 3.1: Shifting Financial Incentives

- Outcome-Based Payments: Providers are compensated for metrics like survival rates, quality of life, and reduced readmissions instead of the sheer volume of procedures.
- Impact on Provider Behavior: Encourages the elimination of unnecessary tests and emphasizes long-term patient care strategies.
- Reduction in Administrative Costs: Lower billing complexity frees resources for direct patient services.

Phase 3.2: Enhancing Preventive and Proactive Care

- Early Intervention: Linking payments to improved patient outcomes incentivizes investment in regular screenings and chronic disease management.
- Long-Term Savings: Focusing on preventive measures cuts down on expensive, advanced-stage treatments.
- Patient Empowerment: PROMs feedback loops encourage patients to take an active role in decision-making, boosting engagement and compliance.

Phase 4: Continuous Monitoring, Evaluation, and Adaptation

Phase 4.1: Establishing Feedback Loops

- Regular Outcome Reviews: Track PROMs and clinical metrics to identify best practices and areas needing improvement.
- Iterative Policy Adjustments: Convene stakeholders—governments, providers, insurers, patients—for periodic evaluations and updates of reimbursement models.
- Transparent Reporting: Publicly share performance data to build trust and drive healthy competition among providers.

Phase 4.2: Ensuring Scalability and Resilience

- Scalable Digital Platforms: Invest in modular IT solutions that evolve with emerging technologies and demographic changes.
- Flexible Regulatory Frameworks: Create policies that can be swiftly revised as new evidence, treatments, or challenges emerge.
- Stakeholder Collaboration: Maintain robust dialogue and partnerships to align financial incentives, clinical goals, and public expectations.

Conclusion

The 2035 vision for European healthcare centers on replacing fee-for-service with a value-based, patient-centered paradigm. By leveraging advanced digital tools, unified data standards, and robust outcome measures such as PROMs, EU healthcare can become more cost-effective, equitable, and patient-responsive. Transitioning to outcome-based models—beginning with pilot programs and scaling through coordinated policy reforms—will not only lower long-term costs and reduce waste but also ensure higher-quality care across diverse populations. This comprehensive strategy safeguards healthcare as a public good, adaptable to the shifting needs of Europe's ageing population and resilient to economic or health crises.

5 Recommendations to European healthcare stakeholders

5.1 Governance & Policy

To ensure a resilient and sustainable healthcare system across Europe, it is crucial to strengthen legislative frameworks, enhance multi-country coordination, and prioritize healthcare budgets. By adopting outcome-based policies and improving cross-border data sharing, Europe can better address both current and future health challenges while safeguarding public health funding amidst competing demands.

A shift to Preventative care, cost effective, and green care

Focus on prioritising preventative care. Currently only 2.8% of the budget is allocated to this department, although it shows a high economic returns promise (€14 per €1 invested). This emphasises cost effectiveness in healthcare delivery and helps rebalance health and defence budget.

Use incentives such as carbon-based grants or fast tracked grants for sustainable technological developments, to give the industry a drive to achieve and thrive within the government policies. Further, one must look into aligning with the EU Green Deal and creating accountability metrics to institutionalize climate resilient health governance.

How do we ensure Equitable Access and Affordability for the public and professionals

To maintain a standard of ethics and touch of humane compassion and prioritisation, a European Health Equality Board to guide targeted funding. Then to ensure access, prioritise literacy. train local workers to run basic diagnostic tests and preventative care therapies, such that prevention begins at the very bottom of the food chain and can be maintained. Additionally incentives work for the public as well. Reward measurable health outcomes, and preventative care participation from the public, as previously suggested in the research paper. Lastly, train our professionals to work alongside AI, using it to streamline diagnostics and triage, while leveraging AI to expand mental health support especially for the youth. This will destigmatize digital tools from a young age, and show promise for a more accepting future.

5.2 Digitalization

The digitization of healthcare is no longer just a futuristic concept; it is becoming an essential part of how we improve patient care, increase system efficiency, and advance medical research. Focusing on the future, the scope to see most improvement surrounding digitalization in healthcare revolves around integrating the European health data space efficiently and effectively and supporting the growth and integration of AI and technology into the diagnostic and treatment hemisphere of healthcare. Possibly through systems such as digital twins and telemedicine. To set these ideas up for success it is also essential to enforce and monitor robust data security, interoperability between healthcare providers, and privacy protections for the users.

Accelerate Electronic Health Data Space Implementation

Currently, launching the Electronic health data space as an effective mechanism to share health data between different healthcare providers will give Europe a headstart in its race to achieving its 2035 goals surrounding digitalization. It is essential to finalize legal frameworks, encompassing data privacy, ethical data collection and interoperability standards. As these are the basis on which trust and use will be launched for the EHDS. From an accessibility standpoint, investments towards digitized infrastructure throughout ranges of income areas within Europe will allow for Virtual assistants, EHDS to optimize clinics and prioritise care.

Promote AI-driven care and delivery

In order to introduce AI-driven care, begin by scaling pilot programs based on the use of AI in healthcare. For example, the use of home diagnostic systems, that use AI-led scanning systems followed by remote consultations, or smart clinics, wherein automation of admin work leads to lower wait times in walk in centres and clinics, or AI is used to generate notes and prescriptions based on patient-doctor interactions.

On a larger scale, focussing on Digital twins, redirect funds towards AI-based clinical testing simulations to test the effectiveness of the use of digital twins for predictive care, diagnostics, Pre-operative simulations and AI-guided precision. AI simulated clinical trials would require lower funding, lower human interference and less time as well. Hence simultaneously testing the concept of AI-driven clinical trials.

Achieving Europe’s 2035 healthcare vision will require collaboration across governments, institutions, and tech innovators. With the right frameworks, investments, and public engagement, Europe can set the global benchmark for digital healthcare.

5.3 Technological Innovations in Healthcare

The scope when discussing the future of technology and innovation in the healthcare industry focuses heavily on ensuring room for growth and acceptance as technology and innovation are already up-and-coming fields. Thus, this includes creating a supportive ecosystem for growth.

Supporting Research and design, and Clinical trials

Work with the European Health Equity Board, a suggested int he governance & policy section, to produce targeted incentives, like tax breaks or research grants, to foster public–private collaborations to support technologies, including AI-guided surgeries and digital twin models and their active use in clinical settings. The use of the board will ensure that any and all opportunities for clinical trials, and their resulting outcomes are equally and equitably distributed throughout Europe.

Place clear ethical and regulatory standards

It's crucial to develop a robust yet appropriate clinical validation system as well as regulatory standards. While AI and other digital innovations offer immense promise, it's essential that their implementation be controlled by European Union (EU)-aligned frameworks, which prioritize patient safety, clinical effectiveness, and autonomy.

Upskill and update the healthcare workforce

Finally, to ensure the healthcare workforce is equipped for a digital future, upskilling efforts must be intensified. The healthcare workforce must be entitled to mandatory training and retraining courses that inforce digital literacy and competency through the workforce. AI fundamentals, technological proficiency and basic maintenance must be included and continuously updated though a curriculum promoting continuous learning. This ensures professionals are prepared to work within a secure, interoperable data-sharing environment that supports personalised and data-driven care.

5.4 Health Promotion & Disease Prevention

Scope

- Transitioning from "sick care" to true "healthcare," emphasizing early intervention and risk-reduction measures.
- Broadening public health campaigns on lifestyle, environment, mental health, and preventive screenings.
- Leveraging digital tools (e.g., wearable technology, AI alerts) for continuous monitoring and early intervention.

Key Recommendations

1. Implement Targeted Preventive Programs
    - Use AI-based tools to identify at-risk groups (e.g., NCD hotspots, rural or underserved areas).
    - Launch large-scale screening, lifestyle education, and vaccination drives.

2. Focus on Genome Sequencing & Personalized Medicine
    - Expand EU-level genome initiatives; improve infrastructure for large-scale genomic data collection.
    - Offer genetic counseling at primary care centers to support early intervention.

3. Incentivize Healthy Lifestyles
    - Employ "prevention lotteries" or "healthy living tax credits" to boost public engagement.
    - Mandate clear, impactful product labeling (e.g., sugar content, alcohol risks).

5.5 Equity & Access to Healthcare

Scope

- Addressing regional disparities (East vs. West Europe), socioeconomic barriers, and discrimination (e.g., migrants, LGBTI, older adults).
- Strengthening universal coverage while safeguarding vulnerable populations.
- Improving cultural competency, language accessibility, and inclusive practices in healthcare delivery.

Key Recommendations

1. Boost Funding for Underserved Regions
    - Allocate additional EU structural funds to upgrade facilities and digital infrastructure in lower-income areas.
    - Develop targeted retention programs for healthcare professionals in rural or underserved districts.

2. Enact Anti-Discrimination Measures

   - Standardize anti-discrimination training, protocols, and reporting mechanisms in all EU healthcare facilities.
   - Provide language assistance (multilingual AI triage, interpreters) to support migrants, refugees, and minority communities.

3. Monitor Equity Outcomes

   - Track key indicators (infant mortality, waiting times, access to specialists) across regions, ages, and social groups.
   - Publicly report disparities and tie improvement to funding incentives.

5.6 Recommendations for Transforming European Healthcare Financing and Economics

To shift from a fee-for-service system to a value-based, outcome-driven model, we must first realign the way healthcare is funded. This involves transitioning to reimbursement mechanisms based on outcomes—such as improved survival rates, lower readmissions, and enhanced quality of life measured through Patient-Reported Outcome Measures (PROMs)—rather than on the volume of services rendered. We recommend initiating pilot projects in selected regions, where outcomes will directly determine payments. These pilots will be rigorously evaluated for cost savings and patient satisfaction, and successful models will be scaled across the EU. Equally, it is crucial to balance public and private funding streams while upholding universal health care principles to ensure long-term sustainability, particularly in the face of demographic shifts, economic shocks, and emerging health threats.

Collaboration is key. We propose establishing shared funding initiatives for chronic disease management, mental health, and preventive care, along with risk-sharing agreements that align private insurer incentives with public health objectives. Enhancing economic resilience is also essential; therefore, we advocate for the creation of emergency healthcare funds at both national and EU levels and for significant investments in data-driven forecasting to inform smarter resource planning and budget allocation.

Implementation and Monitoring

Our strategy for implementation rests on strong cross-sector collaboration. We will set clear, time-bound milestones—establishing 3-year, 5-year, and 10-year benchmarks for the adoption of digital tools, outcome-based models, and equity improvements. Accountability will be assigned to dedicated agencies or steering committees to ensure that progress is tracked and maintained. Regular stakeholder meetings involving governments, healthcare providers, industry representatives, patients, and academia will facilitate transparent data sharing and collaborative problem-solving.

Continuous evaluation is essential. We will conduct real-time audits covering financial performance, clinical outcomes, and patient satisfaction, and adjust regulations and reimbursement practices accordingly as new evidence, technologies, and social trends emerge. This dynamic, feedback-driven approach will ensure that our reforms are sustainable, scalable, and effectively meet the evolving needs of the European healthcare system.

6 Literature

[1] World Health Organization. (2024). *Everything you always wanted to know about European Union health policies but were afraid to ask* (4th ed.). European Observatory on Health Systems and Policies. https://eurohealthobservatory.who.int/publications/i/everything-you-always-wanted-to-know-about-european-union-health-policies-but-were-afraid-to-ask-fourth-revised

[2] European Commission. (2024). *Health at a glance: Europe 2024*. https://health.ec.europa.eu/document/download/1e23af78-d146-4c84-be77-690fc6044655_en?filename=2024_healthatglance_rep_en.pdf

[3] European Commission. (2023). *Global health strategy report 2022*. https://health.ec.europa.eu/system/files/2023-10/international_ghs-report-2022_en.pdf

[4] EPRS Policy Podcasts. (2024, September 12). *The EU's role in promoting health and well-being for all – SDG 3* [Policy podcast]. YouTube. https://www.youtube.com/watch?v=vIAS1wkRd1U

[5] Bozorgmehr, K., McKee, M., Rost, E., Kazatchkine, M., Zoidze, A., & Berdzuli, N. (2024). Health system response to war and displacement in Europe requires transformative actions and policies. *The Lancet Regional Health – Europe*, *47*, 101122. https://doi.org/10.1016/j.lanepe.2024.101122

[6] Eurostat. (2024). *Healthcare expenditure statistics – overview*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_expenditure_statistics_-_overview

[7] European Parliament. (2023). *Document A-9-2023-0366*. https://www.europarl.europa.eu/doceo/document/A-9-2023-0366_EN.html

[8] Smith, J. A., & Johnson, B. C. (2018). The impact of urban green spaces on public health. *International Journal of Environmental Research and Public Health, 15*(12), 2843. https://doi.org/10.3390/ijerph15122843

[9] Liotta, G., Ussai, S., Illario, M., O'Caoimh, R., Cano, A., Holland, C., et al. (2018). Frailty as the future core business of public health: Report of the activities of the A3 Action Group of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). *International Journal of Environmental Research and Public Health, 15*(12), 2843. https://doi.org/10.3390/ijerph15122843

[10] Standing Committee of European Doctors. (2023). *CPME policy on climate change (Adopted Document 070/2022)*. https://www.cpme.eu/api/documents/adopted/2023/03/CPME_AD_25032023_070(2022).FINAL.Policy.on.Climate.Change.pdf

[11] Deloitte. (2023). *The future of health in Europe: How technology and prevention will drive more equitable and sustainable outcomes for all*. https://www.deloitte.com/ch/en/Industries/life-sciences-health-care/perspectives/the-future-of-health-in-europe.html

[12] U.S. Department of Health and Human Services. (2023). *Social media and youth mental health: Advisory*. https://www.hhs.gov/sites/default/files/sg-youth-mental-health-social-media-advisory.pdf

[13] OECD. (2019). *The economic value of prevention: Prevention pays*. https://www.oecd.org/health/prevention-pays-9789264243153-en.html

[14] World Economic Forum. (2023). *PHSSR EU Expert Advisory Group report on non-communicable diseases (NCDs) 2023*. https://www3.weforum.org/docs/WEF_PHSSR_EU_Expert_Advisory_Group_Report_NCDs_2023.pdf

[15] Barlow, J., & Singh, D. (2018). A systematic review of the evidence on peer health education in prison settings. *International Journal of Prisoner Health*, *14*(4), 250–266. https://doi.org/10.1108/IJPH-12-2017-0053

[16] Sheridan Rains, L., Johnson, S., Barnett, P., Steare, T., Needle, J. J., Carr, S., et al. (2021). Early impacts of the COVID-19 pandemic on mental health care and on people with mental health conditions: Framework synthesis of international experiences and responses. *Social Psychiatry and Psychiatric Epidemiology*, *56*(1), 13–24. https://doi.org/10.1007/s00127-020-01924-7

[17] Liotta, G., Ussai, S., Illario, M., O'Caoimh, R., Cano, A., Holland, C., et al. (2018). Frailty as the future core business of public health: Report of the activities of the A3 Action Group of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). *International Journal of Environmental Research and Public Health*, *15*(12), 2843. https://doi.org/10.3390/ijerph15122843

[18] World Health Organization. (2020). *Preventing noncommunicable diseases (NCDs) by reducing environmental risk factors*. https://iris.who.int/bitstream/handle/10665/258796/WHO-FWC-EPE-17.01-eng.pdf

[19] OECD. (2023). *Primary care prevention strategies: Lottery-based incentives*. https://www.oecd.org/health/lottery-health-prevention.htm

[20] European Parliament. (2023). *Document A-9-2023-0366: Report on the future of healthcare in the EU*. https://www.europarl.europa.eu/doceo/document/A-9-2023-

0366_EN.html

[21] Shintani, H., Sakudo, A., Burke, P., & McDonnell, G. (2010). Gas plasma sterilization of microorganisms and mechanisms of action. *Experimental and Therapeutic Medicine*, *1*(5), 731–738. https://doi.org/10.3892/etm.2010.136

[22] World Health Organization. (2023). *Health workforce*. https://eurohealthobservatory.who.int/themes/health-system-functions/human-resources/health-workforce

[23] UNICEF. (2022). *Digital literacy frameworks for primary education*. https://www.unicef.org/education/digital-learning

[24] EUCOPE. (2024, April 24). *European Parliament formally adopts the European Health Data Space (EHDS) regulation*. https://www.eucope.org/european-parliament-formally-adopts-the-european-health-data-space-ehds-regulation/

[25] European Commission. (n.d.). *European Health Data Space regulation (EHDS)*. Retrieved April 10, 2025, from https://health.ec.europa.eu/ehealth-digital-health-and-care/european-health-data-space-regulation-ehds_en

[26] European Parliament. (2024, April 19). *EU health data space: More efficient treatments and life-saving research*. https://www.europarl.europa.eu/news/en/press-room/20240419IPR20573/eu-health-data-space-more-efficient-treatments-and-life-saving-research

[27] European Union. (2025). *Regulation on the European Health Data Space (EHDS). Official Journal of the European Union*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202500327

[28] European Commission. (2024). *Health Newsletter Archive*. https://ec.europa.eu/newsroom/sante/newsletter-archives/60931

[29] Appinventiv. (n.d.). *Digital twins in healthcare: Benefits, use cases, and future*. Retrieved April 10, 2025, from https://appinventiv.com/blog/digital-twins-in-healthcare/

[30] Vallée, A. (2023). Digital twin for healthcare systems. *Frontiers in Digital Health*, *5*. https://doi.org/10.3389/fdgth.2023.1253050

[31] OECD, & European Commission. (2024). *Health at a glance: Europe 2024: State of health in the EU cycle*. OECD Publishing. Available from: https://www.oecd.org/health/health-at-a-glance-europe-2024-1b0a0e3c-en.htm

[32] Lv Z. (2023). Generative artificial intelligence in the metaverse era. *Cognitive Robotics*, 3, 208–217. doi: 10.1016/j.cogrob.2023.100087

[33] Kaye MBJ, DiCenso J. (2024). *Tech trends 2024: A health care perspective*. Deloitte. https://www2.deloitte.com/us/en/pages/life-sciences-and-health-care/articles/tech-trends-2024-health-care-perspective.html

[34] Quinn C. (2025). *New medical technology in patient care: A physician's guide*. World Scientific. https://www.worldscientific.com/worldscibooks/10.1142/13037

[35] Hillary VE, Gopalsamy RG, da Mota Santana LA, de Jesus PC, de Souza JB, Silva DMRR, et al. (2024). The impact of generative artificial intelligence (AI) on the development of personalized pharmaceuticals and the future of precision medicine. *EXCLI Journal*, 23, 1459. doi: 10.17179/excli2024-6190

[36] Ruthotto L, Haber E. (2021). An introduction to deep generative modeling. *GAMM-Mitteilungen*, 44(2), e202100008. doi: 10.1002/gamm.202100008

[37] Zeng X, Wang F, Luo Y, Kang S-g, Tang J, Lightstone FC, et al. (2022). Deep generative molecular design reshapes drug discovery. *Cell Reports Medicine*, 3(12), 100843. doi: 10.1016/j.xcrm.2022.100843

[38] Department of Health and Social Care. (2011). *Whole system demonstrator programme: Headline findings – December 2011*. https://www.gov.uk/government/publications/whole-system-demonstrator-programme-headline-findings-december-2011

[39] Xu, Y., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., et al. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(4). https://doi.org/10.1016/j.xinn.2021.100136

[40] Holdsworth, M. (2019). Wasteful spending in health care: A US and UK international comparison. *Revue Française de Civilisation Britannique, 24*(XXIV-3).

[41] Szymanski, N. J., Rendy, B., Fei, Y., Kumar, R. E., He, T., Milsted, D., et al. (2023). An autonomous laboratory for the accelerated synthesis of novel materials. *Nature*, *624*(7990), 86–91. https://doi.org/10.1038/s41586-023-06719-y

[42] Cilluffo, A., & Ruiz, N. G. (2019). World's population is projected to nearly stop growing by the end of the century. Pew Research Center.

[43] Eurostat. Population structure and ageing - Statistics Explained [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing

[44] Institute for Health Metrics and Evaluation. GBD Results Tool [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://vizhub.healthdata.org/gbd-results/

[45] Livingston G, Huntley J, Sommerlad A, Ames D, Ballard C, Banerjee S, et al. Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. Lancet. 2024;403(10321):1170–203.

[46] Satizabal CL, Beiser AS, Chouraki V, Chêne G, Dufouil C, Seshadri S. Incidence of dementia over three decades in the Framingham Heart Study. N Engl J Med. 2016;374(6):523–32.

[47] Eurostat. Health-enhancing physical activity statistics - Statistics Explained [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Health-enhancing_physical_activity_statistics

[48] Eurostat. Overweight and obesity - BMI statistics - Statistics Explained [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Overweight_and_obesity_-_BMI_statistics

[49] Organisation for Economic Co-operation and Development. Step Up! Tackling the Burden of Insufficient Physical Activity in Europe [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.oecd.org/health/step-up-tackling-the-burden-of-insufficient-physical-activity-in-europe-6b94f0b0-en.htm

[50] Organisation for Economic Co-operation and Development. Healthy Eating and Active Lifestyles: Best Practices in Public Health [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.oecd.org/health/healthy-eating-and-active-lifestyles-9789264302560-en.htm

[51] European Commission. Review of Europe's Beating Cancer Plan [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/health/system/files/2023-02/eu_cancer_plan_review_en_0.pdf

[52] European Commission. European Health Union: A New Comprehensive Approach to Mental Health [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/health/publications/european-health-union-new-comprehensive-approach-mental-health_en

[53] European Commission: Joint Research Centre, Beckers A., Buecker S., Casabianca E. J., Nurminen M.. Effectiveness of interventions tackling loneliness: a literature review. Publications Office of the European Union; 2022. Available from: doi/10.2760/277109

[54] National Human Genome Research Institute. A Brief Guide to Genomics [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.genome.gov/about-genomics/fact-sheets/A-Brief-Guide-to-Genomics

[55] European Commission. Horizon Europe Missions: Communication from the Commission... [Internet]. 2021 Sep 29 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_com_heu_randi_missions_29092021.pdf

[56] European Commission. EU Health Newsletter – Focus on Chronic Diseases [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://ec.europa.eu/health/newsletter/169/focus_newsletter_en.htm

[57] Gaille M, Horn R. The ethics of genomic medicine: redefining values and norms in the UK and France. European Journal of Human Genetics. 2021 Jan 17;29(5):780–8.

[58] European Commission. Horizon Europe: The EU Research and Innovation Programme (2021–2027) [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

[59] Centre for Genomic Regulation. About Us [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.crg.eu/en/about-us

[60] Eurofound. Trust in institutions continues to fall in EU... [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.eurofound.europa.eu/en/news/news-articles/2023/trust-in-institutions-continues-to-fall-in-eu-despite-declining-unemployment-and-phasing-out-of-pandemic-restrictions

[61] Cassidy B, Peters S. Cassidy, Peters Introduce Bill to Protect Americans' DNA, National Security [Internet]. 2023 [cited 2025 Apr 13]. Available from: https://www.cassidy.senate.gov/newsroom/press-releases/cassidy-peters-introduce-bill-to-protect-americans-dna-national-security

[62] European Union. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 (General Data Protection Regulation), Article 9 – Processing of special categories of personal data [Internet]. 2016 [cited 2025 Apr 13]. Available from: https://gdpr-info.eu/art-9-gdpr/

[63] The Nobel Prize. The Nobel Prize in Physiology or Medicine 2020 [Internet]. 2020 [cited 2025 Apr 13]. Available from: https://www.nobelprize.org/prizes/medicine/2020/summary/

[64] Jumper J, Evans R, Pritzel A, Green T, Figurnov M, Ronneberger O, et al. Highly accurate protein structure prediction with AlphaFold. Nature. 2021;596(7873):583–9.

[65] Sharma N, Cutting GR. The genetics and genomics of cystic fibrosis. J Cyst Fibros. 2020;19(Suppl 1):S5–S9.

[66] Ibañez K, Polke J, Hagelstrom RT, Dolzhenko E, Pasko D, Thomas ERA, et al. Whole genome sequencing for the diagnosis of neurological repeat expansion disorders in the UK: a retrospective diagnostic accuracy and prospective clinical validation study. Lancet Neurol. 2022;21(3):234–45.

[67] Rossing M, Sørensen CS, Ejlertsen B, Nielsen FC. Whole genome sequencing of breast cancer. APMIS. 2019;127(5):303–15.

[68] Bjørnstad PM, Aaløkken R, Åsheim J, Sundaram AYM, Felde CN, Østby GH, et al. A 39 kb structural variant causing Lynch Syndrome detected by optical genome mapping and nanopore sequencing. Eur J Hum Genet. 2024;32(4):513–20.

[69] Bagnall RD, Ingles J, Dinger ME, Cowley MJ, Ross SB, Minoche AE, et al. Whole genome sequencing improves outcomes of genetic testing in patients with hypertrophic cardiomyopathy. J Am Coll Cardiol. 2018;72(4):419–29.

[70] Lazarte J, Hegele RA. DNA sequencing in familial hypercholesterolaemia: the next generation. Eur J Prev Cardiol. 2021;28(8):873–4.

[71] Cure Alzheimer's Fund. Alzheimer's Genome Project. [Internet]. Available from: https://curealz.org/the-research/areas-of-focus/alz-genome-project/

[72] Wang C, Liu H, Li XY, Ma J, Gu Z, Feng X, et al. High-depth whole-genome sequencing identifies structure variants, copy number variants and short tandem repeats associated with Parkinson's disease. NPJ Parkinsons Dis. 2024;10:134.

[73] Tamiya G, Shinya M, Imanishi T, Ikuta T, Makino S, Okamoto K, et al. Whole genome association study of rheumatoid arthritis using 27 039 microsatellites. Hum Mol Genet. 2005;14(16):2305–21.

[74] Esposito F, Osiceanu AM, Sorosina M, Ottoboni L, Bollman B, Santoro S, et al. A whole-genome sequencing study implicates GRAMD1B in multiple sclerosis susceptibility. Genes (Basel). 2022;13(12):2392.

[75] Ben Halima M, Ben Jemaa L, Ben Ayed M, Ben Ali M, Ben Hmida S, Ben Romdhane H, et al. Whole-exome sequencing reveals novel variants of monogenic diabetes in Tunisia: impact on diagnosis and healthcare management. Front Genet. 2023;14:1224284.

[76] Moyer TP, O'Kane DJ, Baudhuin LM, Wiley CL, Fortini A, Fisher PK, et al. Warfarin sensitivity genotyping: a review of the literature and summary of patient experience. Mayo Clin Proc. 2009;84(12):1079–94.

[77] Bond C, LaForge KS, Tian M, Melia D, Zhang S, Borg L, et al. Single-nucleotide polymorphism in the human mu opioid receptor gene alters beta-endorphin binding and activity: possible implications for opiate addiction. Proc Natl Acad Sci U S A. 1998;95(16):9608–13.

[78] 3billion. Can genetic testing help diagnose autism (ASD) more accurately? [Internet]. 2023 Sep 8. Available from: https://3billion.io/blog/genetic-testing-for-autism-asd

[79] Inside Precision Medicine. Largest genetic study of bipolar disorder identifies nearly 300 risk-associated genome regions. [Internet]. 2025 Jan 23. Available from: https://www.insideprecisionmedicine.com/topics/translational-research/largest-genetic-study-of-bipolar-disorder-identifies-nearly-300-risk-associated-genome-regions/

[80] Abdolazimi, O., Salehi Esfandarani, M., Salehi, M., Shishebori, D. & Shakhsiniae, M. (2023). Development of sustainable and resilient healthcare and non-cold pharmaceutical distribution supply chain for COVID-19 pandemic: A case study. *The International Journal of Logistics Management*, 34, 363-389.

[81] Agarwal, L. (2023). Building a resilient digital health ecosystem in India. *Accelerating Global Health*, 82.

[82] Aquino, Y. S. J., Rogers, W. A., Jacobson, S. L. S., Richards, B., Houssami, N., Woode, M. E., Frazer, H. & Carter, S. M. (2024). Defining change: Exploring expert views about the regulatory challenges in adaptive artificial intelligence for healthcare. *Health Policy and Technology*, 13, 100892.

[83] Bayramzadeh, S. & Aghaei, P. (2021). Technology integration in complex healthcare environments: A systematic literature review. *Applied Ergonomics*, 92, 103351.

[84] Butow, P. & Hoque, E. (2020). Using artificial intelligence to analyse and teach communication in healthcare. *The Breast*, 50, 49-55.

[85] Corvalan, C., Villalobos Prats, E., Sena, A., Campbell-Lendrum, D., Karliner, J., Risso, A., Wilburn, S., Slotterback, S., Rathi, M. & Stringer, R. (2020). Towards climate

resilient and environmentally sustainable health care facilities. *International Journal of Environmental Research and Public Health*, 17, 8849.

[86] Curran, V. R., Fleet, L. & Kirby, F. (2006). Factors influencing rural health care professionals' access to continuing professional education. *Australian Journal of Rural Health*, 14, 51-55.

[87] Davis, K. (1991). Inequality and access to health care. *The Milbank Quarterly,* 253-273.

[88] Dickman, S. L., Himmelstein, D. U. & Woolhandler, S. (2017). Inequality and the health-care system in the USA. *The Lancet*, 389, 1431-1441.

[89] Dymyt, M. & Wincewicz-Bosy, M. (2024). A concept of a sustainable digital healthcare system. *Adoption of Emerging Information and Communication Technology for Sustainability*. CRC Press.

[90] Fahy, N., Mauer, N. & Panteli, D. (2021). European support for improving health and care systems.

[91] Gijare, C., Bagade, S. & Deshpande, A. (2017). Adaptive artificial intelligence for inpatient monitoring and healthcare management. *Biochem. Ind. J.*, 11, 109.

[92] Gulzar, L. (1999). Access to health care. *Image: The Journal of Nursing Scholarship*, 31, 13-19.

[93] Hazarika, I. (2020). Artificial intelligence: Opportunities and implications for the health workforce. *International Health*, 12, 241-245.

[94] Herranz, C. (2023). An adaptive case management approach to prevent unplanned hospital admissions in a care continuum scenario.

[95] Imran, M., Khan, S., Nassani, A. A., Haffar, M., Khan, H. U. R. & Zaman, K. (2023). Access to sustainable healthcare infrastructure: A review of industrial emissions, coal fires, and particulate matter. *Environmental Science and Pollution Research*, 30, 69080-69095.

[96] Jain, A., Singh, R. K. & Bhushan, P. (2025). Policy and regulatory frameworks for financing smart healthcare. *Driving Global Health and Sustainable Development Goals with Smart Technology*. IGI Global Scientific Publishing.

[97] Krapivin, V. & Shutko, A. M. (2012). Information technologies for remote monitoring of the environment. Springer Science & Business Media.

[98] Lenz, R. & Kuhn, K. A. (2004). Towards a continuous evolution and adaptation of information systems in healthcare. *International Journal of Medical Informatics*, 73, 75-89.

[99] Li, J.-L. (2017). Cultural barriers lead to inequitable healthcare access for aboriginal Australians and Torres Strait Islanders. *Chinese Nursing Research*, 4, 207-210.

[100] Longo, V. & Saadati, S. A. (2025). Future-proofing health systems: Strategies for sustainable universal healthcare. *Journal of Foresight and Public Health*, 2, 1-14.

[101] Luxon, L. (2015). Infrastructure–the key to healthcare improvement. *Elsevier*.

[102] Mackenbach, J. P., Meerding, W. J. & Kunst, A. E. (2011). Economic costs of health inequalities in the European Union. *J Epidemiol Community Health*, 65, 412-9.

[103] Mahesh, K., Aithal, P. & Sharma, K. (2022). Seven pillars of inclusive ecosystem-transforming healthcare special reference to MSME & SME sectors. *Int. J. Case Stud. Bus. IT Educ. IJCSBE*, 6.

[104] Moreno-Serna, J., Sánchez-Chaparro, T., Stott, L., Mazorra, J., Carrasco-Gallego, R. & Mataix, C. (2021). Feedback loops and facilitation: Catalyzing transformational multi-stakeholder refugee response partnerships. *Sustainability*, 13, 11705.

[105] Oliver, A. & Mossialos, E. (2004). Equity of access to health care: Outlining the foundations for action. *Journal of Epidemiology & Community Health*, 58, 655-658.

[106] Orzechowski, M., Nowak, M., Bielińska, K., Chowaniec, A., Doričić, R., Ramšak, M., Łuków, P., Muzur, A., Zupanič-Slavec, Z. & Steger, F. (2020). Social diversity and access to healthcare in Europe: How does European Union's legislation prevent from discrimination in healthcare? *BMC Public Health*, 20, 1-10.

[107] Palm, W., Webb, E., Hernández-Quevedo, C., Scarpetti, G., Lessof, S., Siciliani, L. & Van Ginneken, E. (2021). Gaps in coverage and access in the European Union. *Health Policy*, 125, 341-350.

[108] Rastogi, P. (2024). Convergence of smart health, data mining, and dynamical systems: A paradigm shift in healthcare. *American-Eurasian Journal of Scientific Research*, 11.

[109] Saxena, S. & Joshi, H. (2024). Digital health innovations: Advancing climate–health–sustainability synergies. *The Climate-Health-Sustainability Nexus: Understanding the Interconnected Impact on Populations and the Environment*. Springer.

[110] Schmidt, B. J., MacWilliams, B. R. & Neal-Boylan, L. (2017). Becoming inclusive: A code of conduct for inclusion and diversity. *Journal of Professional Nursing*, 33, 102-107.

[111] Schneider, S. M. & Popic, T. (2018). Cognitive determinants of healthcare evaluations–A comparison of Eastern and Western European countries. *Health Policy*, 122, 269-278.

[112] Shaheen, M. Y. (2021). Applications of artificial intelligence (AI) in healthcare: A review. *ScienceOpen Preprints*.

[113] Spagnol, G. S., Min, L. L. & Newbold, D. (2013). Lean principles in healthcare: An overview of challenges and improvements. *IFAC Proceedings Volumes*, 46, 229-234.

[114] Sturmberg, J. P. & Bircher, J. (2019). Better and fulfilling healthcare at lower costs: The need to manage health systems as complex adaptive systems. *F1000Research*, 8, 789.

[115] Sun, L., Booth, A. & Sworn, K. (2024). Adaptability, scalability and sustainability (ASaS) of complex health interventions: A systematic review of theories, models and frameworks. *Implementation Science*, 19, 52.

[116] Tortorella, G. L., Fogliatto, F. S., Mac Cawley Vergara, A., Vassolo, R. & Sawhney, R. (2020). Healthcare 4.0: Trends, challenges and research directions. *Production Planning & Control*, 31, 1245-1260.

[117] Väänänen, A., Haataja, K., Vehviläinen-Julkunen, K. & Toivanen, P. (2021). AI in healthcare: A narrative review. *F1000Research*, 10, 6.

[118] Vignesh, U. & Amirneni, A. (2025). Breaking language barriers in healthcare: A voice activated multilingual health assistant. *Interdisciplinary Journal of Information, Knowledge, and Management*, 20, 008.

[119] Waldman, S. A. & Terzic, A. (2019). Healthcare evolves from reactive to proactive. *Clinical Pharmacology and Therapeutics*, 105, 10.

[120] Yamada, T., Chen, C.-C., Murata, C., Hirai, H., Ojima, T., Kondo, K. & Harris III, J. R. (2015). Access disparity and health inequality of the elderly: Unmet needs and delayed healthcare. *International Journal of Environmental Research and Public Health*, 12, 1745-1772.

[121] OECD (2024). OECD Health Statistics. [online] OECD. Available at: https://www.oecd.org/en/data/datasets/oecd-health-statistics.html.

[122] Eurostat (2020). Healthcare expenditure statistics - Statistics Explained. [online] ec.europa.eu. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_expenditure_statistics.

[123] Soman, N. (2024). Understanding the basics: What is 'fee for service' in healthcare | decent. [online] www.decent.com. Available at: https://www.decent.com/blog/understanding-the-basics-what-is-fee-for-service-in-healthcare.

[124] www.euro.who.int. (n.d.). Data and evidence. [online] Available at: https://www.euro.who.int/en/data-and-evidence.

[125] Wikipedia Contributors (2019). Universal health care. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Universal_health_care.

[126] Wikipedia Contributors (2019). Public hospital. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Public_hospital.

[127] Wikipedia Contributors (2024). Universal health care by country. [online] Wikipedia. Available at: https://en.wikipedia.org/wiki/Universal_health_care_by_country.

[128] Wikipedia Contributors (2025). EU4Health. Wikipedia.

[129] eurohealthobservatory.who.int. (n.d.). Search European Observatory publications. [online] Available at: https://eurohealthobservatory.who.int/publications.

[130] OECD. (2024). Innovative providers' payment models for promoting value-based health systems. [online] Available at: https://www.oecd.org/en/publications/innovative-providers-payment-models-for-promoting-value-based-health-systems_627fe490-en.html.

[131] OECD. (2025). Measuring What Matters. [online] Available at: https://www.oecd.org/en/publications/measuring-what-matters_2148719d-en.html

[132] Who.int. (2021). The rise of telehealth in the European Region: insights from Norway. [online] Available at: https://www.who.int/europe/news-room/10-10-2024-the-rise-of-telehealth-in-the-european-region--insights-from-norway.