

GOVERNANCE OF TRANSFORMATIVE VALUE-BASED HEALTHCARE SERVICES IN THE DIGITAL ERA – A POLICY AND RESEARCH AGENDA*

Abstract

Governance of healthcare services is worldwide predominantly pursued in competitive quality-sensitive markets, which are nowadays drastically influenced by strong digitalization trends. This paper explores a value-based approach to enhancing healthcare delivery through the integration of emerging advanced digital technology access and the use of customized strategic decision and policy frameworks. The study begins by addressing the urgent policy and societal need for value-based healthcare systems, particularly in response to global or urgent health crises like the COVID-19 pandemic. The novel integrated healthcare intelligence framework, proposed in our study, aims to enhance healthcare management by leveraging cross-cutting digital approaches, strategic performance management, and big data analytics. This study addresses, in a systematic way, a collection of three elected key contextual conditions, including a mind mapping presentation, smart wellbeing conditions, and institutional corporate challenges. Each section in this paper examines consistently various specific operational strategies and digital technologies aimed at improving healthcare policy outcomes and setting a global benchmark for service innovation in the healthcare sector. The study presents at the end the contours of an integrated digitally-inspired early warning system for quality enhancement in the healthcare sector. The concluding section proposes operational anchor points for innovative healthcare service delivery, showcasing sustainable and equitable healthcare solutions through illustrative AI-driven pilot projects, practical capacity building, and public health engagement initiatives.

Keywords: healthcare innovation, integrated healthcare intelligence, digitalization in healthcare, machine learning, healthcare management, smart living conditions, institutional challenges, global health crises.

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1. Introduction

Cost-effective healthcare delivery has become an important focal point in the public sector. Healthcare has, over the past decades, become a prominent social and economic sector that needs many resources and, hence, professional governance and effective management. In response to the urgent need for evidence-based decision-information systems in the healthcare sector, as was highlighted by the recent COVID-19 pandemic, this study proposes an integrated healthcare intelligence framework. This transformative system aims to provide digitalization-inspired contours for governance, data management, and decision support in healthcare (Ferrinho *et al.*, 2023).

The recent healthcare crises have underscored the critical need for robust and adaptive governance of healthcare systems. The healthcare sector's response to such unprecedented challenges has highlighted gaps in governance, data management, and decision support mechanisms. Hospitals and healthcare providers worldwide faced immense pressures, struggling with data interoperability, resource allocation inefficiencies, and timely decision-making processes. These challenges have exposed vulnerabilities that must be urgently addressed to enhance resilience and effectiveness in future health crises.

The corona pandemic crisis has clearly shown that traditional healthcare systems often lack the agility and data-driven capabilities required to respond swiftly to evolving health threats. Fragmented data sources, incompatible information systems, and outdated governance structures hindered the ability to coordinate responses effectively and deploy resources where they were most needed (WHO, 2020). As a result, healthcare delivery faced significant disruptions, impacting patient outcomes and straining healthcare professionals and infrastructure alike.

Moreover, the pandemic highlighted significant disparities in healthcare access and outcomes, disproportionately affecting vulnerable populations and underserved communities. These disparities underscore the urgent need for innovative solutions that can improve equity in healthcare delivery and address systemic inefficiencies (CDC, 2025). There is a clear need for information-driven, equitable and effective healthcare systems supported by high-tech, evidence-based and professionally handled services so as to improve general well-being in a digital-oriented society (see e.g., Lee *et al.*, 2013; Das *et al.*, 2020).

In this policy-oriented paper, an integrated healthcare intelligence framework is designed to address and cope with critical gaps in healthcare services by enhancing AI-technologies so as to achieve several key objectives that serve the client or patient, hence the term value-based healthcare services (Porter and Teisberg, 2006; Blackstone and Fuhr, 2007). This term originates from the emerging need for value-based competition in the health care sector, caused by inefficiency and quality problems in this sector all over the world. To deliver high-quality and affordable health care services, we need a reorganization of the sector as well as a wide use of ICT. Only in this case can health care providers deliver better products. Porter and Teisberg (2006) made a plea for a restructuring of the

health care system by introducing more competition on value in terms of high-quality outcomes, more service delivery to the patients, and more ICT-driven strategies in the health care market. This fundamental paradigm of ‘value for money’ needs a market organization with at least the following characteristics:

- **Enhanced Decision-Making:** By integrating AI (artificial intelligence) – driven analytics and predictive modeling, the framework aims to empower healthcare agents with real-time insights. This capability will enable proactive decision-making, optimizing resource allocation, and improving operational efficiency across healthcare systems (Sanders *et al.*, 2019; Majeed and Hwang, 2022).
- **Improved Healthcare Delivery:** Through streamlined data management and interoperable systems, the framework seeks to enhance care coordination and continuity. Seamless integration of patient data, combined with AI-enabled diagnostics and treatment recommendations, will support personalized medicine and improve patient outcomes (HIMSS, 2024; Reddy *et al.*, 2018; Majeed and Hwang, 2022).
- **Fostering Innovation:** The framework aims to foster a culture of innovation by facilitating collaborative research and development in AI-driven healthcare technologies. By supporting interdisciplinary partnerships and data-driven experimentation, it seeks to accelerate the discovery and implementation of novel healthcare solutions (Porter and Teisberg, 2006).

The integration of AI into healthcare represents a transformative opportunity to build more resilient and patient-centric healthcare systems. By harnessing AI’s capabilities to analyze complex datasets, predict health trends, and personalize care, healthcare providers can enhance efficiency, effectiveness, and equity in healthcare delivery. This framework not only addresses immediate challenges highlighted by the pandemic but also lays the groundwork for sustainable improvements in healthcare quality and accessibility globally. The proposed integrated healthcare intelligence framework represents a pivotal advancement in healthcare technology. By addressing the urgent need for adaptive, data-driven healthcare solutions, this paper aims to establish a precedent for enhanced healthcare delivery worldwide, following the sequence: knowledge, smart management, continuous innovation, and institutional collaboration.

The present study is organized as follows. After this introductory section, we will analyze and address in Section 2 a range of contemporaneous knowledge issues in modern healthcare systems. Next, Section 3 addresses smart wellbeing conditions, while Section 4 pays attention to healthcare institutions. This sequence is followed by an illustrative exposition on early warning systems – as a digital healthcare management tool – in Section 5. Finally, this exploratory study is concluded with some retrospective and prospective observations on future research on healthcare systems.

2. Key issues in health care knowledge

To understand the complexity of the health sector, a mind mapping of this complex system is needed. This section aims to explore and address key knowledge and operational issues in health care research, focusing on improving the quality of life and livability for various target groups, including the elderly, children, and vulnerable populations. Additionally, it seeks to understand the challenges posed by epidemics, pandemics, health disasters, and the promotion of healthy lifestyles and social participation.

2.1. Key issues

Understanding and mitigating health disparities among various populations is crucial for any policy seeking to advance global health outcomes. Key issues encompass improving quality of life through targeted interventions, addressing the unique health needs of vulnerable groups, and developing resilient healthcare systems capable of managing health crises effectively.

- **Quality of Life/Livability:** Enhancing overall well-being by addressing health determinants and socio-economic factors is pivotal. Quality of life (QoL) encompasses physical health, psychological well-being, social relationships, and environmental factors, all of which influence health outcomes and satisfaction with life (WHO, 2020).
- **Target Groups:** Strategies focusing on the elderly, children, and vulnerable populations are essential. These groups require tailored healthcare services to improve health equity and outcomes, considering factors like aging-related health issues, childhood development, and barriers to healthcare access (WHO, 2023; UNICEF, 2018; CDC, 2021).
- **Social Participation:** Facilitating community engagement and support networks is pivotal for promoting health and well-being. Socially connected communities tend to exhibit better health outcomes, emphasizing the importance of inclusive spaces and civic engagement in public health strategies (Putnam, 2000).
- **Specific Professional Target Groups:** Addressing health risks associated with specific professions, such as nurses and construction workers, requires targeted healthcare interventions to mitigate occupational hazards and improve overall health outcomes.

These key issues underscore the multifaceted problems faced in healthcare research delivery and strategy. By addressing these challenges through research-driven policies and innovative healthcare solutions, we can foster a more equitable, resilient healthcare system that enhances quality of life and health outcomes for populations worldwide, in accordance with value-based completion strategies.

2.2. Research challenges

Several research challenges can be identified, highlighting the need for a novel, integrated knowledge framework. Examples include:

- **Epidemics/Pandemics/Health Disasters:** Developing robust systems for crisis management is critical, as highlighted by the recent COVID-19 pandemic. Effective

surveillance, emergency response strategies, and public health interventions are necessary to mitigate the impact of health crises on communities and healthcare systems (MacIntyre *et al.*, 2023; O’Shea, 2017; Balajee *et al.*, 2021).

- **Healthy Lifestyle:** Promoting behaviors that enhance physical and mental health is essential for population well-being. Initiatives encouraging regular physical activity, balanced nutrition, and mental wellness play a vital role in improving public health outcomes globally (WHO, 2018).
- **Access to Medical Services:** Ensuring equitable access to healthcare services for all individuals is fundamental. Overcoming barriers related to geography, economics, and cultural diversity is essential to achieving universal health coverage and improving health outcomes globally (WHO, 2022).

It goes without saying that healthcare is a complex and dynamically evolving research and policy field. Some important focal points of wellbeing as a collective value will be given in the subsequent sections. Health is more than physical health; it also captures wellbeing as an important social value.

3. Governance of smart wellbeing conditions

3.1. Key issues

Health care systems require not only advanced knowledge of the sector’s intrinsic mechanisms, but also expertise in managing health care from a broad societal perspective on health outcomes.

The cost-effective integration of smart wellbeing and living conditions into healthcare research and policy represents a radical change aimed at transforming our living environment through a synergetic application of technological advancements and sustainable practices. This initiative seeks not only to enhance the physical infrastructure of habitats but also to optimize health outcomes and improve overall well-being (Voukelatou *et al.*, 2021).

Smart wellbeing and living environments are designed to leverage cutting-edge technologies to create spaces that are responsive, adaptive, and conducive to health promotion. By embedding sensors, IoT devices, and advanced data analytics into the fabric of homes and communities, these environments enable real-time monitoring and management of critical health indicators such as air quality, temperature, and energy consumption. This proactive approach not only mitigates health risks associated with environmental factors but also supports preventive healthcare measures by providing early insights into potential health hazards.

Furthermore, sustainable health practices play a pivotal role in smart living environments, emphasizing energy efficiency, waste reduction, and ecological balance. Smart eco-houses, for instance, incorporate renewable energy sources and energy-efficient systems that minimize environmental impact while promoting a healthier indoor environment. These innovations align with global sustainability goals and contribute to creating

resilient communities capable of adapting to environmental challenges. They call for cost-effective social healthcare strategies.

The efficient integration of smart technologies extends beyond physical infrastructure to encompass behavioral aspects of health and well-being. Initiatives promoting healthy lifestyles, such as nutrition education and access to green spaces, are facilitated through smart living conditions. By encouraging balanced diets and physical activity, these environments foster habits that prevent chronic diseases and improve longevity.

In essence, the adoption of smart wellbeing conditions in a broad healthcare policy strategy is not merely about technological innovation but about redefining the way we conceptualize and inhabit our living spaces. By creating environments that are intelligent, sustainable, and health-enhancing, we aim to build communities that thrive both socially and economically while promoting equity in health outcomes across diverse populations. The integration of smart living conditions into healthcare aims to create environments that support and enhance health through technological advancements and sustainable practices. Examples are:

- **Healthy Environment:** Ensuring clean air and water and minimizing pollutants and harmful substances. A healthy environment is crucial for preventing disease and promoting health. This includes ensuring clean air and water, reducing exposure to hazardous substances, and promoting green spaces. Environmental health research has shown that reducing pollutants and improving environmental conditions can significantly reduce health risks (EPA, 2020).
- **Air & Water Quality:** Monitoring and improving air and water standards to prevent health issues. Technologies that provide real-time data on air and water quality can help communities take proactive measures to protect public health (WHO, 2019).
- **Smart Eco-House:** Implementing energy-efficient, health-promoting housing solutions. Smart eco-houses incorporate technologies and designs that promote energy efficiency and a healthy living environment. These houses are equipped with smart systems that monitor and regulate air quality, temperature, and energy use, contributing to residents' overall well-being (DOE, 2015; Rehman *et al.*, 2025).
- **Healthy Food Plate:** Promoting balanced diets and nutritional education. Initiatives like the healthy food plate encourage the consumption of a variety of nutrients essential for maintaining health. Public health nutrition guidelines emphasize the importance of fruits, vegetables, whole grains, and lean proteins.

Smart wellbeing conditions are essential for value-based health goals as identified above. The intelligent policy integration of smart living conditions into healthcare environments represents a pivotal shift towards fostering environments that are not only technologically advanced but also sustainable and health-enhancing. By leveraging cutting-edge technologies such as IoT devices and advanced data analytics, coupled with sustainable practices like energy efficiency and waste reduction, these environments promote proactive health management and mitigate risks associated with environmental factors. Initiatives like smart

eco-houses and initiatives promoting healthy lifestyles through nutrition education and access to green spaces underscore the multifaceted benefits of this approach. Moreover, by prioritizing the creation of resilient communities capable of adapting to environmental challenges, smart living conditions contribute significantly to improving overall well-being and quality of life. Moving forward, continued investment in smart living conditions is essential for building communities that thrive both socially and economically, while ensuring equitable access to health-enhancing environments for all.

3.2. Research challenges

The actual realization of smart individual and social wellbeing from a health perspective is a task fraught with many scientific knowledge barriers. Examples of challenges to be met are:

- **Successful Green Ageing:** Supporting aging populations through eco-friendly and health-oriented practices. This involves creating environments that facilitate physical activity, social interaction, and access to healthcare. Successful green aging promotes sustainability and well-being among older adults (AARP, 2017).
- **Social Capital/Community:** Building strong community ties to foster social support and improve mental health. Communities with high social capital tend to have lower rates of illness and higher levels of well-being. Strategies to enhance social capital include fostering community engagement and creating supportive social networks (Putnam, 2000).
- **Urban Density/Proximity:** Planning urban spaces to ensure accessibility to healthcare services and promote active lifestyles, such as walking or cycling. Urban planning that considers proximity to healthcare services, green spaces, and community centers can promote active lifestyles and improve health outcomes. Higher urban density can enhance accessibility and reduce travel time for essential services, contributing to better public health (WHO, 2016).

The previous observations clearly show that environmental, social, and geographical factors are central to the governance of healthcare systems, contributing to high individual and social value through professional organization and effective market structures (including market competition).

4. Reorganization of health care institutions

4.1. Key issues

The complexity of healthcare has prompted the rise of a web of institutions and regulations, which sometimes frustrates innovation in the sector. Healthcare institutions worldwide encounter a myriad of challenges that necessitate strategic solutions to enhance delivery service and improve patient outcomes. These challenges span from operational inefficiencies to financial sustainability and require comprehensive approaches grounded

in evidence-based practices and innovative solutions. Healthcare systems globally are confronted with a complex array of challenges that impact their ability to deliver effective and equitable care. Addressing these challenges is crucial not only for optimizing healthcare delivery but also for ensuring that all individuals have access to timely and quality healthcare services. Healthcare institutions face a diverse array of challenges that impact their ability to provide effective and equitable care. These challenges include ensuring accessibility to healthcare services, optimizing healthcare delivery structures, promoting specialized healthcare services tailored to community needs, implementing value-based competition strategies, managing healthcare capacities effectively, ensuring sustainable financial models, and leveraging advanced information systems for better decision-making (WHO, 2020; Porter and Teisberg, 2006; HIMSS, 2024). Addressing these challenges requires a multifaceted approach that integrates innovative practices, evidence-based strategies, and collaborative efforts across healthcare sectors. By prioritizing efficiency, patient-centered care, and continuous improvement, smart healthcare institutions can enhance healthcare delivery on a global scale. Focal points of institutional dimensions of health policy are, in particular:

- Proximity of Healthcare: Ensuring accessibility to healthcare services is fundamental for improving health outcomes, especially in emergencies. The geographical distribution of healthcare facilities significantly influences access to care and patient outcomes (WHO, 2015). Proximity plays a critical role in reducing barriers to healthcare access, such as travel time and transportation costs, thereby enhancing patient satisfaction and adherence to treatment plans.
- Hierarchy of Healthcare Supply: Establishing an efficient healthcare delivery structure is essential to ensure that patients receive appropriate care based on their needs. The hierarchy of specialized healthcare supply, encompassing primary, secondary, and tertiary care levels, ensures a continuum of care that is coordinated and comprehensive (WHO, 2018). This structured approach not only improves healthcare efficiency but also enhances patient safety and clinical outcomes by facilitating timely referrals and specialized interventions.
- Smart Local Medical Specialization: Promoting specialized digital healthcare services tailored to local community needs enhances the quality and effectiveness of care delivery. Developing centers of excellence within local contexts allows healthcare institutions to focus on specific health issues and deliver specialized treatments (Porter and Teisberg, 2006). This localized approach fosters collaboration between healthcare providers and community stakeholders, resulting in more personalized and responsive healthcare services.
- Value-Based Competition: Implementing value-based strategies incentivizes healthcare providers to deliver high-quality care that emphasizes patient outcomes and efficiency, rather than volume (Porter and Lee, 2013). This approach promotes competition based on healthcare value, driving continuous improvement in service delivery

and patient satisfaction. By aligning financial incentives with quality metrics, healthcare institutions can achieve better clinical outcomes and cost-effective care management.

This list of important key governance issues also prompts the need for advanced healthcare strategies, as is illustrated in the subsequent list of institutional-oriented and decision-directed research challenges. Clearly, knowledge supported by ICT is key to a successful healthcare society.

4.2. Research challenges

There is a range of multifaceted challenges facing healthcare institutions charged with the task of implementing evidence-based strategies and innovative solutions. By enhancing accessibility, optimizing healthcare delivery structures, promoting specialization, and embracing technology-driven approaches, healthcare systems can achieve significant improvements in patient care quality, efficiency, and sustainability. Continued investment in healthcare innovation and strategic management practices is essential for building resilient healthcare systems that meet the evolving needs of populations worldwide. Examples of such challenging plans and initiatives are:

- Capacity Management: Effectively managing healthcare resources and capacities is critical for meeting fluctuating demand and maintaining service quality. Optimization of facilities, personnel, and equipment utilization ensures that healthcare services are available when needed, minimizing waiting times and enhancing operational efficiency (WHO, 2023). Strategic capacity planning enables healthcare institutions to respond proactively to population health needs and healthcare trends, thereby improving resource allocation and patient flow.
- Finance: Ensuring sustainable financial models is essential for the long-term viability of healthcare institutions and their ability to deliver quality care. Exploring diverse funding mechanisms, implementing cost-control strategies, and efficiently allocating financial resources are crucial for mitigating financial pressures and supporting healthcare service provision (WHO, 2020). Sustainable financial management enables healthcare organizations to invest in infrastructure, technology, and workforce development, fostering resilience and innovation in healthcare delivery.
- Information Systems (Supply and Demand): Advanced information systems play a pivotal role in optimizing healthcare supply and demand dynamics. These systems provide real-time data on resource availability, patient needs, and service utilization, enabling informed decision-making and resource allocation (HIMSS, 2024). By leveraging data analytics and predictive modeling, healthcare institutions can anticipate demand fluctuations, streamline operations, and improve overall service delivery efficiency.
- Dashboards and Early Warning Systems: Developing robust dashboards and early warning systems enhances healthcare management by facilitating proactive

decision-making and risk mitigation (CDC, 2025). These tools enable healthcare providers to monitor trends, identify emerging health threats, and implement timely interventions to prevent adverse outcomes (Ivanković *et al.*, 2021; Nijkamp and Kourtit, 2022; Kogan *et al.*, 2021). By integrating real-time data analytics and predictive algorithms, healthcare institutions can enhance patient safety, optimize resource utilization, and improve clinical outcomes. This development will be further described in Section 5.

A distinctive benefit of a novel management framework for effective healthcare services lies in its ability to provide real-time insights into healthcare operations and patient conditions. By analyzing streaming data from diverse sources such as electronic health records (EHRs), wearable devices, and IoT sensors, healthcare systems can maintain continuous monitoring of patient health status. This capability facilitates proactive interventions upon detection of anomalies or deteriorating trends (Jafleh *et al.*, 2024). Such proactive measures not only elevate patient safety and care quality but also optimize resource utilization by preempting costly hospitalizations and emergency visits.

Integral to the policy and institutional framework is its capacity to support strategic decision-making and governance within healthcare organizations. AI-driven analytics empower healthcare leaders to make informed, data-driven decisions aligned with organizational objectives and priorities. By visualizing trends, identifying bottlenecks, and forecasting future demands, healthcare administrators can allocate resources more efficiently, streamline operational workflows, and optimize the delivery of care services (Sanders *et al.*, 2019; Jafleh *et al.*, 2024). Furthermore, the integration of AI enhances management frameworks by ensuring compliance with regulatory standards and ethical guidelines in data management and patient privacy (Sanders *et al.*, 2019). In a quality-driven competitive market environment, many new opportunities for high-value added services do clearly arise.

5. Early warning systems as an illustration: A well-being perspective

ICT is a cross-cutting technology that can influence and support all aspects of the complex healthcare system. Healthcare policy may be enhanced by rigorously resorting to the potential of digital technology. The exploration of innovative approaches in healthcare underscores the critical need for transformative solutions to overcome existing challenges and enhance healthcare delivery worldwide. This study has explored several key areas where advancements in technology, data analytics, and strategic frameworks can significantly impact healthcare outcomes, generating an enhancement of individual and collective well-being. By focusing on smart wellbeing conditions, addressing key health research issues, and navigating institutional challenges, the proposed integrated healthcare intelligence framework emerges as a pivotal initiative poised to revolutionize healthcare systems.

Healthcare systems globally are at a crossroads, facing multifaceted challenges ranging from demographic shifts and rising healthcare costs to the increasing burden of chronic diseases and global health crises. These challenges necessitate a paradigm shift towards innovative approaches that leverage technology and data-driven insights to optimize care delivery, improve patient outcomes, and ensure sustainability in healthcare practices, including medical prevention approaches.

The integration of smart living conditions represents a forward-thinking approach to healthcare infrastructure. By incorporating AI, IoT, and advanced data analytics, healthcare environments can become more responsive and adaptive, enhancing the quality of care and promoting healthier living environments (DOE, 2015; EPA, 2020; WHO, 2019; Rehman *et al.*, 2025). This initiative not only addresses immediate healthcare needs but also aligns with sustainable development goals by reducing environmental impact and fostering community well-being. In this context, early warning systems may play a key role in proactive and preventive healthcare policy. In the digital age, these systems have become increasingly popular.

Effective healthcare solutions also hinge on accessible research and evidence-based practices. Addressing key health research issues, such as improving quality of life across diverse populations, understanding the impact of epidemics and pandemics, and promoting healthy lifestyles, is crucial for shaping future healthcare policies and interventions (UNICEF, 2018; CDC, 2021). By investing in research that addresses the social determinants of health and supports targeted interventions, healthcare systems can enhance resilience and equity in healthcare delivery. The use of healthcare dashboards and early warning systems is essential.

Institutional challenges, including financial sustainability, resource allocation, and governance, pose significant barriers to effective healthcare delivery. The integration of value-based competition, capacity management strategies, and advanced information systems can optimize operational efficiency and improve healthcare outcomes (Porter and Teisberg, 2006; WHO, 2020; HIMSS, 2024). By fostering a culture of digital innovation and continuous improvement induced by AI, modern healthcare institutions can adapt to evolving demands and ensure equitable access to high-quality care, so as to enhance individual and social well-being. This is briefly illustrated in Figure 1, which maps out the systematics of well-being determinants – in an early warning framework – in a systematic form.

Over the past years, several operational studies have been pursued on data-analytical and data-managerial issues seeking to improve the level of health outcomes and human well-being. A brief summary is given in Table 1. The focus in this table is in particular on the use of digital support tools for early warning systems (EWS). These are effective vehicles in modern healthcare governance, which are strongly influenced by ICT.

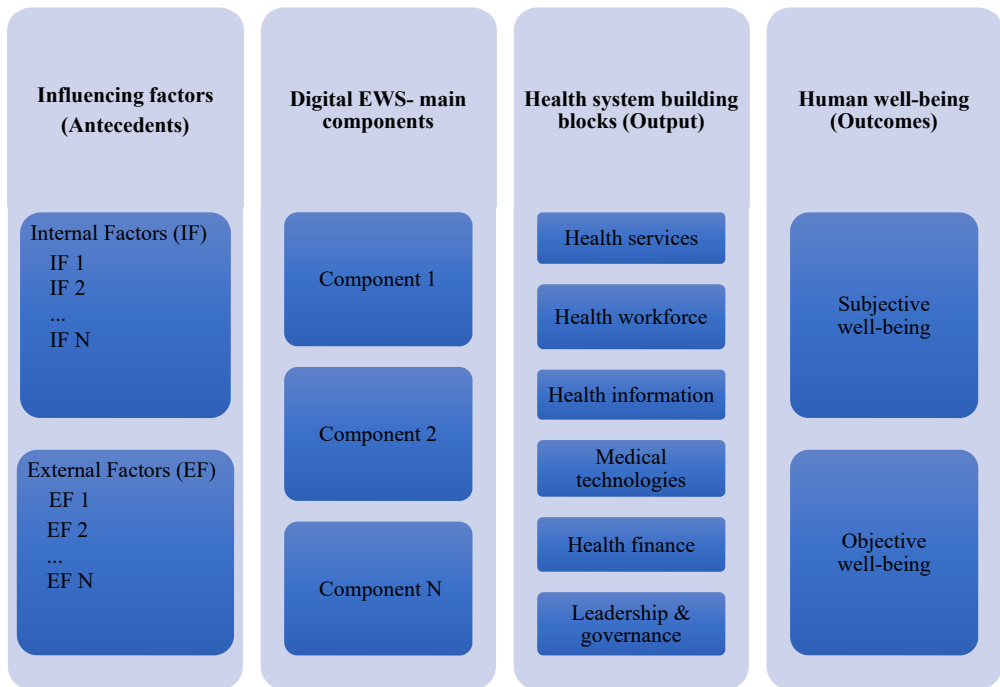


Figure 1: Conceptual framework of Digital Early Warning System (EWS) for Enhanced Well-being Policy Strategies

Source: Authors' own processing

Table 1: Architectural components of digital EWS

Architectural Component	Description	References
Data Acquisition Engines	Engines that gather vast amounts of open-source data from sources like social media, news reports, clinical data, and other publicly available information. These engines support real-time collection of data from diverse sources, enabling timely outbreak detection.	El Morr <i>et al.</i> (2024), MacIntyre <i>et al.</i> (2023)
Data Filtering and Curation	Algorithms and AI models that filter, curate, and prioritize data to remove noise and focus on relevant information for early warning. They enable automated classification, ensuring relevant data is processed for analysis.	Cresswell <i>et al.</i> (2020), MacIntyre <i>et al.</i> (2023)
Classification and Prediction Models	Machine learning models used to classify data and predict epidemic outbreaks based on patterns found in real-time and historical data.	Cresswell <i>et al.</i> (2020), El Morr <i>et al.</i> (2024), MacIntyre <i>et al.</i> (2023)
Modeling and Simulation	AI-based approaches that simulate disease outbreaks and assess the impact of potential interventions on epidemic growth.	MacIntyre <i>et al.</i> (2023), O'Shea (2017)
User Interfaces and Visualization	Interfaces that display data, often in real-time, through dashboards or maps, allowing users to visualize disease spread and other outbreak data.	Cresswell <i>et al.</i> (2020), MacIntyre <i>et al.</i> (2023), O'Shea (2017)
Data Integration	AI-based systems rely on integrating multiple data sources from diverse platforms (e.g., clinical, environmental, social media).	Cresswell <i>et al.</i> (2020), El Morr <i>et al.</i> (2024), O'Shea (2017)

Architectural Component	Description	References
Bias Mitigation and Explainability	Architectural components ensure transparency and fairness, reducing biases in the model's predictions and ensuring ethical AI use.	Cresswell <i>et al.</i> (2020), El Morr <i>et al.</i> (2024)
Modular Design for Adaptability	Design elements that allow the system to be scaled up and adapted for different diseases, geographical locations, and emerging outbreaks.	Cresswell <i>et al.</i> (2020), O'Shea (2017)
Automated and Manual Processing	Automated algorithms (text mining, parsing) and manual moderation for more accurate data processing and filtering of relevant epidemic information.	El Morr <i>et al.</i> (2024), O'Shea (2017)
Data Collection and Processing	Systems collect and process data through various methods, such as social media mining and search engine queries, using text-mining and classification algorithms.	Cresswell <i>et al.</i> (2020), MacIntyre <i>et al.</i> (2023)
Event-based Data Sources	Systems use event-based, unstructured data collected from informal sources like social media, crowdsourcing, and news outlets to improve real-time reporting in outbreak detection.	MacIntyre <i>et al.</i> (2023), O'Shea (2017)

Source: Authors' own processing

6. Lessons and guidelines for policy

Healthcare is currently experiencing a radical transformation driven by rapid advancements in technology and the integration of sophisticated data analytics. The development of a pioneering conceptual framework that seamlessly incorporates these innovations is essential for elevating global healthcare decision-making and management. This framework represents a fundamental shift towards harnessing state-of-the-art technologies, particularly AI and machine learning (ML), to comprehensively analyze vast datasets within healthcare. By leveraging AI capabilities, healthcare providers can gain real-time insights, identify intricate patterns, and predict future trends with unparalleled accuracy, thereby significantly amplifying the efficiency and effectiveness of healthcare delivery (Sanders *et al.*, 2019).

Building upon the transformative capabilities of AI and ML, the strategic Tipping Point framework is instrumental because it introduces an innovative approach to healthcare management. Its framework originates from social sciences and was adapted for healthcare by Gladwell (2000). It identifies critical junctures or 'tipping points' where minor adjustments can yield substantial impacts on patient outcomes and operational efficiencies. These pivotal moments underscore strategic intervention opportunities that have the potential to lead to exponential improvements in patient care quality, resource allocation, and overall system performance.

A major game changer in the health care sector is the large-scale introduction of, access to, and use of digital technology in the management and operation of health care, including AI. The present paper seeks to depict the complex force field of modern health care systems – and their intrinsic challenges – by zooming in on three interconnected focal

domains:

- identification of new opportunities in light of prevailing problems and hurdles in the health care system (Section 2)
- exploration of new solution trajectories that enhance human and social wellbeing (Section 3).
- effective organization of the delivery of health care services by developing new management and medical control mechanisms (Section 4).

It goes without saying that ICT applications call for a rather drastic adjustment of the health care world-wide, for instance, in disease prevention (Section 5). It is plausible that ICT will become the new integrative and cost-effective vehicle for affordable high-quality healthcare in the future.

The integration of AI and ML technologies continues to revolutionize healthcare decision-making processes. AI-driven algorithms excel in processing complex datasets at unprecedented speeds and scales, enabling the discovery of correlations and the development of predictive models that enhance clinical decision support systems (Jafleh *et al.*, 2024). For example, AI-powered diagnostic tools assist healthcare professionals in achieving precise and timely diagnoses, thereby reducing diagnostic errors and enhancing treatment outcomes (Sanders *et al.*, 2019). Moreover, machine learning algorithms continuously evolve by learning from new data inputs, refining their predictive capabilities over time, and adapting to the evolving challenges within the healthcare landscape.

Looking ahead, the successful implementation of the integrated healthcare intelligence framework requires collaborative efforts and strategic actions across stakeholders. Key directions and recommendations include:

- Investment in Technological Infrastructure: Continue investment in AI, ML, and IoT technologies to strengthen healthcare analytics and decision support systems.
- Collaboration and Knowledge Sharing: Foster international collaboration and knowledge exchange to accelerate innovation and adoption of best practices in healthcare management.
- Policy and Regulatory Support: Develop robust policies and regulatory frameworks that promote ethical use of data, protect patient privacy, and facilitate integration of emerging technologies in healthcare.
- Continuous Evaluation and Adaptation: Implement mechanisms for ongoing evaluation and adaptation of healthcare strategies based on real-time data insights and evolving patient needs.

To capitalize on the full potential of the integrated healthcare intelligence framework characterized by much uncertainty, stakeholders are encouraged to address in particular:

- Pilot Projects and Demonstrations: Initiate pilot projects to validate the effectiveness and scalability of the framework across diverse healthcare settings.

- Capacity Building: Invest in training and development programs to equip healthcare professionals with the necessary skills to leverage new technologies effectively from a client-oriented perspective.
- Public Engagement: Engage stakeholders and the public through awareness campaigns and participatory initiatives to ensure widespread support and adoption of healthcare innovation.

A full realization of the potential of this policy framework means that stakeholders and institutions initiate pilot projects and demonstrations across diverse healthcare settings to validate its effectiveness and scalability. Investment in training and development programs will be crucial to equip healthcare professionals with the skills necessary to leverage new technologies effectively. Furthermore, engaging stakeholders and the public through awareness campaigns and participatory initiatives will ensure widespread support and adoption of healthcare innovation, fostering a collaborative approach towards transformative healthcare solutions. The field of digital-driven healthcare policy is in full motion, and it will be a major challenge for stakeholders and institutions to reap the well-being fruits of digital technology. This paper has sketched the integrated contours of a resilient and customer-oriented framework for advanced (i.e., digital-driven) health care services, based on value-based competitive forces in the healthcare sector. Clearly, more test experiments are needed to transform this framework into actionable strategies and policies.

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