



Ageing Population & Chronic Disease Management

ANALYSIS - EVALUATION - OPPORTUNITIES - KEY DEVELOPMENTS

Agnès Leotsakos

Patient Safety and the Ageing Patient

**Francisco Mera Cordero, Dardo Vargas Eced,
Tamara Rubilar, Alan Zetzelmann**

Long COVID and Chronic Conditions: Multidisciplinary
Innovation for Recovery and Health Resilience

Begoña San José

Ageing, Chronic Illness and Women's Stories

Artem Arutyunyan

Chronic Migraine and Health System Readiness

Wandile Ntuli

Biokinetics as a Clinical Tool within Chronic Disease
Management

**Ejike Nwokoro, Ben Malin, Daniela Zanni,
Joshua Hinton, Tatiana Kalganova**

Medication Adherence Prediction: Potential Implications
for Medicines Wastage

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Elderly Care and Chronic Disease Management in Saudi
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Head of the Heart and Vascular Department, Santa Maria University Hospital, Faculty of Medicine, University of Lisbon, Portugal | Past President, World Heart Federation (WHF) and European Society of Cardiology (ESC) | Editor-in-Chief Cardiology | HealthManagement.org – The Journal

Ageing Population & Chronic Disease Management

The global rise in life expectancy is placing growing pressure on healthcare systems. With age often comes a higher prevalence of chronic diseases, multi-morbidity and complex care needs that stretch traditional service models beyond their limits. Ensuring that elderly individuals receive safe, coordinated and person-centred care is not just a clinical necessity but a societal imperative. With the ongoing change in the populational pyramid, the ageing population is not a future concern, but a present reality that requires urgent and sustained action from all levels of healthcare and policy.

Responding to these challenges requires a comprehensive shift towards integrated care pathways, digitally enabled innovation and greater patient empowerment. From prevention to long-term management, the intersection of ageing and chronic illness calls for bold leadership, strategic investment and inclusive policies that close equity gaps and prioritise outcomes over processes. As demographic shifts accelerate, aligning clinical practice with evolving patient needs becomes essential to preserve health, dignity and independence in later life.

This issue examines a wide spectrum of strategies that address the realities of ageing and chronic disease, from frontline innovations to systemic reforms. It features expert insights into safety, digitalisation, predictive tools, workforce and patient engagement.

Dr. Agnès Leotsakos examines how ageing patients are increasingly exposed to preventable safety risks due to fragmented care, medication-related harm and inadequate system responses, calling for urgent, patient-centred healthcare reforms.

Dr. Mera Cordero et al. describe how multidisciplinary, patient-centred strategies combining clinical care, functional rehabilitation and scientific innovation can enhance recovery and resilience in Long COVID management.

Begoña San José explores how ageing women's chronic care is shaped by lifelong habits, cultural norms, digital exclusion and under-recognised emotional burdens.

Artem Arutyunyan draws attention to chronic migraine as a widespread, disabling condition still largely neglected by health systems and often left untreated.

Wandile Ntuli presents the role of biokinetics in chronic disease management as a patient-centred approach that restores function, reduces readmissions and supports holistic care.

Ejike Nwokoro et al. demonstrate that predictive tools integrated into Clinical Homecare can significantly improve medication adherence, reduce medicines wastage and generate substantial cost savings for the NHS.

Abdulrahman Alyami outlines how Saudi Arabia is leveraging digital health, AI and patient self-management to reform elderly care amid growing chronic disease and ageing population pressures.

Richard Dasselaar argues that digital self-care should evolve from fragmented apps into integrated, equitable systems embedded in value-based healthcare frameworks.

Yuri Vasilev et al. detail how Moscow researchers have developed advanced medical phantoms and a dedicated materials database to enhance imaging training, diagnostic accuracy, and international collaboration in AI-driven healthcare innovation.

Jens Kögler explains that achieving connected, data-driven care depends on interoperability, smart regulation, investment and active patient participation.

Dr. Frederic Llordachs proposes a Zero Click Health model that leverages AI, automation and intuitive interfaces to reduce digital friction, ease clinician burnout and enhance care quality by reclaiming valuable medical time.

George Glass et al. showcase the CHI-FLYING Hackathon model, enabling healthcare professionals to collaboratively develop validated and sustainable innovations.

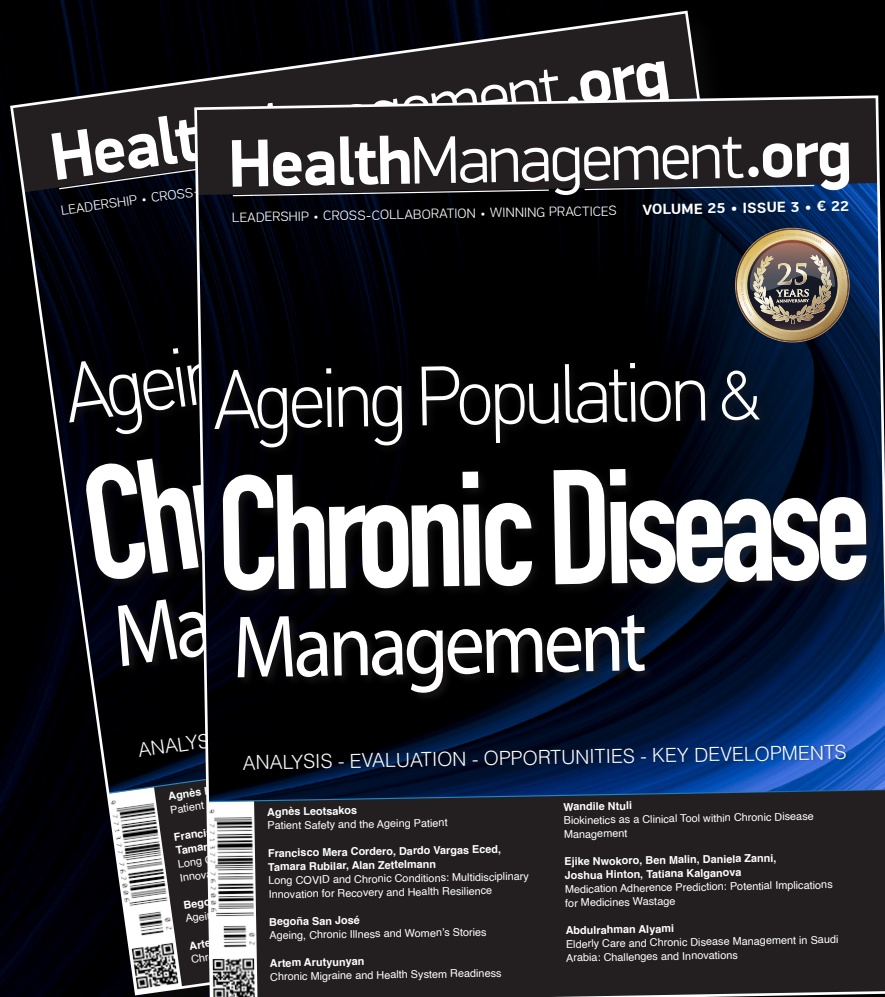
Rita Veloso and Renato Magalhaes discuss how XR is revolutionising medical education by boosting skill development and teamwork, despite barriers like cost and limited access.

Jeff Richards analyses how AI-driven staffing tools can address the nurse shortage, provided leaders and policymakers ensure systems truly support caregivers.

We hope these contributions will stimulate a fruitful dialogue, reflection and action in your organisations and communities and inspire meaningful steps towards more resilient and inclusive models of care.

Happy reading!

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Richard Dasselaar serves as Chair of AI in Cardiology (ISTeH/WHO) and is a PhD graduate in Digital Health Strategy, with executive training from Erasmus, MIT and Harvard Business School. Founder of Global Advisory Digital, he is an expert in medical AI, value-based healthcare and digital transformation. With over 12 years of experience, he leads global efforts to integrate AI into healthcare systems for early diagnosis and equitable care delivery.

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Josh Hinton has a varied background, beginning in Economics and Behavioural Science and later transitioning into tech-enabled health solutions and innovative care platforms. He now focuses on implementing bespoke AI tools to support clinical decision-making and applies UX-first principles to maximise impact. He has co-authored publications on medication adherence and currently leads digital tools implementation for a major Clinical Homecare Provider in the UK.

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Hacking Forward – CHI-FLYING Hackathon Model to Create Tomorrow's Solutions

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Tatiana Kalganova, UK



Professor Tatiana Kalganova, Director of the Research Centre on AI at Brunel University London, is a leading expert in intelligent systems with 30+ years' experience. Her work in sustainable deep learning ranks first on datasets like MNIST and SKAD. She holds six patents and 150+ peer-reviewed papers. Widely funded and recognised, she contributes to the academic community through editorial roles, EPSRC panels and leadership in IEEE conferences.

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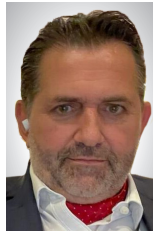
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Spotlight



Düsseldorf: Europe's Rising Capital for Health Care Congresses

Düsseldorf has become a significant hub for health and medical conferences, combining top hospitals, research centres and international events like MEDICA and REHACARE. Its strong infrastructure, central location and support from the Convention Bureau make it easy to host successful events. With excellent transport, diverse hotels and a high quality of life, the city offers a seamless experience for organisers and delegates alike. Sustainability and digital tools strengthen its future outlook.

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key points

- Düsseldorf hosts major medical events, such as MEDICA and REHACARE, every year.
- The city offers top hospitals, research centres and over 3,000 practising doctors.
- Excellent transport links make travel easy by air, train or road.
- The Convention Bureau supports organisers with planning and local connections.
- Modern venues, green projects and digital tools ensure future-ready events.

Introduction

Düsseldorf may be best known for its fashion and riverside promenades. Still, over the last twenty years, it has also become one of Europe's busiest meeting spots for doctors, researchers, and life science companies. The city's growth in health care is no accident. Local hospitals, the university, and city leaders have worked together to attract major medical trade fairs, build first-class venues, and make travel easy. Today, Düsseldorf hosts events like MEDICA and REHACARE, which draw tens of thousands of visitors from all over the world, showcasing why the city has become a strong choice for health and medical conferences.

A Strong Health and Life Sciences Scene

Düsseldorf sits in North Rhine-Westphalia, Germany's most populous state. The region has long been home to chemical and pharmaceutical firms, so the move toward health care innovation made sense. The local university, Heinrich Heine University, now runs

respected programmes in molecular medicine, digital health and biotechnology. Students often conduct hands-on work in nearby hospitals or start-ups, so new ideas leave the lab and reach patients quickly. Venture capital funds and government grants help young companies stay in the region, creating a steady flow of fresh research topics for conference agendas.

Hospitals, Clinics and Doctors

Numbers paint the picture: the city offers 15 large, multi-disciplinary hospitals, more than 80 specialist clinics and over 3,000 practising doctors. That density means almost any medical field, from heart surgery to dermatology, has local experts who can speak at events or run live workshops. For conference planners, finding keynote speakers or arranging on-site medical support is simple because the talent pool is right next door. Delegates also take comfort knowing that high-quality care is available should they need it during their stay.



Big Medical Conferences Choose Düsseldorf

Two events show the city's pulling power. **MEDICA** is the world's biggest medical trade fair. Its most recent edition filled seventeen halls, hosted about 5,300 exhibitors and welcomed more than 80,000 professional visitors. Six weeks later, **REHACARE** arrives, bringing nearly 1,000 exhibitors and approximately 40,000 visitors focused on rehabilitation and assistive technology. Running shows at this scale proves that Düsseldorf's transport links, hotels and event staff can handle heavy crowds without breaking stride.

Easy to Reach from Almost Anywhere

Location is half the battle for a successful meeting. Düsseldorf wins here. The international airport (code DUS) lies just three kilometres from the main trade fair grounds. It connects to roughly 200 destinations in 50 countries and offers direct trains to the city centre

Congress Center Düsseldorf (CCD)

Sitting beside the Rhine and next to the main Messe halls, the Congress Center Düsseldorf serves as the city's main engine for conferences. Forty-one flexible rooms, multiple foyers with daylight and a total capacity of 7,500 delegates (expandable to over 20,000 when nearby halls are added) make it possible to host everything from small symposia to giant plenary sessions: Fast Wi-Fi, in-house streaming studios, and on-site medical teams round out the package. Organisers can switch room layouts overnight, so breakout tracks, poster areas and networking lounges appear exactly where they are needed.

Plenty of Places to Stay

A significant event requires a large number of beds. Düsseldorf boasts around 35,000 hotel rooms, spread across more than 250 properties. Options range from five-star hotels on the stylish Königsallee to budget-friendly chains near the airport. Busy weeks like MEDICA can push occupancy high, but the Convention Bureau's partnership with travel firm Kuoni Tumlare Congress keeps prices under control. Their online tool, **Hotelmap**, displays live room rates and allows attendees to book quickly, filtering by distance, star category or price. Less time hunting for a room means more time focusing on science.

Quality of Life Counts

Delegates judge a conference not only by its sessions but also by the city in which it is held. Düsseldorf scores well in terms of safety, cleanliness, and public transportation. The riverfront promenade offers sunset

“Düsseldorf's promise is clear: world-class medical expertise, excellent transport links and a city that treats visitors like neighbours.”

that take about twelve minutes. High-speed ICE trains place Cologne only 22 minutes away and link directly to Frankfurt, Berlin, Amsterdam and Brussels. Major motorways surround the city, allowing freight trucks carrying exhibits to arrive on time for unloading. All this means less travel stress for delegates and lower shipping risk for exhibitors.

walks, and the historic Altstadt—sometimes called “the world's longest bar” because of its many pubs—is a favourite spot for informal networking. Food lovers enjoy a diverse range of dishes, from hearty Rhineland specialities to sushi, thanks to Germany's largest Japanese community. Many visitors extend their trip by a day or two to explore, thereby boosting local tourism spending and attendee satisfaction scores simultaneously.



A City That Welcomes Everyone

Düsseldorf's diverse population makes it an ideal location to host international groups. Event signs are displayed in both English and German, and professional interpreters are available to cover languages such as Mandarin, Arabic, and Spanish.

solar panels and smart energy grids. When finished, the campus will host approximately 4,000 workers from clean tech and health-tech firms. Conference organisers can book tours of the site or hold sessions there to highlight green solutions in hospital design, medical logistics and digital health.

How the Düsseldorf Convention Bureau Helps

Behind every smooth event is a team that knows the city inside out. The **Düsseldorf Convention Bureau (DCB)** offers free advice on choosing venues, setting budgets and drafting bid documents. Once an event is confirmed, the bureau helps arrange public transportation passes, connects planners with local experts and even provides templates for marketing materials. Once a year, the bureau hosts the **Health Marketing Forum**, where hotels, PCOs

“By choosing Düsseldorf, organisers spend less time fixing problems and more time advancing science.”

Venues offer prayer rooms, kosher or halal catering options, and facilities for individuals with disabilities. For example, tram stops have low floors and tactile paving, and the Messe grounds include ramps, induction loops and wheelchair friendly restrooms. These touches help all delegates feel comfortable and respected.

A Green Future: The EUREF Campus

Sustainability is high on the agenda for modern meetings, and Düsseldorf is taking clear steps. The new **EUREF Campus Düsseldorf** will be an 80,000 square metre innovation quarter that operates entirely carbon neutral. It utilises lake water cooling, rooftop

and hospital managers share tips and updates. This open exchange means lessons from one event quickly improve the next.

Digital Tools Make Planning Easier

DCB's tie-in with Hotelmap creates real-time dashboards that show how quickly room blocks are selling, which countries' delegates are coming from, and whether more budget rooms are needed. Organisers can adjust marketing focus or open extra room blocks early, avoiding last-minute scrambles. After the event, detailed reports list actual arrivals versus registrations and estimate the show's economic impact— solid figures that help justify budgets for future editions.

Why Organisers Keep Coming Back

Running a medical conference is a complex puzzle of freight, visas, Wi-Fi demands and health regulations. Düsseldorf reduces those headaches. Customs agents with fair ground offices handle ATA Carnets in hours, not days. On-site clinics, staffed by local doctors, manage minor injuries during events. The city's compact layout means that most hotels, restaurants, and social venues are within a 20-minute





tram ride. That saves money on shuttles and frees up evenings for networking dinners on river boats or rooftop terraces.

Looking Forward

The city is not standing still. A half-billion-euro upgrade of the Messe South Entrance will feature timber-hybrid construction, improved rainwater collection and increased daylight. The Convention Bureau is testing a “digital twin” of the city, utilising data from past events to model future delegate flows, identify pinch points and enhance security planning. As hybrid meetings evolve—with remote delegates joining through VR headsets or telepresence robots—Düsseldorf’s strong fibre network and 5G rollout will make high-quality streaming reliable and affordable.

Conclusion

Düsseldorf’s promise is clear: world-class medical expertise, excellent transport links and a city that treats visitors like neighbours. Its dense cluster of hospitals and research labs ensures rich scientific content. Its airport, trains and motorways make travel painless. Its hotels, restaurants and river views turn work trips into memorable experiences. Add the hands-on support of the Convention Bureau, and it becomes easy to see why so many health and medical conferences now call Düsseldorf home.

By choosing Düsseldorf, organisers spend less time fixing problems and more time advancing science. Delegates spend less time in traffic and more time sharing ideas. Everyone goes home with new knowledge and good memories— and that is what great conferences are all about.

Conflict of Interest

Spotlight articles are the sole opinion of the author(s), and they are part of the HealthManagement.org Corporate Engagement or Educational Community Programme.





Measuring the Invisible: The Quanterix Revolution

Quanterix is transforming biomarker detection with its Simoa® technology, enabling ultra-sensitive measurement of disease markers in blood. Its platforms (HD-X, SP-X® and SR-X®) support early diagnosis and research across neurology, oncology and more. Clinical validation, including in Alzheimer's detection, demonstrates global relevance. Through partnerships and scalable systems, Quanterix is helping bring advanced diagnostics to broader clinical practice.

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key points

- Quanterix enables ultra-sensitive biomarker detection at femtogram levels in blood samples.
- Simoa® platforms support multiplexed, reproducible assays for diverse clinical applications.
- Plasma biomarkers like pTau217 improve early Alzheimer's detection and risk stratification.
- Global partnerships are expanding access to blood-based diagnostics in routine healthcare.
- Flexible instruments allow rapid assay development with minimal sample volume.

A New Era in Diagnostic Sensitivity

Scientific discovery has often been driven by the need to see more clearly, to measure more precisely, to understand more deeply. In the world of diagnostics, this translates to detecting diseases earlier and with greater accuracy. For decades, the limits of detection have constrained how early a disease can be identified or how precisely its progression can be tracked. Quanterix, with its Single Molecule Array (Simoa®) technology, has broken through those limits, enabling the measurement of biomarkers at levels once thought unreachable. This leap in sensitivity is not merely a technical advance but a clinical and scientific milestone—one that is redefining how researchers and clinicians approach disease.

By pushing detection thresholds down to the femtogram per millilitre (fg/mL) range, Quanterix offers a new lens into human biology. Diseases can be identified earlier, treatments monitored more effectively, and scientific questions approached with a resolution previously impossible. Across a wide range of fields—neurology, oncology, cardiology, immunology and infectious disease—this technology helps uncover the biology that traditional tools have left invisible.

This capability is not only advancing academic science but also redefining the clinical pathways available to patients.

The Science Behind Simoa®

At the heart of Quanterix's platform is its proprietary Simoa® technology. Using either bead-based or planar array formats, the system isolates and quantifies individual biomolecules with a level of precision that transforms the way diagnostic science is conducted.

In bead-based assays, paramagnetic beads are coated with antibodies that bind specific target proteins. These beads are then loaded into over 200,000 microwells, each so small it can hold just one bead. A fluorescent signal is generated and amplified if the target molecule is present, enabling single-molecule detection. Planar array assays operate on a different principle, spotting antibodies in circular arrays on microplates. These enable multiplex detection of up to 10 analytes per well, providing scalability and robustness ideal for immuno-oncology and systems biology.



Both approaches are enhanced through proprietary fluid dynamics, surface chemistry and image analysis algorithms. Together, they create a platform that is not only sensitive but reproducible, user-friendly and adaptable to diverse clinical and research environments.

A longitudinal study in Brazil (Santos et al. 2025) exemplifies this progress. Researchers analysed plasma samples from a cohort of 145 elderly participants, using the HD-X platform to measure phosphorylated tau (pTau181 and pTau217), NfL, GFAP and other key biomarkers. Results showed

“Blood-based diagnostics powered by Simoa® open the door to earlier intervention, better disease tracking and more inclusive research.”

Platform Versatility: SP-X®, SR-X® and HD-X

Quanterix has developed a suite of instruments to make its technology accessible to a wide variety of users. The HD-X platform is the most comprehensive, supporting full automation and multiplex detection with a catalogue of over 80 assays. It is the instrument of choice in high-throughput research settings where scale and consistency are essential.

For labs focused on imaging and high-plex analysis, the SP-X® system uses Simoa® planar array technology to detect up to 10 biomarkers per well. With its compact design and built-in machine learning for image analysis, SP-X® offers powerful multiplexing capabilities while remaining user-friendly and space-efficient.

The SR-X® system provides a more compact and affordable solution while retaining the core sensitivity and flexibility of the platform. Supporting up to four analytes per assay, it is particularly suitable for settings where sample volume is limited or throughput is moderate. Researchers benefit from intuitive touch screen controls, minimal maintenance and streamlined workflows.

These systems share compatibility with a wide range of commercial and custom assays. Researchers can adapt pre-existing kits or develop their own, allowing full control over study design and target selection. This interoperability also simplifies technology adoption across different institutions and laboratories.

Clinical Validation in Neurodegeneration

Nowhere is the impact of ultra-sensitive detection more visible than in neurodegenerative diseases. Alzheimer's disease, long diagnosed by exclusion or through invasive procedures, can now be detected and monitored with blood-based biomarkers using Quanterix technology.

that pTau217 levels, particularly when considered in relation to Aβ42, closely mirrored cerebrospinal fluid (CSF) biomarker profiles. The pTau217/Aβ42 ratio achieved an area under the curve (AUC) of 0.98, indicating excellent diagnostic performance.

Moreover, these plasma markers predicted disease progression. Elevated levels of pTau181 and pTau217 at baseline were associated with conversion from mild cognitive impairment to Alzheimer's disease, offering a non-invasive way to identify individuals at risk.

This work is particularly valuable in low- and middle-income countries, where access to PET scans and CSF analysis is often limited. Blood-based diagnostics powered by Simoa® open the door to earlier intervention, better disease tracking and more inclusive research. Importantly, these biomarkers performed reliably even in a cohort with diverse comorbidities, reflecting real-world clinical variability.

Partnerships Extending Clinical Reach

Quanterix is also building the clinical and operational infrastructure needed to bring its technology into routine use. In the United States, ARUP Laboratories has launched a blood test for pTau217 using the SP-X® platform. This test supports clinicians in diagnosing cognitive decline in older adults, enabling more accurate differentiation between Alzheimer's and other causes.

Neurogen Biomarking has also adopted the technology to support an at-home blood collection service. Patients can now access Alzheimer's biomarker testing remotely, making early detection more convenient and accessible. This model represents a new era of proactive health engagement and decentralised diagnostics.

In Australia, NSW Health Pathology has validated neurofilament light chain (NfL) for routine use, further illustrating the growing international footprint of



Quanterix platforms. These examples demonstrate how biomarker innovation is being embedded into national healthcare systems.

Beyond Neurology: Broad Applications Across Disciplines

The advantages of Simoa® are not limited to neurodegenerative disease. In oncology and immuno-oncology, the SP-X® enables researchers to measure cytokines, chemokines and checkpoint inhibitors simultaneously, even at baseline levels. This supports studies on tumour microenvironments, immune response and therapeutic impact.

As the field moves toward more personalised, accessible diagnostics, platforms like Simoa® will be essential in ensuring that scientific advances reach the populations who need them most. Expanding biomarker access helps create a more inclusive diagnostic ecosystem.

Conclusion: Seeing Deeper, Acting Sooner

In the past, detection limits often defined the boundary between early intervention and late diagnosis, between insight and uncertainty. Quanterix has shifted that boundary. By enabling scientists and clinicians to measure at femtogram levels, to detect changes before symptoms arise and to monitor disease with

“From academic laboratories to public health systems, Quanterix technology proves that when you can measure more, you can do more.”

In cardiology and infectious disease, subtle fluctuations in inflammation markers can have prognostic significance. The ability to detect these at early stages supports preemptive intervention and personalised treatment.

Furthermore, the platform's flexibility ensures that researchers can respond rapidly to emerging questions. Custom assays can be developed and scaled across compatible instruments, conserving precious samples while enhancing reproducibility. The simplicity of workflows and short assay times make it easier for labs to keep pace with evolving research priorities.

Global Relevance and Scientific Equity

Validation studies in underrepresented populations are essential for equitable healthcare innovation. The Brazilian dementia cohort is a step toward ensuring that blood-based biomarkers are effective across diverse demographic and clinical backgrounds. Given the global burden of Alzheimer's and the high rate of underdiagnosis, particularly in developing regions, these findings carry substantial implications.

Quanterix technology meets this need not only through its performance but through its practicality. Instruments are designed to integrate into existing laboratory workflows, with intuitive interfaces, low maintenance requirements and scalable throughput. Compatibility with electronic laboratory management systems and data export functions also supports broader data integration.

exquisite precision, the company has changed what is possible in biomedical research and clinical care.

This transformation is not just about sensitivity. It is about making complex science accessible, turning discovery into action and bringing innovation to the point of care. From academic laboratories to public health systems, Quanterix technology proves that when you can measure more, you can do more. And in healthcare, doing more—sooner, smarter and for more people—can make all the difference.

Looking ahead, the continued expansion of assay panels, broader clinical validation and integration into digital health platforms will only increase the relevance of Quanterix systems. With science pushing further into the molecular foundations of disease, the ability to detect what was once invisible will define the next generation of medicine. Quanterix has already shown that future is not only possible—it is within reach.

Conflict of Interest

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Cover Story

Patient Safety and the Ageing Patient

The ageing population faces increasing patient safety risks due to complex care needs, multimorbidities, reduced physiological reserve and often cognitive decline, all managed within fragmented health systems. Common issues such as delirium, falls, pressure ulcers, malnutrition, dehydration, healthcare-associated infection and medication-related harm are often preventable. Ensuring safer, coordinated and patient-centred care requires systemic changes, better training and a strong safety culture across all care settings.

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key points

- The ageing are at increased risk for adverse events in every clinical setting and are disproportionately affected by unsafe and low-quality care.
- Geriatric syndromes like delirium and falls are common patient safety challenges which are often preventable.
- Polypharmacy increases medication-related harm and adverse drug events in older adults.
- Care is often fragmented with poor coordination across diverse healthcare settings.
- A culture of safety and integrated, patient-centred care is urgently needed.

Introduction

Populations are ageing faster than ever before, while healthcare infrastructures are struggling to keep pace. As people live longer—due to medical advancements and better living conditions—they are also living with more complex health needs. This is not just a trend. It's a global shift with implications on how good quality care is provided to ensure patient safety.

The Ageing Surge

By 2050, the global population of ageing people will surpass 2 billion (WHO). Already, older adults outnumber children under five, and this trend is not limited to high-income countries. Low- and middle-income countries (LMICs) already have 80% of the world's older adults—a number set to rise in the next decades (The Lancet Healthy Longevity 2021).

Population ageing is a key driver of the growing disease burden among older adults, significantly reshaping healthcare needs and straining health systems. They are prone to multiple chronic illnesses,

comorbidities, disabilities and cognitive decline. Consequently, there is a growing need for specialised care. This necessitates continuous, coordinated support across a broad range of services—from prevention and treatment to rehabilitation and end-of-life care.

A Storm of Pressure

Research studies show that the burden of disease is mainly from non-communicable diseases. Ischaemic heart disease, stroke and chronic lung disease are the biggest killers. Diabetes, dementia, visual and hearing impairment as well as osteoarthritis are the main causes of disability. Of particular relevance is the growing-in-numbers group of people living with dementia, entirely relying on family, caregivers and the state to a life of health security (WHO 2021; WHO 2012; Wimo et al. 2013). As the needs of older patients grow, so too do the risks of receiving fragmented, low-quality and unsafe care.



Why Ageing Patients are at Greater Risk of Care Delivery Challenges

- **Multimorbidity:** Older adults often live with multiple chronic conditions, requiring treatment by several different specialists. This increases the risk of frequent hospitalisations, longer hospital stays, more readmissions, polypharmacy and higher costs.
- **Lack of a consistent coordination:** Ageing patients frequently move between healthcare settings—clinics, hospitals, long-term care—without consistent coordination.
- **Cognitive or emotional challenges:** Conditions such as dementia or depression can impair communication.
- **Untrained caregivers:** Many older individuals depend on family or informal caregivers who may lack the skills or support needed to manage complex medical needs.
- **Medication-related harm:** Polypharmacy is common in ageing populations, with inappropriate prescribing or drug-drug interactions posing serious patient risks (eg falls, confusion).
- **Physiological vulnerability:** Older adults have reduced organ function, lower physiological reserve, altered drug metabolism, more body fat that interferes with pharmacokinetics, resistance to any stressor, cognitive deterioration and atypical disease presentation. These factors increase care complexity.

Patient Safety: An Overlooked Crisis for the Ageing Population

Despite three decades of global focus on patient safety, ageing patients remain particularly vulnerable. Older people are more likely to experience adverse events not because of their disease and comorbidities, but because of the way these diseases are treated. Ageing patients have complicated health needs and require a mix of services delivered by numerous health professionals in different types of facilities. When care is poorly coordinated—for instance, when treatments for one condition negatively affect another, or when medication causes harmful side effects—it is not just inefficient; it means that care is unsafe and of poor quality. In many cases, no single provider takes ownership of a patient's full care journey. On many occasions, patient records are not shared among

health professionals leading to dangerous gaps and missed information.

Ageing patients can be marginalised in healthcare. Even in resource-rich countries, chronically ill and home-bound patients have limited access to health services with delayed or no clinical responses, posing a serious risk. Cognitive decline (dementia), emotional and behavioural disorders require sensitive and safe healthcare approaches. These patients often cannot advocate for themselves and rely entirely on families or overstretched systems. Standardised treatment protocols may overlook their unique needs, leading to unintentional harm.

Nursing homes: A Gap in Patient Safety

Growing numbers of older people find themselves in nursing homes, residential care facilities (St Clair et al. 2022) rehabilitation centres and long-term care hospitals—places intended to offer support for those who cannot be cared for at home. Evidence shows that the safety culture in many of these environments lags behind that of hospitals (Bakerjian 2024). Nursing homes and rehabilitation centres performed poorly across nearly all safety domains and scored lower than hospitals (Castle 2007; Halligan 2014; Allen 2016).

Geriatric Syndromes: Preventable Harm in Ageing Patients

Geriatric syndromes—delirium, falls, pressure ulcers and malnutrition/dehydration—represent common and serious patient safety concerns. These conditions often stem from mismanagement of treatment, are largely preventable and demand a systems-based approach to care (Inouye et al. 2008).

Delirium

A frequent and serious neuropsychiatric syndrome, characterised by a sudden disturbance in consciousness, attention and cognition. Up to 67% of cases go undiagnosed, are mistaken for dementia, psychosis or depression—largely due to a lack of screening and staff training (Wass et al. 2008). Delirium increases the risk of falls, dementia and accelerates towards death.

Prevalence: 30–50%; ICU up to 80%; post-surgery 15–70% (Martins et al. 2012).

Mortality: 25–33% in-hospital mortality (Al Farsi et al. 2023).

Length of hospital stay: 21 days vs. 9 days without delirium (Martins et al. 2012).

System-Level Challenges Leading to Unsafe and Poor-Quality Care

- **Lack of care coordination:** no single healthcare professional manages an ageing patient's health.
- **Fragmented care:** healthcare professionals working in silos, which leads to poor communication and conflicting treatment plans.
- **Inadequate information-sharing:** patient records do not always follow patients across settings, leading to data duplication, delays or mistakes.
- **Insufficient patient-centred care:** protocols may overlook cognitive or behavioural issues that impact patient understanding or adherence to treatment.
- **Inequitable access:** even in high-income countries, weak and home-bound older people may struggle to access timely care.
- **Overlooked safety risks:** treating one condition may unintentionally worsen another if not carefully managed. For example: a sedative given for anxiety might increase fall risk.

Preventing delirium in ageing patients requires a multifaceted approach:

- Implement routine screening for early recognition of patient risk.
- Regularly review medications, particularly anxiolytics and sedatives.
- Support patients' physical health through proper nutrition and hydration.
- Address sleep deprivation.
- Enhance nursing care quality and provide targeted staff training.

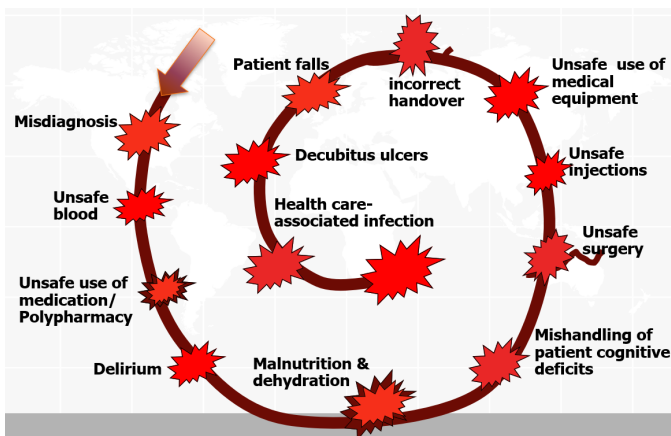


Figure 1. Multiple risks in the healthcare journey of ageing patients (A. Leotsakos, 2017)

Falls

Another patient safety concern relates to falls among ageing patients. Falls are common and serious, occurring at high rates at home-bound and hospitalised patients.

Prevalence: 28% and 35% of people over 64, and 32% to 42% over 70, experience at least one fall each year (Xing et al. 2023).

Morbidity or mortality: 30% of falls lead to injury, with 4–6% of fractures, subdural hematomas or death (Krauss et al. 2005).

Length of hospital stay: 37.2 days of hospitalisation—compared to 25.7 days for controls (Locklear et al. 2024); according to one analysis in the UK, additional stay was 2.4 weeks per patient (Al Sumadi et al. 2023).

Preventing falls in ageing patients requires the following measures:

- Enhance the environment with safety modifications such as non-slip flooring, bed mat alarms and motion-sensitive lighting.
- Improved nursing care through hourly rounding and targeted staff training.
- Address patients' sensory impairments by improving vision and hearing support.
- Conduct regular medication reviews, focusing on drugs that may cause dizziness, confusion, frequent urination or impaired balance.
- Educate patients and family members on fall risks and prevention strategies.

Pressure Ulcers

A third patient safety concern relates to pressure or decubitus ulcers, a significant concern for those who are immobile or in long-term care. Its high incidence indicates a diminished quality of care that can be considered unsafe.

Prevalence: 6.24% of patients over the age of 70 years compared to 3.41% in other age groups (NHS 2013). In nursing homes, the prevalence is around 11% (Lyder et al. 2008).

Morbidity or mortality: the risk of death doubles compared with those without ulcers (Song et al. 2019). 66% of those with pressure ulcers died within a 12-week follow-up (Khor et al. 2014).

Length of hospital stay: an average of 5–8 days to hospitalisation per ulcer (Labeau et al. 2020). 0.9 up to 14.1 days, depending on severity and setting (Triantafyllou et al. 2021).

Patient Predisposing Factors	Healthcare-Related Trigger Factors
Cognitive impairment	Infection or inflammation
Functional impairment	Use of sedatives, anxiolytics or opioids
Low blood pressure	Anaesthesia or surgery (especially with hypotension or sedation)
Old age	Admission to intensive care (eg ventilator use)
Dehydration	Busy, noisy, brightly lit environments

Table 1. Common predisposing and trigger factors contributing to delirium

Preventing pressure ulcers in ageing patients requires the following interventions:

- Conduct regular risk assessments using validated pressure ulcer assessment tools.
- Reposition patients at least every two hours to relieve pressure on vulnerable areas.
- Use pressure-redistributing surfaces, such as specialised mattresses, cushions or smart mattresses with sensors and alarms.
- Perform daily skin inspections, moisturise dry skin and manage incontinence.
- Ensure adequate nutrition and hydration with high-protein, high-calorie diets.
- Improve nursing care and provide ongoing staff education on pressure ulcer prevention.

Malnutrition and Dehydration

Malnutrition and dehydration in ageing population is a widespread yet an under-recognised patient safety issue. Millions of older patients across diverse

healthcare settings worldwide suffer from malnutrition and dehydration. Both are associated with poor clinical outcomes, preventable contribution to illness and increased mortality.

Prevalence: A U.S. study found malnutrition affects 0–15% of ambulatory outpatients, 35–65% of hospitalised patients with acute illness and 25–60% of nursing home residents (Hajjar et al. 2003).

Morbidity or mortality: Malnutrition in hospitalised ageing patients is 2–3 times higher mortality compared to well-nourished peers (Norman et al. 2008). Loss of lean body mass leads to frailty, falls and fractures. Dehydration may lead to falls and orthostatic hypotension, urinary tract infections, impaired glucose control in diabetes, constipation and many other problems.

Malnutrition and dehydration stem from a combination of individual risk factors and systemic failures in care delivery. Improving them requires the implementation of the following strategies:

Patient Predisposing Factors	Environmental Factors
Age-related muscle weakness and impaired balance	Unsafe environments, such as cluttered spaces, poor lighting or slippery floors
Sensory deficits such as vision or hearing loss	Inadequate nursing support and insufficient staff training
Previous falls with high risk of recurrence	Absence of preventive equipment, including call bells, bed/chair alarms or handrails
Underlying medical conditions: depression, anxiety, dementia, arthritis, diabetes, delirium, hypotension and cardiovascular disease	Unfamiliar environments leading to disorientation
Polypharmacy, especially involving anxiolytics, sedatives, psychotropic drugs and antihypertensives	

Table 2. Common predisposing and trigger factors contributing to ageing patient falls

Patient Predisposing Factors	Environmental Factors
Chronic medical conditions, including arthritis, diabetes and cardiovascular disease	Immobility
Polypharmacy, particularly the use of anxiolytics, sedatives, psychotropic medications and antihypertensives	Skin damage from pressure, friction or incontinence
Malnutrition or dehydration	
Medical conditions impairing blood flow	

Table 3. Common predisposing and trigger factors contributing to pressure ulcers incidence

- Screen patients regularly to identify those at risk of malnutrition or dehydration.
- Provide accessible food and fluids at all times in hospitals, clinics and nursing homes.
- Assist patients who require help with eating or drinking.
- Record all food and fluid intake accurately to monitor nutritional and fluid status.

More information is available in the landmark Francis Report (Francis 2013).

Medication Safety

Medication safety in older adults is a significant concern due to age-related physiological changes and the high prevalence of polypharmacy. As people age, they are more likely to use several medications simultaneously because of their multiple chronic conditions.

The hidden risks of polypharmacy in ageing patients include:

- **Polypharmacy:** Taking five or more medications simultaneously—a common scenario among older patients—is one of the most significant risk factors for ADEs.
- **Age-related physiological changes:** Decline in liver and kidney function affects how drugs are metabolised and cleared from the body.
- **Cognitive impairment:** Some medicines can trigger dementia. At the same time, dementia impacts the ability to manage medications safely and consistently.
- **Frailty and mental decline:** These factors can affect adherence and increase vulnerability to adverse effects.

Polypharmacy is a major factor contributing to medication-related harm. For instance, drugs used

“Older people are more likely to experience adverse events not because of their disease or comorbidities, but because of the way these diseases are treated.”

Ageing people process medicines less efficiently, making them more vulnerable to adverse drug events (ADEs). Compounding this risk is the tendency of healthcare providers to prescribe—and often overprescribe—medications for the multiple conditions that typically affect ageing patients. ADEs account for around 20% of emergency department visits among older people in the U.S., with nearly half being preventable (Pretorius et al. 2013; Shevni et al. 2019).

for one condition may negatively affect another. A medication prescribed for glaucoma might lower blood pressure too much, reducing brain oxygen supply and impairing cognitive function. In polypharmacy, adherence to treatment regimens can be challenging due to cognitive decline or physical limitations.

Medication errors can occur at any stage of the treatment process—prescribing, dispensing, administering or monitoring. **Errors of commission,**

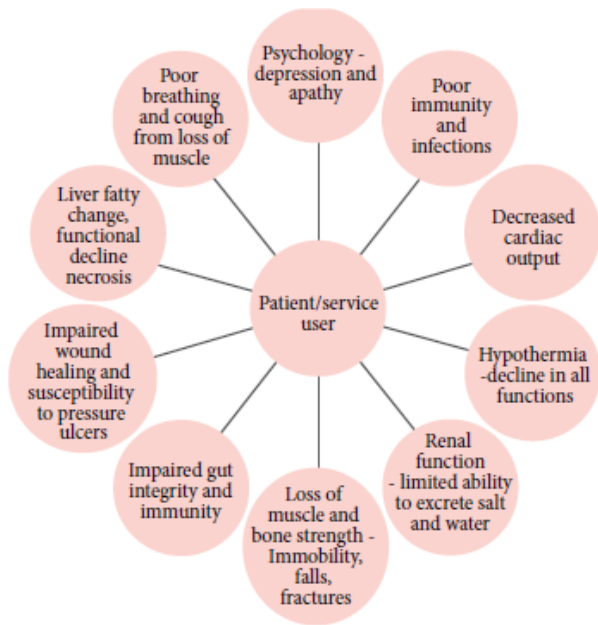


Figure 2. The consequences of malnutrition (adapted from Dr M. Stroud, Nutrition and Hydration week, UK, 2012)

involve wrong action taken such as prescribing the wrong dose or choosing an inappropriate route of administration. **Errors of omission**, involve failure to act, such as failing to consider a medication's impact

including pneumonia, stroke and kidney injury, and should be reserved for short-term use when strictly necessary. Benzodiazepines, commonly used for anxiety or insomnia, significantly increase the risk of falls, memory impairment and dependence.

Most ADEs are caused by commonly used medications that have risks but offer significant benefits if used properly. These include:

- antidiabetic agents;
- oral anticoagulants;
- antiplatelet drugs;
- opioid pain medications.

Their potent physiological effects can complicate patient safety—for example, blood pressure medications may lower blood pressure too much, leading to dizziness and increasing fall risk.

Drug–drug interactions pose another serious concern. Warfarin, a commonly used anticoagulant, is especially prone to interactions with other drugs like antibiotics, and such interactions are a major cause of medication-related hospitalisations. If not used appropriately, these four medication classes are responsible for nearly 60% of emergency department visits for ADEs among patients over 65 (Shehab et al. 2016).

“When care is poorly coordinated (...) it is not just inefficient; it means that the care is unsafe and of poor quality.”

on co-morbidities, its organ toxicity or potential drug–drug interactions. Both types of errors can lead to significant patient harm.

Even when medications are used correctly, some patients may experience side effects. The risk is particularly high in nursing homes, where residents may experience up to 10 ADEs per 100 resident–months, with 40% being preventable (Al-Jumaili et al. 2017).

Some medications carry heightened risks for ageing patients, particularly anticholinergics, psychiatric drugs and antibiotics. Anticholinergic agents—often used to treat incontinence or depression—can lead to confusion, memory loss and increased risk of dementia, especially with long-term use. Antipsychotics, sometimes prescribed for behavioural symptoms in dementia, are linked to serious complications

Patient Safety Challenges

Clinicians may initiate a treatment for a specific symptom but fail to follow up or re-evaluate the drug's effectiveness or side effects. Over time, this can result in continued use of a medication that poses more risk than benefit. In other cases, important signs of drug-induced complications, such as cognitive decline or impaired balance, are overlooked or misattributed to ageing itself.

Patient Safety Issues in Medication Errors

Medication errors can result from both active failures and latent system flaws. **Active errors**, made by frontline clinicians, involve prescribing the wrong dose or medication and typically stem from cognitive issues: biases or knowledge gaps due to

inadequate training. In some cases, clinicians may rely on outdated practices or fail to consider updated guidelines.

Latent errors, by contrast, arise from broader system weaknesses, including poor communication, time pressure, information overload, lack of standardised review processes and undue influence from pharmaceutical companies.

A persistent **blame culture** in healthcare further exacerbates the issue. When professionals fear punishment, they may avoid reporting near misses or ADEs, limiting opportunities for institutional learning and safety improvement.

Interventions to Reduce Medication-Related Harm

System-level interventions include regular pharmacist-led medication reviews, which are proven to reduce ADEs, and incorporating pharmacists into multidisciplinary care teams during hospital rounds to ensure that drug regimens are correct and optimised.

Person-centred care encourages shared decision-making and re-evaluation of medications in light of patient needs.

Education and training are also crucial. For healthcare professionals, understanding medication safety in ageing patients—such as recognising high-risk drug classes or common drug interactions—can significantly improve patient safety.

Technology-driven solutions, such as AI support tools, computerised physician order systems and bar-coded medication administration, enhance tracking, reduce transcription errors and promote safe administration of medicines.

Culture of safety is also critical. Encouraging the open reporting of errors and near misses, without fear of blame, enables health systems to detect patterns, identify systemic vulnerabilities and inform targeted interventions to improve medication safety. Preventing patient harm from medication error requires a shift toward more individualised, appropriate prescribing and administration practices, as well as regular medication reviews. System-level changes—such as improved training, better reporting cultures and use of safety tools and technology—must complement person-centred care.

Healthcare-Associated Infections

Although not classified as a geriatric syndrome, healthcare-associated infections (HAIs) pose a significant risk to ageing patients due to weakened immune function, multiple comorbidities, malnutrition and reliance on invasive medical devices. Older adults account for approximately 55% of all HAI infections. Common HAIs in this population include catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP), surgical site infections (SSI), central line-associated bloodstream infections (CLABSI) and secondary bacteraemia.

Prevalence: A 2011 prevalence study (Cairns et al. 2011) reported HAI rates as follows:

- 11.5% in patients >85
- 11.27% in ages 75–84
- 10.64% in ages 65–74
- 7.37% in those <65

Reducing HAI burden in the ageing patient requires:

- Strict hand hygiene protocols;
- Effective antibiotic stewardship programmes;
- Standard precautions: gloves, masks, gowns, safe handling of sharps;
- Ongoing education and performance feedback for healthcare workers;
- Active surveillance and screening for multidrug-resistant organisms (MDROs);
- Targeted prevention strategies in high-risk patients (for example, catheter use) (WHO 2009).

Interconnected Factors Contributing to Unsafe and Poor-Quality Care

The diagram illustrates the complex interconnections between medications, the four geriatric syndromes and HAI contributing to significant patient safety challenges in ageing patients. The overlapping arrows emphasise the interconnected nature of these health challenges.

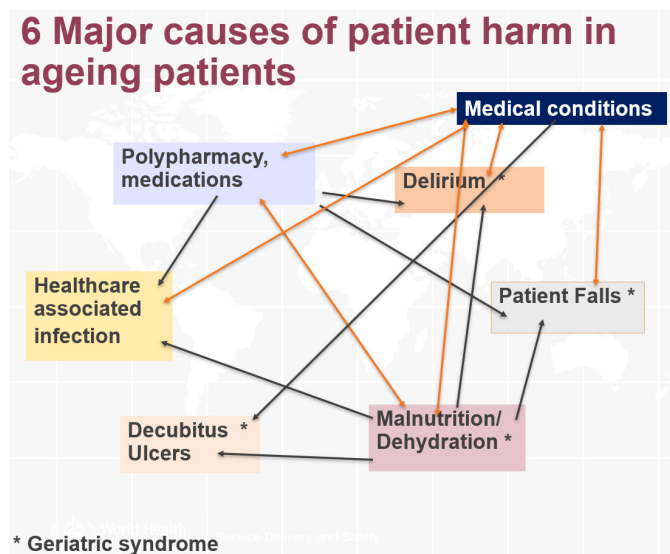


Figure 3. Six major causes of patient harm in ageing patients. (Source: A. Leotsakos, 2017)



Other common patient safety challenges in ageing populations include:

- Misdiagnosis or missed or delayed diagnosis.
- Clinical decision making, for example, failure to act on test results, overuse or underuse of treatments, cognitive bias in clinical judgment.
- Mishandling of patient sensory, cognitive or functional impairments by healthcare professionals.
- All priority patient safety challenges affecting all ages, such as unsafe surgery, unsafe injections, unsafe blood products, injuries due to medical devices and others.

- no regulation or accreditation;
- inadequate staffing or skill mix or untrained staff;
- fatigue and burnout of healthcare professionals;
- fragmented care coordination and others.

Conclusion

The global rise in ageing populations is creating unprecedented challenges for health systems. Ageing patients face a heightened risk of harm due to their complex health needs, care delivered across different settings, and environments not designed for their vulnerabilities. Geriatric syndromes, along with HAI, unsafe use of medication and other patient safety

“Preventing patient harm from medication error requires a shift toward more individualised, appropriate prescribing and administration practices.”

In addition, there are many structural factors contributing to unsafe care for the ageing populations including:

- communication failures such as poor coordination during patient handovers across different care settings;
- language and health literacy or understanding with patients;
- inadequate communication among healthcare professionals;
- organisational failures such as absence or weakness of safety culture in hospital and non-hospital facilities (nursing homes, rehabilitation centres and long-term care institutions);

challenges, are major but preventable contributors to poor outcomes, extended hospital stays, morbidity and mortality. The current care landscape often lacks the safety culture, coordination, healthcare staff training and specialised attention ageing patients require. Meeting the needs of this growing population demands urgent investment in integrated, patient-centred and safety-focused care systems.

Conflict of Interest

None

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Long COVID and Chronic Conditions: Multidisciplinary Innovation for Recovery and Health Resilience

Long COVID, now recognised globally as a chronic condition, affects multiple organ systems and demands coordinated, multidisciplinary care. Countries are responding with specialised clinics, rehabilitation pathways and digital innovations. Combining clinical precision, functional recovery and scientific research offers a path to personalised, tech-driven health resilience.

**DR. FRANCISCO
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key points

- Long COVID impacts multiple organ systems and presents a wide range of persistent symptoms.
- Several countries now recognise Long COVID as a chronic illness with dedicated care pathways.
- Multidisciplinary teams are essential to address the complexity of Long COVID treatment.
- Digital tools and AI enable personalised care and continuous patient monitoring.
- Scientific research explores marine compounds and supplements for symptom management.

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Introduction

Global health systems continue to deal with the long-term aftermath of the COVID-19 pandemic, and Long COVID (also referred to as post-acute sequelae of SARS-CoV-2 infection, or PASC) has been recognised as a chronic condition with broad systemic, economic and human implications. The World Health Organisation defines Long COVID as symptoms lasting more than two months that begin at least three months after a probable or confirmed COVID-19 diagnosis. These symptoms often include fatigue, shortness of breath, cognitive dysfunction and psychological distress.

Several countries, including France and the United Kingdom, now officially recognise Long COVID as a chronic illness, granting access to public health services and disability support. Its impact extends beyond individuals: healthcare costs rise, workforce participation drops and long-term disability challenges both employers and social security systems.

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Addressing this complex condition requires coordinated care that integrates medical, functional and scientific innovation. In this article, three professionals from different fields — clinical medicine, kinesiology and biotechnology — explore how multidisciplinary and evidence-based approaches can contribute to comprehensive recovery.

Global Responses to Long COVID

Long COVID has been officially recognised as a chronic illness in several countries. In **France**, it is classified as an “affection de longue durée” (long-term condition), granting patients access to extended healthcare coverage under the national health system. **The United Kingdom** has established over

“No single speciality can fully address the spectrum of Long COVID.”

Understanding Long COVID as a Multisystemic Condition

Long COVID affects various organ systems, including respiratory, cardiovascular, neurological, gastrointestinal and musculoskeletal. It also involves mitochondrial dysfunction, immune dysregulation and inflammatory processes. This leads to a wide range of symptoms: brain fog, post-exertional malaise, palpitations, chronic pain, anxiety and more.

These symptoms often overlap with those of other chronic conditions and post-viral syndromes, further complicating diagnosis and treatment. Many patients face disbelief or fragmented care. Thus, a holistic, coordinated model is essential.

80 dedicated Long COVID clinics through its National Health Service (NHS), providing multidisciplinary support that includes general practitioners, physiotherapists, psychologists and occupational therapists. In **the United States**, Long COVID is listed as a potentially disabling condition under the Americans with Disabilities Act (ADA), enabling affected individuals to request workplace and educational accommodations.

In **Spain**, regional health services have created specific care pathways for Long COVID, including dedicated units for diagnosis and rehabilitation, particularly in Catalonia and Madrid. **Canada** has developed patient-informed guidelines and launched post-COVID condition clinics

Common Symptoms of Long COVID

Up to 200 symptoms have been reported. These are among the most frequent and impactful.

These are among the most frequently reported and persistent symptoms of Long COVID across clinical studies.

Physical



Fatigue



Shortness of breath



Persistent cough



Chest pain



Muscle/joint pain

Neurological



Brain fog



Headache



Sleep disorders



Dizziness



Loss of smell/taste

Psychological



Anxiety



Depression



Irritability

Others



Gastrointestinal issues



Skin rashes

Sources: CDC, WHO, clinical experience.

Figure 1. Common Symptoms of Long COVID

across provinces, with an emphasis on primary care coordination. **China** has focused on early rehabilitation and long-term symptom tracking, integrating traditional Chinese medicine in some public hospital programmes.

data analysts and researchers. In the future, they will increasingly include AI experts and digital engineers to interpret patient-generated health data and develop predictive tools.

“The future of healthcare [is] driven by tech-enhanced teams.”

In **Russia**, clinical research and state registries have supported classification of Long COVID symptoms and testing of pharmacological options, especially in cardiopulmonary care.

Across **Latin America**, responses have varied widely due to resource limitations, but initiatives in **Argentina, Chile and Brazil** include hospital-based multidisciplinary clinics, public education campaigns and recognition of persistent symptoms in occupational health policies.

Despite these efforts, disparities in diagnosis, treatment access and insurance coverage remain, emphasising the need for global consensus on Long COVID management protocols.

A Multidisciplinary Ecosystem for Care

No single speciality can fully address the spectrum of Long COVID. As such, multidisciplinary teams are fundamental. These teams include physicians, rehabilitation specialists mental health professionals,

Our collaboration reflects this integrated approach:

- **Dr. Francisco Mera Cordero**, a clinical physician and global leader in Long COVID research and innovation.
- **Dr. Dardo Vargas**, a rehabilitation specialist and Long COVID survivor focused on functional and neurophysiological recovery.
- **Dr. Tamara Rubilar**, a scientist specialising in marine bioproducts and the investigation of marine-derived bioactive compounds.

Though we do not form a clinical team, our combined perspectives present a shared vision for interdisciplinary, science-based and patient-centred care.

Clinical Innovation and Tech-Enhanced Models

Dr. Mera Cordero leads the Long COVID Unit at Blue Healthcare and organised the first international Long COVID congress. His approach emphasises precision medicine, integrating symptom mapping, tailored

Patient-centered, collaborative care across interconnected specialties

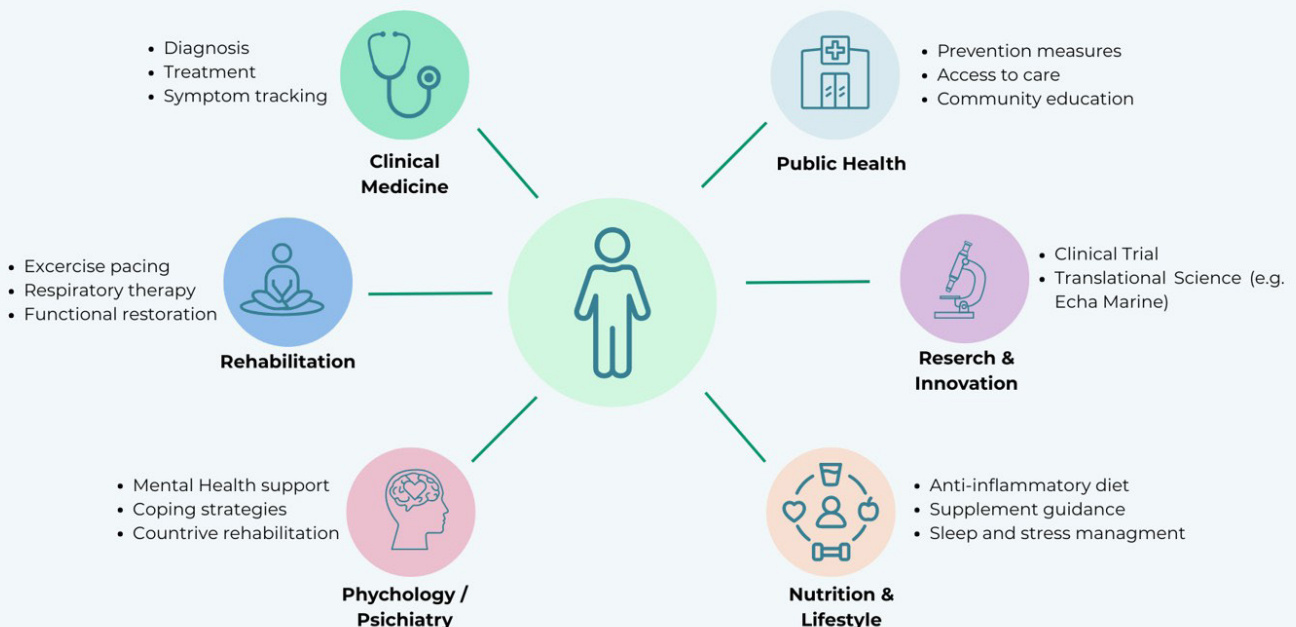


Figure 2. Patient-centred, collaborative care across interconnected specialties

treatments and clinical trials such as E-SPERANZA, which evaluates anti-inflammatory interventions.

He also envisions the future of healthcare driven by tech-enhanced teams: data analysts decoding

protective effects in both preclinical and pharmacological studies. Notably, it is the active compound in drugs approved in Russia for cardiac and retinal applications.

“Long COVID reveals the urgent need for collaborative, human-centred and technology-integrated healthcare models.”

wearable metrics, AI specialists building risk prediction models and digital engineers supporting patient engagement. These professionals enable early intervention, hyper-personalised therapies and real-time monitoring. For example, remote monitoring and AI models have reduced readmissions in chronic illness care by up to 50%.

Functional Rehabilitation and Human-Centred Recovery

As a Long COVID survivor, Dr. Vargas emphasises the vital role of rehabilitation. Many patients experience intolerance to exercise, dizziness, proprioceptive deficits and emotional symptoms. His programmes use breathing techniques, pacing, postural training and cognitive exercises tailored to each patient's capacity.

His experience at the G20 Global Long COVID Summit in Rio de Janeiro and work with Long COVID Physio reflect his commitment to global standards of care. He advocates for energy budgeting, patient education and integration of digital tools such as apps and wearable data to optimise recovery.

Scientific Innovation: Exploring Complementary Approaches

In addition to clinical and rehabilitative strategies, scientific innovation plays a growing role in addressing Long COVID. Research has explored the potential of several complementary and adjunctive approaches, including:

- **Nutritional and metabolic support**, such as vitamin D, NAD+ precursors and anti-inflammatory flavonoids.
- **Mitochondrial function restoration**, with compounds that support redox balance and cellular energy recovery.
- **Marine-derived polyphenols**, such as Echinochrome A, which has demonstrated antioxidant, anti-inflammatory and mitochondrial

These compounds are being increasingly considered in the context of chronic viral syndromes. While more international, peer-reviewed studies are needed, marine biotechnology illustrates how natural bioactive molecules may contribute to post-viral recovery frameworks.

Integration: The Future of Health Resilience

Together, these three approaches form the foundation for a new model of care:

- Clinical teams that personalise treatment and monitor progress through digital platforms.
- Rehabilitation protocols tailored to each patient's physiology and symptom dynamics.
- Complementary scientific innovations rooted in evidence and sustainability.

With the development of the AI, artificial general intelligence (AGI) may soon synthesise genomics, environment and behavior into predictive insights, further empowering multidisciplinary teams.

Conclusion

Long COVID reveals the urgent need for collaborative, human-centred and technology-integrated healthcare models. From wearable data and precision medicine to functional rehabilitation and complementary innovations, the future lies in synergy. Healthcare systems must invest in interoperable platforms, cross-disciplinary training and equitable access to emerging tools. Through cooperation, we can transform reactive care into resilient health ecosystems.

Conflict of Interest

Dr. Tamara Rubilar is the founder of Promarine Antioxidants, a company that commercialises a nutraceutical product derived from Echinochrome A extracted from sea urchin eggs.

Ageing, Chronic Illness and Women's Stories

Many ageing women with chronic conditions face challenges rooted in past hardships, cultural habits and care burdens. Deeply embedded behaviours, digital exclusion and unaddressed grief hinder health management. Systemic gaps, low patient activation and psychological weight further complicate care. Sustainable solutions require empathy, accessible technology, culturally relevant support and recognition of women as both patients and caregivers.

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key points

- Lifelong habits and cultural norms hinder effective chronic disease management.
- Digital tools often exclude ageing women due to poor design and low literacy.
- Mental health issues are frequently unspoken or mislabelled.
- Many women are both caregivers and patients, lacking adequate support in either role.
- Sustainable care must prioritise empathy, accessibility and cultural relevance.

"Picture it: Sicily, 1924..."

— *The Golden Girls*

Blanche, a character from *The Golden Girls* series, always began telling a story with place and year, then unfolded a woman's life. Let's borrow this narrative device: to design care that finally fits ageing women we must first see how yesterday's realities shape today's multimorbidity.

Below are **four composite stories based on real-world patterns**, drawn from Europe, Latin America, the Middle East and beyond. Their names are fictional—but their needs are not. Their paths differ, but their struggles converge. After the stories, we reflect on what this means for care, support and shared responsibility.

Maria — Sicily, 1944

Childhood: Post-war ration cards, olive-oil scarcity, walked barefoot to school until 11.

Adulthood: Married at 18; five pregnancies by 30; double workload—field and household.

Medical timeline: 1972: borderline blood pressure; 1988: "mild sugar" (no follow-up); 2003: type 2 diabetes; 2014: knee arthritis; 2021: depression after husband's stroke.

Today (80): Recently widowed; must now manage bills and transport her husband once handled. Uses feature phones only; reject continuous glucose monitor (CGM), as its font is too small.

Maria's challenge is not resistance—it's unfamiliarity. When she is asked to eat low-carb, the advice clashes with a lifetime of carb-heavy staples. Pasta, bread, potatoes were not indulgence—they were survival. Asking her to unlearn that is not simple; it is a psychological ask, not just nutritional.

Layla — rural Jordan 1951 → Amman 1980

Childhood: Desert village life; early marriage at 16; raised seven children; no formal schooling.

Adulthood: Managed household, cooked for extended family; rarely saw doctors unless pregnancy-related.

Medical timeline: 1996: hypertension; 2003: obesity (BMI 38) noted during check-up for foot pain; 2010: diagnosed with diabetes; 2017: neuropathy; 2022: mobility issues, her weight remains taboo topic.

Isabel shows us how unspoken grief, gendered mental health stigma and generational norms delay care. Her care journey is deeply shaped by what was never said—and what still feels shameful to name.

“The psychological toll of lifelong caregiving becomes a condition itself.”

Today (73): Widowed. Her sons live abroad; her daughters are overloaded. Feels shame about her body and dependence. Refuses glucose tracking, as she cannot read English interface and is ashamed to ask for help.

Layla’s story illustrates how modesty norms, digital illiteracy and silent suffering obstruct effective care. She has internalised her health problems as personal failure, not preventable burden—mirroring millions of women across the Middle East and beyond.

Isabel — rural Galicia 1958 → Madrid 1979

Childhood: Farm chores, winter hunger, one-room school.

Adulthood: Cleaner on rotating shifts; two children; caregiving for a cousin with dementia.

She’s also navigating the downstream health effects of historical knowledge gaps—like the fact that delivering a high-birthweight baby (a known risk factor for Type 2 diabetes) was not widely recognised until well after her daughter’s loss. Those past unknowns still shape today’s chronic realities.

Carmen — La Paz 1946 → Barcelona 1970 (nurse)

Childhood: High-altitude sun, polio scare.

Adulthood: 35 years as ward nurse; night shifts; union representative; back injuries; primary carer for mother with heart failure.

Medical timeline: 1999: chronic lumbago; 2007: hypertension; 2015: chronic kidney disease (due to nonsteroidal anti-inflammatory drug overuse); 2022:

“She does not want sympathy. She wants dignity, relevance and relief.”

Medical timeline: 2000: her daughter is diagnosed with a gestational diabetes; 2002: her daughter delivers a 4.4 kg baby who dies suddenly weeks later—family never speaks of it; paediatrician tells Isabel to “watch the sugar” but no test is done; 2012: formal type 2 diabetes diagnosis; 2018: diabetic retinopathy; 2022: depression finally diagnosed after years of believing that “all the women in our family are moody.”

Today (66): Retired and widowed within a year, moved into daughter’s flat—lost rural network, gained informal caregiver. Does not count carbs; her eye-strain limits app use; worries about retina surgery being delayed.

burnout & chronic insomnia—still wakes to phantom call-bells thinking that “someone must need me.”

Today (78): Officially retired. Skips nephrology when the ward is short-staffed; guilt lives on both sides of the stethoscope.

Carmen reminds us that many women are both patients and providers—and often under-supported in both roles. The psychological toll of lifelong caregiving becomes a condition itself.

What Shapes Their Care Experience Today

These women live with multimorbidity, yes. But they also carry:



- **Psychological weight:** Depression dismissed as “moodiness,” internalised fatalism, shame around poor literacy or failed habits.
- **Behavioural inertia:** Habits from decades past are deeply embedded. Pasta is not “just a carb” — it’s cultural identity, economy and taste. How do you “go low-carb” in places where rice, bread or plantains were the base of every meal?
- **Social shifts:** Widows with vanished roles, daughters now distant, friends also ageing. Their support network shrinks while needs rise.
- **Low patient activation:** Not because they do not care—but because they do not know where or how to start. Prioritising themselves was never encouraged.
- **Tech mismatches:** Vision loss, low digital literacy and confusing user experience keep many tools irrelevant or inaccessible.
- **Global variation:** These stories may start in Europe, Latin America or the Middle East, but they echo across continents. And the challenges—lifestyle mismatch, digital exclusion, under-recognised mental health—are magnified in regions where care access is even more fragile.

The System Has Changed

Healthcare has evolved from personal to procedural. These women remember when a doctor **knew their name, their family and their story**—not just their laboratory results. Today, they’re referred across specialties, see different faces at every visit and often hear their names shortened or mispronounced. They leave 10-minute appointments with questions they did not have time to ask, or only think of after the door closes. They are asked to use devices (What’s a CGM? Why there are two blood pressure readings?) or log symptoms in apps that do not accommodate

failing eyesight or digital illiteracy. They remember when their doctor looked at **them**, not a screen. Now, the responsibility to coordinate, track, understand and comply falls heavily on **them**—when that capacity may be at its lowest.

What Must Change: A Shared Responsibility

Holistic care is not about adding more professionals—it’s about designing around **real lives**. To make care sustainable, it is necessary to:

1. **Reimagine patient journeys with these women at the centre**, not on the margins.
2. **Train clinicians in health psychology:** how to meet resistance with curiosity, not blame.
3. **Fund community-based coaching**, peer support and caregiver respite.
4. **Design tech accessibly**, using large fonts, audio navigation and family-linked accounts.
5. **Make mental health universal in care pathways**, especially for older women.
6. **Value the ageing female healthcare workforce** with flexibility and recognition.
7. **Map global variability in care norms** and make behavioural change tools culturally and historically relevant.
8. **Update risk frameworks:** Many key predictors—like delivering a macrosomic baby—were unknown or ignored when these women gave birth. They should not pay twice for a gap in the system’s memory.
9. **Support empathy as a core clinical skill:** Healthcare professionals, especially under pressure, are often guided by KPIs but lack insight into what truly matters to the patient. A simple pause in assumption and a trained eye for context can lead to better care and less frustration—for both sides.
10. **Ask yourself this:** If you are reading this and you are in medtech, pharma or hospital leadership, how will you bring this shared responsibility into your roadmap, strategy or meeting agenda? These women are not edge cases. They are the centre of your care population.

“Compassion is not soft. It’s smart. And it’s strategic.”

Empathy as Strategy

This is not charity. This is resilience. If we understand the history of these women, we can design the care for their future. If we train healthcare workers not just in protocols but in **empathy and health psychology**,

we can help patients make meaningful changes without moralising or overwhelming them.

Compassion is not soft. It's smart. And it's strategic. The key to sustainable secondary prevention lies in knowing which barriers matter—and which levers actually move.

Change the Prompt

Your chronic patient is not average.

She is female, ageing, overloaded and underseen.

She does not want sympathy. She wants dignity, relevance and relief.

Let's change the prompt. Let's see her first.

Conflict of Interest

None

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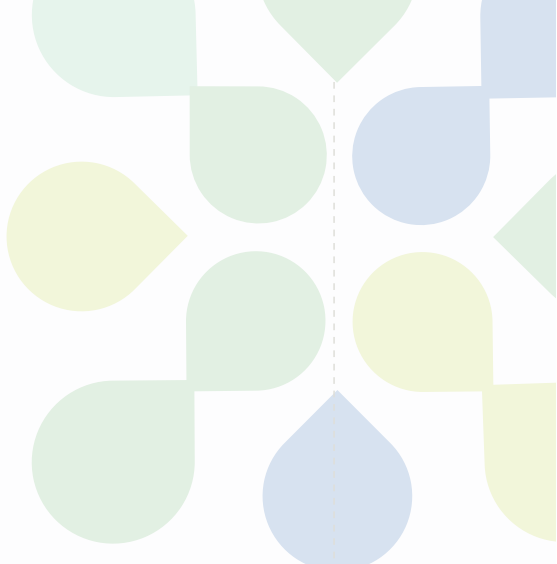


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Chronic Migraine and Health System Readiness

Chronic migraine is a disabling, prevalent neurological disorder that remains underdiagnosed and undertreated. It significantly affects quality of life, productivity and health system costs, particularly among women. Many patients lack awareness, self-medicate or do not receive proper care. Despite advancements such as CGRP inhibitors and botulinum toxin, access and adherence remain low. Greater awareness, accurate diagnosis and coordinated care are essential to reduce its burden.

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key points

- Chronic migraine is highly disabling and often underdiagnosed and undertreated worldwide.
- It disproportionately affects women and is linked to anxiety, depression and poor quality of life.
- Many patients rely on self-medication due to low awareness and limited access to specialist care.
- Diagnostic processes are often delayed despite clinical guidelines requiring no special tests.
- New treatments exist, but uptake and long-term effectiveness remain limited in many settings.

Despite being one of the most disabling and prevalent neurological disorders worldwide, chronic migraine remains underdiagnosed, undertreated and often overlooked in broader health policy discussions. With populations ageing and the chronic illness burden growing, health systems face increasing pressure to address migraine within long-term disease management frameworks. Understanding its prevalence, socioeconomic impact and barriers to effective care is essential for optimising service delivery and improving treatment.

Migraine: Definition, Epidemiology and Actuality

Primary headaches are the most widespread neurological disorders. The most serious maladaptation, and consequently economic losses, are caused by chronic headaches, in which the frequency of headache days varies from 15 per month to daily pain episodes for more than 3 months. The most common form among chronic daily headaches is chronic migraine. Migraine is a highly disabling

primary headache disorder with a 1-year prevalence of ~15% in the general population. According to the Global Burden of Disease Study, migraine is the second most prevalent neurological disorder worldwide and is responsible for more disability than all other neurological disorders combined.

The Global Burden of Diseases study reports that headaches are the leading neurological issue in the working-age population (15–49 years), with migraine occupying a leading position among women in this group. At the same time, recent epidemiological data show a steady increase in migraine cases, particularly among young people and school-age children.

It is known that the level of medical treatment among migraine patients is extremely high. However, most of them never receive a professional diagnosis and are engaged in self-diagnosis and self-medication. According to the French Nationwide Population-Based Survey (FRAMIG 3), only 60% of people with migraines had ever sought medical advice, 34% were under active specialist supervision, and only 8% received treatment prescribed by a doctor. About 60%



of migraine patients were unaware of the existence of this disease, and the average time between the onset of the disease and the first consultation was 3.7 ± 5.8 years. 78.6% of respondents had to take medications with every migraine attack, of which only 38.6% used drugs recommended by doctors, and 51.1% used drugs not recommended for the treatment of migraines. In general, more than 50% of patients experiencing migraine attacks never see a doctor, and only 20% are diagnosed with migraine. Awareness of patients about the disease and current strategies of behavioural and pharmacological treatment is still unsatisfactory, and overall literacy remains low.

a serious economic burden for patients and the healthcare system as a whole. In addition to affecting individual quality of life, chronic migraine contributes significantly to lost productivity, increased healthcare utilisation and disability-adjusted life years, posing a growing challenge for health system sustainability.

Migraine disproportionately affects women, with population studies showing it is two to three times more common in females than in males. Puberty marks the increase in migraine prevalence in women. Hormonal influence, genetic predisposition and environmental stressors are considered contributing factors. As migraine is less common in men, it is often under-

“Migraine is the second most prevalent neurological disorder worldwide and is responsible for more disability than all other neurological disorders combined.”

In both America and Europe, health information is one of the most sought-after topics on the Internet, and many patients use the Internet before seeking a professional diagnosis. C.F. Mullins analysed Twitter activity using pain-related keywords. During a 14-day period, 941 tweets from 715 authors were identified. The most common keywords were “headache,” “migraine” and “back pain.”

Clinical Manifestations and Health System Burden

Migraine manifests as recurrent attacks of headache with a range of accompanying symptoms. In approximately one-third of individuals, headache is preceded or accompanied by transient neurological disturbances referred to as migraine aura. A minority develop chronic migraine, in which attacks become highly frequent. The pathogenesis of migraine is believed to involve peripheral and central activation of the trigeminovascular system, with cortical spreading depression underlying migraine aura. However, much remains unknown about the specific pathogenic processes and few mechanism-based treatment options currently exist.

Chronic migraine is widespread globally, including in Russia, and is associated with a significant decrease in quality of life and daily functioning. It presents

recognised; as a result, male patients are less likely to consult health services or receive appropriate care.

This neurological disease is frequently comorbid with emotional disorders, especially depression and anxiety, as well as oromandibular disorder and fibromyalgia. Without timely diagnosis and treatment, these conditions raise the risk of chronic migraine, increase patient disability, lower quality of life and burden health systems further. Depression is diagnosed in 8.6–47.9% of chronic migraine patients, and anxiety disorders occur in 30.2%. The high comorbidity suggests a shared aetiology and pathogenesis.

Diagnosis

According to international guidelines, migraine diagnosis is entirely clinical, that is, it is based on medical history and objective examination of the patient. Laboratory and instrumental studies, including neuroimaging studies, are not included into the standards for the diagnosis of migraine, since most patients with a typical clinical picture do not reveal any specific changes that could indicate the cause or mechanism of the onset of headache.

A study showed that neurologists are the primary specialists patients consult (56% on first visit). The number of involved specialists increases with each

visit. The therapist ranks third, and ophthalmologists second, in frequency of first consultations. Diagnosis of migraine was established at the first visit in 71.3% of cases, which is a very positive indicator. In rare cases (0.1%), patients required up to eight visits. The majority (64%) reported positive experiences with neurologists. Negative feedback were often associated with the perception that “no one can help.” Among the examinations conducted by patients,

In 2010, botulinum toxin type A was approved for chronic migraine following an extensive PREEMPT (Phase III Research Evaluating Migraine Prophylaxis Therapy) clinical research programme. Injections significantly reduced headache frequency — by 30% after the first injection in 71% of patients, and in 80% after the second. Regular injections every 12 weeks are advised during the first year, followed by extended intervals based on effect.

“In general, more than 50% of patients experiencing migraine attacks never see a doctor, and only 20% are diagnosed with migraine.”

general and biochemical blood tests and MRI were the most common procedures. In 63% of cases, diagnostic procedures were independently initiated by doctors. Many patients feel stigmatised, believing their condition is not taken seriously by doctors or family members.

Treatment Gaps

Treatments for migraine include acute and preventive medications and a range of non-pharmacological therapies. Despite these treatment options and the comprehensive diagnostic criteria, clinical care remains suboptimal — misdiagnosis and under-treatment of migraine are substantial public health challenges.

Population-based European data indicate that only 2–14% of eligible individuals use preventive medication, an alarming finding that calls for global action. A comprehensive approach is needed to facilitate accurate diagnosis and evidence-based management.

Many types of treatment are available for those living with migraines. Acute migraine medication, including triptans, paracetamol and nonsteroidal anti-inflammatory drugs (NSAIDs), have been shown to reduce the symptoms and disease burden of migraines, though they could not prevent the occurrence of the condition. Antiepileptics, antidepressants and betablockers are used to reduce the frequency and severity of migraines, but some patients experience side effects and limited effectiveness. Many patients report not being not satisfied with these older conventional treatments, and adherence can be poor.

More recently, four calcitonin gene-related peptide monoclonal antibody (CGRP mAb) treatments have been approved for the prevention of chronic and episodic migraine. These treatments inhibit the vascular CGRP receptors that are suspected to be the cause of migraine pain. However, even with these treatments many patients continue to need acute medications and some people have reported a waning of treatment effect. Most recently, a new oral CGRP receptor antagonist rimegepant has also been approved by the U.S. Food and Drug Administration for both acute and preventive treatment.

Conclusion

Migraine is a highly disabling, costly, underdiagnosed and undertreated disorder which has been shown to have a similarly high prevalence in all countries studied. In most countries, it is consistently ranked among the 10 diseases by burden. Despite these facts, public and political awareness of migraine remains limited compared to many other conditions with lower burdens.

Successful diagnostic and treatment of migraine reduces disease burden and improves quality of life. Many pharmacologic and nonpharmacologic treatment options are available for the prevention of migraine, but increased awareness and system-level change is needed to optimise care delivery and reduce disease burden.

Conflict of Interest

None

Biokinetics as a Clinical Tool within Chronic Disease Management

Biokinetics is a patient-centred, evidence-based exercise therapy that enhances chronic disease management by improving function, reducing hospital readmissions and supporting long-term recovery. Despite being underutilised, it effectively complements pharmaceutical treatment and addresses the physical causes and symptoms of non-communicable diseases. Its integration into multidisciplinary care offers a holistic and cost-effective approach to global health challenges.

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key points

- Biokinetics uses exercise therapy to manage and prevent chronic non-communicable diseases.
- It improves physical function, reduces symptoms and enhances quality of life for patients.
- Biokinetics supports cost-effective care by reducing hospital readmissions and promoting recovery.
- Despite its benefits, biokinetics remains underprescribed in chronic disease treatment.
- Integration with multidisciplinary teams ensures holistic and patient-centred care.

Introduction

Chronic non-communicable diseases (NCDs) like cardiovascular disease, diabetes, respiratory disease and musculoskeletal disorders are the main cause of disability and death worldwide. They need more than medication: they require sequential, continuous care interventions that optimise function and delay deterioration.

Biokinetics, a clinical South African-born profession, is an expert, evidence-based exercise intervention in prevention and rehabilitation. Biokineticists occupy a vital position at the intersection of physical medicine and long-term lifestyle management, particularly in chronically ill patients. Their contributions span clinical, economic and structural dimensions within modern health systems.

Epidemiology of Chronic Diseases and the Role of Biokineticists in their Management

NCDs are still the largest contributors to the world's mortality, disability and healthcare burden. NCDs cause more than 74% of deaths in the world, the lion's share being contributed by cardiovascular diseases (CVDs),

cancer, chronic respiratory diseases and diabetes, according to the World Health Organisation (WHO). Table 1. demonstrates the figures accordingly.

The burden of disease varies across different settings. In urban populations, NCDs are more prevalent due to lifestyle factors such as sedentary employment, poor diet and chronic stress. In contrast, rural and peri-urban populations face increased unmet healthcare needs, primarily due to limited access to diagnostics, rehabilitation and follow-up treatment.

Biokinetics in Practice & Utilisation Gaps

Biokinetics is a clinical science that addresses the functional and systemic consequences of chronic disease by applying goal-oriented, evidence-based physical rehabilitation. Its contribution most closely relates to four main global health objectives. In the first place, it prevents premature death due to NCDs through increased cardiorespiratory fitness, glycaemic control and mobility. Second, biokinetics is indispensable in maximising health-related quality of life by reducing chronic pain, fatigue

Disease Category	Global Prevalence, cases	Annual Deaths	Notable Trends
Cardiovascular Diseases	>520 million	17.9 million	Rising in low- to middle-income countries
Diabetes (all types)	537 million	1.5 million (direct)	Expected to rise to 783 million by 2045
Chronic Respiratory Diseases	300 million (asthma, chronic obstructive pulmonary disease)	3.2 million	Often underdiagnosed in rural areas
Cancer	19.3 million new cases on average (2020)	10 million	Survival rates are increasing with better access to rehabilitation
Mental & Behavioural Disorders	970 million	Variable mortality	Depression is the leading cause of disability
Musculoskeletal Conditions	1.71 billion	Low direct mortality	High functional disability, absenteeism
Standards compliance	Alignment with FHIR, GDPR and interoperability protocols	Alignment with FHIR, GDPR and interoperability protocols	Alignment with FHIR, GDPR and interoperability protocols

Table 1. Global Prevalence and Notable Trends by Chronic Disease Category

and disability. Third, it minimises hospitalisation and readmission by maximising physical function and frequency and severity of disease exacerbation. Lastly, biokinetics adds to economic productivity by promoting functional independence and re-employment into the workforce.

Despite its clear benefits, biokinetics remains significantly underprescribed. Fewer than 15% of South African patients who qualify are referred to biokinetics following cardiac

- for **cardiovascular diseases** (CVDs), risk factors include high blood pressure, smoking, overweight, dyslipidaemia and physical inactivity;
- **type 2 diabetes** is strongly linked with physical inactivity, central obesity and poor dietary quality;
- **osteoarthritis** is often stimulated by joint loading patterns, age and previous injury.

“NCDs need more than medication: they require sequential, continuous care interventions that optimise function and delay deterioration.”

events. In managing NCDs, pharmacotherapy is typically the sole intervention, even though clinical guidelines recommend structured movement as part of treatment. Similarly, physical activity is rarely prescribed for mental health patients, despite evidence showing that exercise can produce effects comparable to antidepressants in certain mild to moderate conditions.

Aetiology of Chronic Disease and Implications for Biokinetics

The aetiology of most chronic diseases involves a multifaceted interaction between genetic predisposition, environment, lifestyle and socio-economic status. For instance:

Biokineticists operate at the level of disease causation, addressing the underlying physical factors that contribute to chronic conditions. Through guided movement prescription, they manage sedentary behaviour, impaired neuromuscular control, strength imbalances and maladaptive movement patterns—factors that form the basis of chronic disease onset and progression.

Pathophysiology and Functional Decline in Chronic Diseases

Most chronic diseases involve progressive dysfunction at the tissue, organ or system level, significantly affecting daily life. These include:



- **Cardiovascular diseases:** Progressive endothelial dysfunction and vascular stiffening impair cardiac efficiency;
- **Respiratory diseases:** Inflammation and obstruction of the airways limit oxygen supply;
- **Musculoskeletal disorders:** Degenerative and inflammatory processes compromise tissue elasticity and joint mobility.

Pharmaceuticals & Biokinetics Synergy in Chronic Disease Management

Chronic disease management typically relies on a combination of pharmaceutical treatment, lifestyle interventions and rehabilitation. While medication is essential for controlling symptoms, slowing disease progression and preventing complications, biokinetics serves as a valuable adjunct therapy that can significantly

“Biokinetics helps the doctor by directly managing these symptoms, restoring function and gaining measurable improvements consistent with therapeutic objectives.”

This is quantified as measurable deficits in functional capacity, cardiovascular reserve, muscular strength and balance, as well as neurocognitive function. Biokineticists prescribe exercise as medicine to reverse or slow this process via structured loading, neural retraining and cardiovascular conditioning.

Clinical Signs and Symptoms During Chronic Illness

Chronic illness is not only identified through tests and scans but also through declines in mobility, function, energy and independence—areas in which biokineticists play a therapeutic role. Some of these clinical manifestations are listed below:

- **Cardiovascular system:** fatigue, dyspnoea, exercise intolerance;
- **Metabolic system:** poor glucose control, weight gain, fatigue;
- **Respiratory system:** breathlessness, reduced lung capacity;
- **Musculoskeletal system:** joint pain, stiffness, reduced range of motion;
- **Neurological system:** gait instability, coordination deficits and cognitive decline;
- **Psychological system:** depression, anxiety and lack of motivation.

Biokinetics helps the doctor by directly managing these symptoms, restoring function and gaining measurable improvements consistent with therapeutic objectives.

improve treatment outcomes. The following paragraph outline major chronic diseases, the pharmaceutical classes commonly used in their management and the complementary role of biokinetics in enhancing clinical outcomes.

Cardiovascular Conditions

In cardiovascular diseases such as hypertension, coronary artery disease, heart failure, peripheral arterial disease and stroke, medications like ACE inhibitors, beta-blockers, diuretics, statins and antiplatelets help manage key physiological parameters. These treatments work to lower blood pressure, control angina, reduce clot formation and enhance cardiac output. Biokinetics complements these effects by improving vascular tone, reducing resting blood pressure, enhancing overall functional capacity and supporting natural antihypertensive responses.

In cases of heart failure, biokinetics contributes to preserving cardiac reserve, increasing peak VO_2 and alleviating dyspnoea. For stroke recovery, it aids neuroplasticity, restores mobility and improves coordination. Without biokinetics, patients may face greater reliance on medication, diminished long-term control, higher hospitalisation rates and increased risks of complications such as recurrent stroke, muscle atrophy and reduced quality of life.

Metabolic and Endocrine Disorders

Conditions like type 2 diabetes mellitus, metabolic syndrome, dyslipidaemias, obesity and polycystic ovary syndrome rely on medications such as metformin, insulin, statins and hormonal therapies to regulate blood glucose, insulin sensitivity and lipid levels. Biokinetics enhances these outcomes by improving glucose uptake, lowering HbA1c

levels, supporting sustainable weight reduction and promoting favourable lipid profiles, including increased HDL cholesterol.

Its inclusion in care plans is vital for addressing all components of metabolic syndrome in parallel and improving endothelial function. Without biokinetics, patients may struggle with poor glycaemic control, rising insulin resistance, heavier medication reliance, worsening syndrome markers and sustained cardiometabolic risk.

Respiratory Diseases

Chronic respiratory conditions, including COPD, asthma, interstitial lung disease, cystic fibrosis and post-COVID-19 syndrome, are primarily managed with bronchodilators, corticosteroids and symptom-specific treatments. These medications work to reduce inflammation, dilate the airways and control fatigue and breathlessness.

While these treatments combat disease progression, they can also lead to fatigue, muscle loss and weakened immunity.

Biokinetics alleviates these effects by preserving muscular strength, improving everyday functioning, supporting immune system recovery and helping with postural and mobility adaptations. In its absence, cancer survivors may experience prolonged fatigue, impaired resilience, reduced mobility and, for children, delays in physical development and reintegration.

Paediatric and Developmental Disorders

Paediatric conditions such as cerebral palsy, childhood obesity, autism spectrum disorder, ADHD and juvenile idiopathic arthritis are often addressed through medication targeting symptoms like spasticity, anxiety or inflammation. Biokinetics plays a central role in improving

“Biokinetics has become an essential part of chronic disease management worldwide.”

Biokinetics reinforces treatment goals by increasing exercise tolerance, improving oxygen use, restoring functional capacity and aiding respiratory recovery. Without it, patients may face worsening dyspnoea, progressive physical deconditioning, more frequent symptoms and greater reliance on relief medications.

Neurological and Neurodegenerative Conditions

In conditions such as Parkinson's disease, multiple sclerosis, peripheral neuropathies, traumatic brain injury, epilepsy and Alzheimer's disease, pharmaceutical approaches help manage motor dysfunction, reduce inflammation or prevent seizures. Biokinetics, however, plays an indispensable role in restoring motor function, improving gait and strength, enhancing coordination and supporting neuroplasticity.

Without biokinetics, recovery may be delayed and patients may face accelerated functional decline, increased fall risk and long-term disability. For vestibular disorders, biokinetics contributes by improving balance and reflex compensation; its absence often results in chronic imbalance, movement avoidance and social isolation.

Cancer and Oncology Rehabilitation

Patients with cancers such as breast, colorectal, lung, prostate, haematologic and gynaecologic types, as well as paediatric cancer survivors, typically undergo chemotherapy, immunotherapy and hormone therapy.

mobility, refining motor skills, supporting behavioural regulation and encouraging physical engagement.

Without biokinetics, children are more likely to experience persistent hyperactivity, diminished coordination, progressive joint deformities and developmental delays. In conditions like congenital heart disease and muscular dystrophies, it helps ensure safe activity, delay muscular decline and reduce the risk of long-term dependence and psychosocial distress.

Referral Pathways Chronic Disease Management

Biokinetics is integrated into the healthcare system through both referral-based and direct-access models. The direction of care, level of coordination, point of entry and expected outcomes are all shaped by how patients enter the system and the role of the referring physician in the broader management of chronic disease.

1. Referral-Based Biokinetics Treatment

When a patient is referred by an allied health professional or specialist, their condition is usually already clinically established, often supported by diagnostic imaging, laboratory results or a documented history of chronic medication use. In these cases, the biokineticist adheres to the referrer's diagnosis and clinical insights and embarks on condition-specific exercise programming. This interprofessional care model ensures alignment of goals, shared accountability and continuity of care. All

interventions are thoroughly documented, with ongoing communication maintained between the biokineticist and the referring practitioner.

Biokineticists play a critical role in managing chronic conditions and optimising function following diagnosis, working under the referral of a health or medical practitioner, as outlined in the scope of practice by the Health Professions Council of South Africa. Table 2 illustrates how interdisciplinary and multidisciplinary collaborations are implemented in clinical practice.

2. Direct Access / Self-Referred Biokinetics Treatment

Biokineticists also work with unreferred patients, particularly at the prevention, wellness or early symptomatic stages, as illustrated in Table 3. These individuals may present with non-specific symptoms such as weight gain, fatigue or mild postural pain, or they may be proactively managing chronic disease risk factors through lifestyle interventions.

In such cases, biokineticists perform risk stratification and a functional baseline assessment. If any clinical red flags or signs of undiagnosed pathology are identified, the patient is referred to a medical doctor prior to initiating the planned intervention.

Regardless of the referral pathway, biokinetics practice is grounded in long-term disease rehabilitation principles. These include:

- individualised exercise prescription guided by scientific standards,
- application of progressive overload and adaptation tailored to medical stability,
- consistent interdisciplinary communication, collaboration and documentation,
- outcome measurement across domains such as pain, strength, balance, quality of life and functional capacity in daily activities.

Referring Practitioner	Common Focus Area	Biokinetics Role
General Practitioner (GP)	• Lifestyle disease (hypertension, obesity)	• Long-term behaviour modification and supervised exercise
Cardiologist	• Heart failure • Post-myocardial infarction rehabilitation	• Maximum oxygen consumption restoration • Aerobic capacity • Gradual return to activity
Endocrinologist	• Type 2 diabetes, • Polycystic ovary syndrome • Metabolic syndrome	• Glucose control • Insulin sensitivity • Weight and strength management
Pulmonologist	• Chronic obstructive pulmonary disease • Asthma • Interstitial lung disease	• Dyspnoea control • Breathing mechanics • Pacing
Orthopaedic Surgeon	• Osteoarthritis, joint replacements	• Gait re-education, muscle balance • Post-operative rehabilitation
Neurologist	• Stroke, Parkinson's • Multiple sclerosis	• Neuroplasticity, balance • Fine motor control
Psychologist	• Depression • Post-traumatic stress disorder • Attention deficit hyperactivity disorder	• Mood elevation, stress regulation through physical activity
Physiotherapist	• Early-stage recovery • Acute rehabilitation	• Chronic-phase continuation • Long-term maintenance planning
Dietitian	• Obesity • Metabolic syndrome	• Exercise integration into nutritional programming
Occupational Therapist	• Functional independence in daily living tasks	• Complementing upper and lower limb strength and endurance
Speech Therapist	• Post-stroke or neuro rehabilitation coordination	• Neuromuscular co-contraction • Posture and support training

Table 2. The Role of Biokinetics in Clinical Practice by Disease Category

Entry Point	Typical Patient Profile	Biokinetics Actions
Self-referred adult	• Sedentary lifestyle • Weight concerns • Hypertension	• Screen for red flags • Functional assessment • Exercise initiation
Employee wellness	• Chronic stress • Back pain • Diabetes risk	• Ergonomics, fatigue management • Cardio-metabolic programming
Paediatric screening	• Attention deficit hyperactivity disorder • Dyspraxia • Obesity	• Motor development • Play-based activity plans
Geriatric wellness	• Fall risk • Osteoporosis • Mild sarcopenia	• Balance • Proprioception • Muscle preservation

Table 3. Patient Categories and Types of Biokineticists Interventions

Interdisciplinary Collaboration in Chronic Disease Management

Biokinetics is most effective when integrated into multidisciplinary and interdisciplinary care teams, working in synergy with other healthcare professionals to maximise patient outcomes. Key contributors to chronic disease management include:

- **Physicians (General Practitioners and specialists):** responsible for diagnosis, prescribing treatments and providing ongoing medical monitoring;
- **Nurses:** play a vital role in patient education, medication administration and symptom monitoring;
- **Dietitians:** develop personalised nutritional plans that support disease management, often integrating dietary changes with physical activity;
- **Physiotherapists:** focus on manual therapy, movement correction and acute rehabilitation, while biokineticists extend this work by enhancing functional capacity through structured exercise;
- **Psychologists:** address mental and behavioural health concerns and often work alongside biokineticists, using exercise as a tool to support psychological well-being.

Interprofessional care in chronic disease management ensures that everything that regards the patient's well-being is taken into consideration, from lifestyle change to pharmaceutical optimisation, leading to a better and longer-lasting process of healing.

Conclusion

Biokinetics has become an essential part of chronic disease management worldwide. It stands as a patient-centred, evidence-based treatment that optimises functional capacity, decreases readmission and enhances quality of life for chronically ill persons.

Since the chronic disease burden will continue increasing across the world, multidisciplinary treatment involving biokinetics offers an effective means of improving clinical outcomes and reducing the long-term economic impact of NCDs. Integrating exercise therapy into medical care enables health systems to adopt more holistic and inclusive approaches that address the diverse needs of patients.

Biokineticists, working alongside other healthcare professionals, help maximising patient rehabilitation and restoring functional autonomy, ultimately contributing to healthier and more resilient populations worldwide. Biokinetics' role as an indispensable adjunct to chronic disease care has just begun to be acknowledged broadly. With continued research, professional training and integration into health systems, biokinetics is set to remain a vital contributor to improved patient outcomes and enhanced quality of life around the world.

Conflict of Interest

None.

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Medication Adherence Prediction: Potential Implications for Medicines Wastage

A machine learning model predicting patient adherence to medication shows potential to enhance Clinical Homecare services in the UK. Tailored, early support improves adherence and reduces medicines wastage, with even modest gains delivering significant cost savings. Scaling these interventions nationally could save millions annually and ease NHS pressures while supporting more patients with chronic conditions at home.

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key points

- Enhanced Clinical Homecare improves medication adherence compared to standard support.
- Early intervention further increases adherence among patients with chronic conditions.
- A machine learning model accurately predicts future non-adherence risk.
- Adherence prediction enables more targeted and timely support for patients.
- Small adherence gains can lead to large national savings on medicines wastage.

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Introduction

The cost of medicines wastage in the UK is substantial, affecting both healthcare providers and the pharmaceutical industry. An estimated €116–€930 million worth of dispensed NHS medicines are discarded annually, equivalent to about €1.2 in every €29 spent on primary care and community pharmaceutical products (Webb 2014). This issue is amplified by a 61.7% increase in prescription items dispensed in England between 2006 and 2024, reaching 1,112.9 million items in 2023/2024 (NHSBSA 2024).

Broadly speaking, medicines wastage arises from various factors. Patient-related (intrinsic) causes include both intentional and unintentional non-adherence (Hazell and Robson 2015), while system-related (extrinsic) factors include inadequate pharmacy reviews and oversized prescription packs (Alhomoud 2020; Hazell and Robson 2015).

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devices—can allow for the efficient and proactive implementation of interventions to support adherence in patients with chronic diseases (González-Villanueva et al. 2013; Zheng et al. 2014).

Methodology

This study has the following objectives:

- to provide evidence that medication adherence improved when Clinical Homecare services are enhanced (ie tailored) and deployed early in a patient's treatment journey;
- to outline a theoretical basis for further improvements in adherence if Clinical Homecare services are underpinned by medication adherence prediction;
- to build on existing research and estimate the additional reduction in medicines wastage that result from using adherence prediction to guide early deployment, service tailoring and expanded Clinical Homecare capacity.

Evidence of Improved Adherence with Proactive and Tailored Clinical Homecare Analytical Approach

The study dataset consisted of anonymised registration data from patients receiving support from a UK-based Clinical Homecare provider (HealthNet Homecare). The processed data included a range of anonymised parameters such as primary diagnosis, therapy area, medication type, service status, socioeconomic and demographic details (eg age and gender), delivery confirmation records and information on the frequency and channels of patient-provider communication. Medication supply was calculated daily for each patient. The dataset covers the period from December 2023 to May 2025 and includes data from 185,387 patients.

The processed data is used to calculate each patient's Proportion of Days Covered (PDC)—the percentage of days a patient has access to their medication relative to the prescribed schedule—on a daily basis. Periods of inactivity are excluded from the analysis, and PDC values are then binarised as either "Adherent" or "Nonadherent." A patient is considered adherent (PDC80) if, during the past 18 months of active engagement, they had access to medication on 80% or more of days. The calculation also accounts for stockpiling, with additional medication deliveries added to the patient's existing supply.

Interestingly, the method by which patients receive their medication—such as traditional NHS delivery routes versus Clinical Homecare services—can also affect the extent and risk of medicines wastage. Clinical Homecare is believed to reduce wastage by minimising losses from missed appointments or damage during patient transit (NCHA 2024).

With nearly half of the UK population affected by long-standing health conditions (45.7% of men and 50.1% of women) (ONS 2022), Clinical Homecare services are becoming increasingly important. These services support the initiation and ongoing adherence to treatment for patients with chronic illnesses who would otherwise need frequent visits to hospitals or pharmacies. They typically involve the delivery of specialist medicines for self-administration at home, along with appropriate support and training from a Clinical Homecare provider (Zanni et al. 2024; NCHA 2024).

Given the rising prevalence of chronic conditions, it is beneficial for the health system to explore ways of both enhancing the capacity of Clinical Homecare, so that more chronic disease patients can be supported, and increasing the effectiveness of these services in improving medication adherence. Doing this can have a significant downstream effect on medicines wastage.

Experts in machine learning have long argued that predicting non-adherence risk in real time—using tools like motion sensors for rehabilitation, real-time measurement of medication dosing and wearable

The dataset is then further segmented to distinguish between patients receiving:

- Standard Clinical Homecare service: medication dispensing and delivery, with or without self-administration training; or
- Enhanced Clinical Homecare service: the standard service plus tailored, ongoing support to help maintain adherence.

The dataset is then filtered into these sub-datasets, with the proportion of adherent patients being calculated for each service level.

We also examined whether enrolling patients earlier in an Enhanced Clinical Homecare Service improves adherence. To do this, we reviewed patient registration data to determine when individuals were referred to Enhanced Nurse Support, then identified the date of their first interaction—defined as the point at which the patient accepted the service after being informed of the referral.

Results

We observed that a relatively higher proportion of the patients receiving Enhanced Clinical Homecare Support were adherent (PDC >80%) compared to those who are receiving just the Standard Clinical Homecare support: 90.73% vs 89.04% (an increase of 1.69%). This demonstrates the utility of the Enhanced/Tailored Clinical Homecare Support. Furthermore, the patients on the Enhanced service received more deliveries on average, across this 18-month timeframe.

The results also show that early access to Enhanced services—within the first month after referral—leads to a further increase in adherence, reaching 92.25% (a 1.52% improvement). This supports the view that providing timely support early in the treatment journey benefits long-term medication adherence.

Theoretical Basis for Adherence Improvement through Medication Adherence Prediction

A Machine Learning Model Predicting Medication Adherence

The Machine Learning (ML) model used in this study is a Convolutional Neural Network (CNN) designed to identify patients at highest risk of future non-adherence, defined as having access to medication on fewer than 80% of days in a given month. Medication stock levels are calculated using delivery confirmation timestamps alongside prescription duration, assuming patients take their medication as prescribed. The model also accounts for stockpiling—common among chronic disease patients—by adding newly delivered quantities to any existing, unconsumed supply (Al Zoubi et al. 2021; Cameron et al. 2021).

Daily tracking of each patient's medication stock enables the calculation of their Proportion of Days Covered (PDC) on a monthly basis. If a patient's PDC falls below 80% for a given month, they are classified as nonadherent, allowing the data to be binarised into “adherent” and “nonadherent” categories. The PDC80 threshold is widely accepted as a standard for measuring adherence (Galozy and Nowaczyk 2020; Sayed et al. 2023; Kumamaru et al. 2018).

To train the predictive model, each patient's most recent month on service is used as the target variable, with preceding medication supply data serving as input features for both training and inference. The resulting model achieved a high Area Under the Curve (AUC) of 98.6% and an adherence prediction accuracy of 92.8% (Malin et al. 2024).

	Patient Subset	Adherent Population	Average Deliveries per Patient	Total number of Patients
Latest 18 months	Overall	89.19%	9.2	185,387
	Patients receiving Standard Clinical Homecare Support	89.04%	9.0	169,304
	Patients receiving Enhanced Clinical Homecare Support	90.73%	11.5	16,084
	Patients receiving Enhanced Support early (0 – 1 month)	92.25%	9.3	1,690

Table 1. Patient Adherence by Support Type over 18 Months



Using Predicted Insight to Support Early Deployment and Better Tailoring of Clinical Homecare Services

Predicting a patient's risk of nonadherence allows for the proactive implementation of support strategies aimed at preventing declines in adherence. Research shows that the factors influencing adherence are

non-adherence, clinicians can make more informed decisions about who is likely to benefit most from specific types of homecare support.

The UK Clinical Homecare market is reportedly growing by over 20% each year (NCHA 2025), with at least 500,000—and potentially over 600,000—patients already receiving consultant- or nurse-led care in

“Even small increases in adherence—achieved through early, tailored support enabled by predictive tools—can lead to meaningful cost savings.”

highly individualised and can change over time, even within the same patient (Kvarnström et al. 2021; Chauke et al. 2022). Therefore, any intervention designed to address poor adherence must account for the dynamic and patient-specific nature of these risk factors.

We have already established that adherence among chronic disease patients receiving Clinical Homecare support improves when that support is tailored—and improves even further when it is introduced early in the treatment journey. Therefore, any tool that enables earlier deployment and more personalised tailoring of support can further strengthen the impact of Clinical Homecare on medication adherence.

The machine learning model outlined earlier is specifically designed to support this goal. By providing early insight into which patients are most at risk of non-adherence, it allows care providers to both prioritise timely intervention and customise support based on individual risk profiles (HealthNet Homecare 2023).

This viewpoint on the positive impact of proactive action on adherence is consistent with findings from other research studies (Patel 2022; Stuurman-Bieze AG et al 2014) that have examined the benefits for long-term adherence by starting interventions early in the patient's treatment and management journey.

Using Predicted Insight to Improve Clinical Homecare Capacity

Predicted insights from a machine learning model can help optimise decision-making around which Clinical Homecare service an NHS physician should refer a patient to (HealthNet Homecare 2023). With greater clarity on each patient's individual risk of

community settings (NCHA 2024; 2025). Given that an estimated 6.8 million people in the UK may be eligible for Clinical Homecare, and that most patients prefer treatment at home over hospital or outpatient care (NCHA 2024), demand for these services is expected to rise significantly.

Assessing suitable candidates for different levels of Clinical Homecare support can often be a time-consuming process, especially for chronic disease patients who self-administer their medication in the community, where prescribing physicians have limited visibility into long-term adherence patterns. Reducing the administrative burden associated with triaging and referring patients to Clinical Homecare can help providers respond more effectively to the growing demand for tailored or enhanced services.

Forecasted Medicines Wastage Savings through Clinical Homecare Enhanced with Adherence Prediction

Analytical Approach

The baseline impact of Clinical Homecare on medicines wastage is drawn from a 2024 study by the National Clinical Homecare Association (NCHA) (NCHA 2024), which employed the following data sources and methodology:

NHS/Hospital Delivery Data: The average number of medicine deliveries per patient in a hospital setting was estimated using the NHS's 28-day repeat prescribing policy (Regal Chambers Surgery 2024). Under this policy, patients typically receive 13 deliveries annually, reflecting a monthly prescription cycle. This figure was used as a reference point

to compare delivery frequency and related costs between hospital-based and Clinical Homecare models. The estimate is grounded in standard NHS prescribing procedures and medication dispensing guidelines.

Cost of Wasted NHS Medicine: Estimates for the cost of wasted NHS medicines were derived from a 2015 NHS England report focused on reducing pharmaceutical waste (NCHA 2024). These figures were adjusted for inflation from 2010 to 2021 using Bank of England data, applying an average annual inflation rate of 1.25%. This adjustment ensures that the estimates reflect current economic conditions and allows for more accurate analysis and comparison with recent data.

context for understanding the financial scale of NHS medication costs and the potential impact of shifting to or expanding Clinical Homecare services.

Based on the above analysis, the NCHA identified the following:

- **improved medication adherence** in patients receiving Clinical Homecare compared to those not receiving it;
- **the average number** of medicine deliveries per patient within the Clinical Homecare setting;
- **cost savings** from reduced medicines wastage per delivery in Clinical Homecare.

Building on these findings, our study estimated how national-level cost savings could change if the

“The UK Clinical Homecare market is reportedly growing by over 20% each year.”

Prescription Data: The annual number of prescription items dispensed was taken from the NHS Prescription Cost Analysis for England 2022/23, which recorded a total of 1.18 billion items (NHSBSA 2024). This dataset offers a detailed overview of medication volumes across England and serves as a key reference point for assessing medication usage patterns and the potential scale of waste.

Average Cost of Clinical Homecare Medicine per Delivery: According to the 2024 NCHA report (NCHA 2024), the average cost of medicines per delivery in a Clinical Homecare setting is £1,350 (€1,575). This figure is a key metric for evaluating the economic efficiency of Clinical Homecare compared to hospital-based medication delivery.

NHS Total Spend: In the 2021/22 fiscal year, NHS expenditure on prescribing costs in hospitals and the community in England totalled £17.8 billion (€20.77 billion), as reported by the NHS Business Services Authority (NHSBSA 2023). This provides a macro-level

improvements in adherence observed in our study population were replicated across the wider Clinical Homecare sector.

Results

National Results from the NCHA Study

According to the National Clinical Homecare Association (NCHA), the cost savings from reduced medicines wastage in Clinical Homecare are estimated at £2.13 (€2.49) per delivery, as a result of a 7.5% improvement in patient adherence (NCHA 2024).

With an average of 5.4 deliveries per patient annually, this equates to £11.55 (€13.48) in savings per patient each year. When applied to the estimated 600,000 patients currently receiving Clinical Homecare support in the UK, the total annual savings from reduced medicines wastage would be approximately £6.9 million (€8.1 million).

Increase in adherence achieved nationally by Standard Clinical Homecare compared to NO Clinical Homecare	7.5%
Average number of deliveries per patient	5.4
Medicines wastage savings per delivery within Clinical Homecare	£2.13 (€2.49)

Table 2. Medicines Wastage Savings from the NCHA Study

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Applicable Patient population	600,000	600,000	6,800,000	6,800,000
Forecasted increase in adherence that can be achieved nationally by early Enhanced homecare compared to no Clinical Homecare	8.3 %	9.1%	8.3%	9.1%
Average number of deliveries per patient	5.4	5.4	5.4	5.4
Medicines wastage savings per delivery within Clinical Homecare	£2.36 (€2.75)	£2.59 (€3.02)	£2.36 (€2.75)	£2.59 (€3.02)
Forecasted total cost savings from reduced medicines wastage	£7,648,357 (€8,925,883)	£8,385,548 (€9,786,209)	£86,681,376 (€101,160,003)	£95,036,208 (€110,910,365)

Table 3. Forecasted Cost Savings from Reduced Medicines Wastage with Adherence Prediction in Clinical Homecare

Assumptions on the Impact of Optimising National Clinical Homecare through Medication Adherence Prediction

As shown in Table 1, Enhanced Clinical Homecare support led to a 1.69% increase in adherence, with early implementation yielding an additional 1.52%—a combined improvement of 3.21% over standard support.

Assuming a conservative national rollout of a machine learning model that predicts patients at risk of poor adherence, thereby enabling earlier intervention and more tailored support, we estimate that only a fraction of this improvement may be replicated at scale. If the model achieves just a quarter (0.8%) or half (1.6%) of the observed adherence gain nationally, it will still result in substantial additional cost savings due to reduced medicines wastage.

Table 3 outlines four forecast scenarios:

- The first two scenarios assume that medication adherence prediction replicates either a quarter (0.8%) or half (1.6%) of the 3.21% improvement observed through early and tailored Enhanced Clinical Homecare (as shown earlier). When added to the 7.5% adherence improvement previously reported by NCHA, the total projected improvements become 8.3% and 9.1%, respectively. These are applied to the current estimated national total of 600,000 patients receiving Clinical Homecare in the UK.

- The remaining two scenarios apply the same projected improvements (8.3% and 9.1%) to a hypothetical national expansion in which all 6.8 million patients who are eligible for Clinical Homecare receive such support.

Discussions & Conclusions

The results of this study address two issues that have been subject of active debate by a number of healthcare stakeholders: the impact of Clinical Homecare on medication adherence, and efforts to reduce medicines wastage. Providing comprehensive, wraparound support for patients with chronic conditions can meaningfully increase their likelihood of adhering to prescribed treatments.

Organisations such as the UK Steering Group on Improving the Use of Medicines have previously undertaken extensive reviews to explore how patients can be better supported in taking their medication as prescribed—recognising the dual benefit of improved health outcomes and greater value for the NHS (DOH 2012). However, no single approach can fully address the complex and variable nature of medication non-adherence. What works for one patient—or at one point in time—may not work for another (Patel 2021). For this reason, tailored interventions are likely to be more effective, particularly when introduced early, while patients remain more engaged. These interventions must also be adaptable, responding to changes in individual risk over time.

Furthermore, previous studies (NCHA 2024) have shown that Clinical Homecare can reduce the likelihood of prescriptions going unused due to early cancellations, patient non-adherence or damage during transit. Building on this, we argue that optimising Clinical Homecare through the use of adherence prediction could further amplify its impact on reducing medicines wastage.

Importantly, our findings demonstrate that even small increases in adherence—achieved through early, tailored support enabled by predictive tools—can lead to meaningful cost savings. This highlights how sensitive medicines wastage costs are to adherence rates and underscores the potential value of integrating adherence prediction into Clinical Homecare services.

In parallel, the UK NHS has begun adopting predictive analytics to support medication adherence. For instance, NHS Digital's AI Knowledge Repository and OpenSAFELY platform are designed to enable large-scale predictive modelling across millions of records (Nab et al. 2024). Additionally, the INTENSE Trial Project—launched through a collaboration between NHS England, NIHR and academic partners—aims to improve adherence in patients with

Type 2 diabetes using structured pharmacist support, AI-personalised SMS reminders and digital monitoring tools (Al-Jabr et al. 2021). These initiatives, whether used independently or alongside Clinical Homecare, may provide complementary benefits across a wide range of patient populations.

In conclusion, medication adherence prediction using machine learning models—such as the one presented in this study—has the potential to strengthen the benefits of Clinical Homecare in three ways:

- by expanding service capacity to support more patients;
- by enabling earlier interventions for those at risk of non-adherence; and
- by allowing for more personalised and responsive care.

Further research will be needed to assess the long-term impact of such tools on both adherence and medicines wastage at scale.

Conflict of Interest

Ejike Nwokoro, Ben Malin, Daniela Zanni and Joshua Hinton are employees of HealthNet Homecare.

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Elderly Care and Chronic Disease Management in Saudi Arabia: Challenges and Innovations

Saudi Arabia faces a rising elderly population and chronic disease burden, prompting urgent health system reforms. Structural barriers include unequal access, limited geriatric expertise and low digital literacy. Innovations like wearables, AI, telehealth and self-management programmes show promising results. Vision 2030 drives preventive care and digital health adoption, aiming to build an inclusive, sustainable system for ageing populations.

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key points

- Saudi Arabia's ageing population is driving demand for more integrated elderly and chronic care.
- Chronic disease and comorbidities are common among older adults, increasing healthcare costs.
- Rural seniors face limited access due to uneven healthcare distribution and staff shortages.
- Digital tools like wearables, AI and telehealth improve monitoring, safety and access to care.
- Self-management programmes empower older adults to take control of their health outcomes.

The Demographic Shift: Ageing and Its Implications

Saudi Arabia is at a critical juncture in its demographic and healthcare transformation. With the increase in life expectancy and a decline in birth rates, the share of citizens aged 60 and above has exceeded 7% of the population and is projected to rise sharply in the coming years. This demographic transition brings with it a complex set of health and policy implications, particularly in managing age-related illnesses and the growing prevalence of chronic diseases.

Among the most pressing health concerns in this population are non-communicable diseases such as diabetes, hypertension and cardiovascular disorders. Many elderly individuals are affected by multiple chronic conditions at once—a phenomenon known as comorbidity—which not only complicates clinical management but also drives up healthcare costs. Mental health is another growing concern. Older adults are increasingly vulnerable to depression,

anxiety and cognitive decline, often exacerbated by social isolation, limited mobility and restricted access to psychological support services.

The convergence of these factors makes it imperative for the Kingdom to re-evaluate healthcare delivery models, reallocate resources effectively and reform public health strategies to meet the changing needs of its senior population.

Systemic Barriers to Healthy Ageing

Several structural challenges hinder the effective management of elderly care and chronic disease in Saudi Arabia. First among these is the high burden of chronic illness. Research shows that nearly 67% of older Saudis are either overweight or obese, a statistic that reflects poor dietary patterns and limited physical activity. These lifestyle factors increase vulnerability to metabolic disorders and contribute to worsening outcomes in existing chronic conditions.

Secondly, the distribution of healthcare resources is uneven across the country. While urban centres are relatively well served, rural and remote communities often face significant access barriers. Residents in these areas may encounter long travel distances, under-resourced facilities and a scarcity of trained personnel. The shortage of healthcare professionals with specialised training in geriatrics and chronic disease management is a particular concern, leading to inconsistent care quality, longer wait times and overburdened health workers.

Technology-Enabled Support

Wearable health devices are playing a growing role in elderly care. Products such as the SANAD and NEDA Bands offer a suite of features including real-time monitoring of vital signs, fall detection, GPS tracking and medication reminders. These tools allow older adults to maintain independence while ensuring that caregivers and healthcare providers can respond swiftly to emergencies.

Telehealth platforms are bridging longstanding access gaps, especially in rural areas. Through

“Older adults enrolled in the programme report greater control over their health, improved quality of life and a reduction in emergency department visits.”

Socioeconomic and educational disparities further compound these issues. Many older adults, particularly in low-income or rural settings, have limited formal education, which can impede their ability to understand medical information, adopt health-promoting behaviours or navigate healthcare systems. Digital literacy is also low among many seniors, posing an additional challenge as health services become increasingly reliant on technology.

Moreover, the current system of elderly care often lacks integration. Care is frequently fragmented across primary care providers, specialists and community services, with poor communication between sectors. This disjointed approach results in gaps in service delivery and undermines continuity of care. Mental health services, despite their growing necessity, remain inadequately embedded within routine geriatric care. High rates of depression and anxiety in older adults go underdiagnosed and undertreated.

Innovations Shaping the Future of Elderly Care

In response to these challenges, Saudi Arabia is implementing a range of innovative solutions, many of which are aligned with Vision 2030—the Kingdom’s national strategy for economic diversification and social reform. Vision 2030 places strong emphasis on enhancing the quality, accessibility and sustainability of healthcare services, with particular attention to preventive care and digital health transformation.

remote consultations, seniors can access primary and specialist care without the need to travel long distances. Chronic conditions such as diabetes and hypertension can now be monitored remotely with regular updates to physicians, thereby improving disease control and reducing the need for in-person visits. Telemedicine is particularly valuable for patients with limited mobility or those living far from major hospitals.

Smart home technologies are another area of innovation. Voice-activated assistants help older adults set reminders for medications or appointments, while fall detection sensors and automated medication dispensers enhance home safety and adherence to treatment plans. These systems make it easier for seniors to age in place, reducing the reliance on hospital-based care and lowering overall healthcare expenditures.

Harnessing AI for Predictive Care

Artificial intelligence is being used to transform the way chronic diseases are monitored and managed. AI-powered platforms analyse patient data to identify patterns and predict health risks, including the likelihood of falls or heart attacks. These insights enable healthcare providers to intervene early, reducing emergency visits. For instance, automated reminders and monitoring systems have been shown to increase medication adherence rates, which in turn enhances the effectiveness of treatment plans.



Empowering Patients Through Self-Management

Patient-centred care is gaining prominence, particularly through programmes designed to empower individuals to manage their own conditions. The Stanford Chronic Disease Self-Management Program (CDSMP) is a notable example. This evidence-based intervention helps patients build skills in symptom management, nutrition, physical activity, medication adherence and communication with healthcare providers. Participants also benefit from peer support and goal-setting techniques that foster confidence and autonomy.

In Saudi Arabia, adoption of the CDSMP is expanding, with promising early results. Older adults enrolled in the programme report greater control over their health, improved quality of life and a reduction in emergency department visits. The emphasis on behavioural change and self-efficacy is especially beneficial for seniors who may face barriers to traditional healthcare access, such as physical limitations or transportation difficulties.

System-Level Reforms and Workforce Development

Policy measures under Vision 2030 and the National Transformation Program aim to shift the focus of the healthcare system from curative to preventive care. Public health initiatives such as sugar taxes and campaigns to promote physical activity are designed to address the root causes of chronic disease. These efforts are complemented by investments in digital health infrastructure, ensuring that innovations like telehealth and AI can be deployed effectively and equitably.

Workforce development is a parallel priority. Recognising the shortage of geriatric specialists and chronic disease experts, the government is funding training programmes and offering incentives for professionals willing to work in underserved regions. These initiatives seek to build a more resilient and responsive healthcare workforce that is better equipped to meet the needs of an ageing population.

The role of social determinants of health is also receiving increased attention. Authorities are investing in initiatives that address broader contributors to health and well-being, including safe housing, access to healthy food, opportunities for social interaction and community-based support networks. These measures not only improve quality of life but also reduce healthcare utilisation by addressing upstream risk factors.

Impact in Practice: Real-World Examples

In many Saudi households, wearable health devices are becoming part of daily life. Designed to be lightweight, water-resistant and equipped with long battery life, these devices connect to mobile apps that track health metrics and issue alerts when anomalies are detected. This allows caregivers and clinicians to monitor patients in real time, enabling early intervention and preventing avoidable hospitalisations. Such technologies also foster a sense of reassurance and control among users and their families.

The rapid expansion of telehealth services has been particularly impactful. Since the COVID-19 pandemic, virtual care models have become integral to healthcare delivery. Seniors living in remote areas now have access to a full spectrum of services—including consultations with specialists, chronic disease follow-up and even psychological support—without leaving their homes. The SEHA Virtual Hospital, officially recognised by Guinness World Records as the largest in the Middle East, exemplifies how large-scale digital health infrastructure can make high-quality care more inclusive and accessible.

Chronic Disease Management Success

The CDSMP continues to demonstrate strong results in the Saudi context. Participants consistently report improvements in health literacy, physical function and emotional well-being. They also experience fewer complications and hospital admissions, which translates into reduced costs for both patients and the health system. The programme's interactive, community-based design makes it especially well suited to older adults who may be reluctant to engage in traditional healthcare settings.

Bridging the Remaining Gaps

While progress has been substantial, several areas still require focused attention. The integration of healthcare services remains a significant hurdle. A more coordinated approach is needed to ensure seamless transitions between primary, specialty and community care and to avoid duplication or fragmentation of services. Comprehensive case management models may offer a pathway toward more efficient and holistic care delivery.

Mental health services must be more fully embedded into routine geriatric care. Many seniors experience psychological distress, yet few receive appropriate support due to limited service availability or cultural stigma. Expanding access to mental health

professionals, training frontline providers in geriatric psychiatry and increasing public awareness are crucial next steps.

Digital inclusion is another critical issue. Many older adults lack the skills or confidence to engage with new technologies. Tailored training programmes and user-friendly design can help bridge this divide, ensuring that all seniors can benefit from digital innovations. In addition, continued research is needed to assess the long-term effectiveness, cost-efficiency and scalability of technologies such as wearable devices and self-management programmes.

Looking Ahead

Saudi Arabia's ageing population and rising chronic disease burden present a dual challenge

and opportunity. Through strategic investment, technological innovation and a commitment to person-centred care, the Kingdom is laying the groundwork for a healthcare system that is more equitable, responsive and sustainable. Realising this vision will depend on ongoing collaboration between policymakers, clinicians, researchers and communities. With careful implementation and continuous evaluation, Saudi Arabia is well positioned to become a regional leader in elderly care and chronic disease management, delivering healthier, more dignified lives for its senior citizens.

Conflict of Interest

None.

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Rethinking Digital Self-Care: From User Burden to System Leverage

The digital health industry is rapidly developing new self-care apps and tools, but many digital self-care solutions add complexity, increase inequity or fail to scale. Patients need smarter, integrated care rather than just more dashboards. The study redefines digital self-care as a strategic infrastructure challenge rather than merely a tech opportunity. It offers a framework to shift from user burden to systemic leverage, emphasising empathy, governance, value-based healthcare and interoperability.

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key points

- Digital self-care must integrate into real-world care systems to deliver sustainable impact.
- Value, equity and integration are essential pillars of effective digital health solutions.
- Co-design with users ensures tools are trustworthy, usable and culturally appropriate.
- Interoperability using standards like HL7 FHIR is key to scalability and continuity of care.
- Funding models should reward outcomes, not app usage or service volume.

From Tools to Ecosystems

Digital self-care is too often introduced as a single-purpose app—counting steps, measuring sleep or offering mental health prompts. While technically sound, these tools often lack integration with care delivery systems. They don't exchange data with electronic health records (EHRs), don't align with reimbursement and don't scale beyond individual curiosity.

What is the result of the current situation? Digital fatigue, silos of unstructured data and disillusioned users. What we need is not another isolated point solution, but embedded tools that support the entire care pathway—from prevention to recovery and from lifestyle to diagnostics. Ecosystem thinking is not a luxury; it's a necessity.

Strategic Anchors: Value, Equity, Integration

A truly sustainable digital self-care model rests on three strategic anchors:

- **Value:** This refers to outcomes that are important to patients, measured against the cost of providing care, in accordance with value-based healthcare principles. The question we need to ask ourselves is: "Does the tool contribute to better decision-making, reduce unnecessary visits or improve the quality of life?"
- **Equity:** The design of digital tools should be inclusive, ensuring they are accessible to populations with limited digital literacy or access, rather than only serving those who are already connected.
- **Integration:** Digital self-care must function inside real-world workflows—clinical, financial and operational—and connect to shared data standards, such as HL7 FHIR (Fast Healthcare Interoperability Resources).

These pillars are interdependent: without value, there's no justification; without equity, there's no legitimacy; without integration, there's no sustainability.

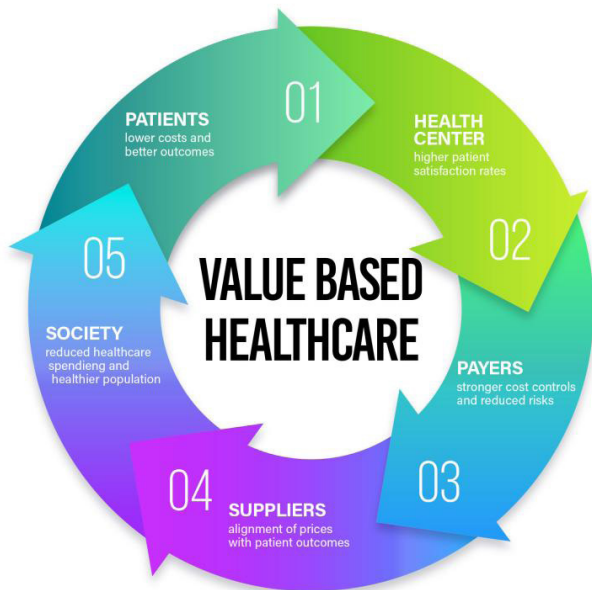


Figure 1. Value-Based Healthcare Stakeholders. Image courtesy of Erasmus MC / Richard Dasselaaar.

From Innovation to Integration: Why Strategy Matters

In boardrooms and ministries alike, there's growing pressure to "go digital." However, without a clear strategy, even the most promising innovation becomes an orphaned tool.

Successful digital self-care solutions are not defined by flashy design or AI hype, but by their ability to embed in national health priorities. Whether it's reducing

studies (Berg et al. 2017) have long warned of the disconnect between technology design and the realities of front-line care.

Instead, co-design must be a foundational principle. This means:

- Involving patients, caregivers and clinicians early in the design process.
- Testing assumptions with ethnographic research and qualitative feedback.
- Adapting content for language clarity, cultural nuance and low-literacy populations.

It is not the tool's technical sophistication that drives its adoption, but rather its trustworthiness, usability and user agency.

Embedding Strategic Insight into Digital Self-Care

As the Chair of the AI in Cardiology working group and a long-time advisor to healthcare boards, investors and ministries, I have witnessed both the promise and pitfalls of digital interventions in healthcare. Digital self-care, in particular, holds immense potential, but only when it is developed and governed as an integral part of the healthcare infrastructure, rather than as an isolated product. From early detection in heart failure to the use of digital triage tools in primary care, success is not solely dependent on innovation; it requires effective integration as well.

"It is not the tool's technical sophistication that drives its adoption, but rather its trustworthiness, usability and user agency."

emergency department visits, enabling remote triage or supporting self-monitoring of chronic conditions, each solution must fit a broader ecosystem. Integration is not an afterthought—it's the foundation.

Investors, too, are shifting focus from user acquisition metrics to real-world health impact. A scalable model requires alignment with procurement policies, clinical guidelines and long-term financing structures.

The User as Stakeholder, Not Receiver

Digital tools often fail because they treat the user as a passive recipient, not an active co-creator. Scandinavian

Key performance indicators (KPIs), developed through collaborative efforts across national health systems, are essential for evaluating the efficacy and equity of digital self-care initiatives. These indicators include metrics such as user satisfaction, dropout rates, adaptation to digital literacy and alignment with care delivery standards. Global networks like ISfTeH emphasise the importance of these metrics to ensure that digital health tools provide measurable value for patients as well as for healthcare systems.

Measuring What Matters: Input and Impact Indicators

Evaluation of digital self-care must consider both **immediate user interaction metrics** (input measures)

Input Measure	Purpose
Frequency of use	Assesses regular engagement and routine adoption
Patient activation	Measures self-efficacy and readiness to manage health
Emotional response	Evaluates user motivation, stress or trust levels
Dropout rates	Identifies friction points or a lack of perceived value
Workflow fit	Checks alignment with the daily practices of healthcare providers
Support quality	Assesses the quality and accessibility of onboarding and help resources.
Infrastructure readiness	Determines if existing systems can support the tool
Perceived value	Captures users' subjective benefit from using the tool

Table 1. Input Measures for the Evaluation of Digital Self-Care Initiatives.

and **broader system-level performance indicators** (strategic KPIs). This dual lens ensures tools are not only used but also useful and aligned with value-based goals.

Input Measures That Matter

These are real-time, experience-level metrics that offer insights into user behaviour, engagement and tool performance within context (see Table 1).

Strategic KPI Framework

Key performance indicators (KPIs) should align with overarching system goals, including safety, equity and measurable value. These KPIs ensure accountability for implementing digital self-care initiatives and guide investment decisions (see Table 2). Strategic KPIs link user-level impacts to long-term transformations within the system.

Interoperability and Infrastructure: Why FHIR Matters

Interoperability is not a technical luxury—it's what makes scale possible. HL7 FHIR is the global standard that enables applications, platforms and providers to exchange health data securely and consistently.

A digital self-care tool lacking FHIR compatibility becomes isolated. In contrast, one that incorporates FHIR can:

- feed real-time dashboards for clinicians;
- participate in public health surveillance;
- ensure continuity of care across providers.

Interoperability remains a fundamental requirement in healthcare. Tools built on open standards such as HL7 FHIR facilitate connectivity with electronic health records and national health infrastructures, promoting scalability, sustainability and safety. Countries that have adopted FHIR as part of their national eHealth architecture, such as Estonia and Singapore, are significantly ahead in developing reliable digital services. They demonstrate improved continuity of care and reduced duplication of services. These insights form the foundation of my advisory work, where interoperability, governance and patient-centred care come together.

Governance, Trust and Value-Based Alignment

The work of Michael Porter and Robert Kaplan on value-based healthcare offers a powerful lens for rethinking how we fund and scale digital self-care. In their seminal Harvard Business Review article "How to Pay for Health Care," they argue that payment models must be directly

Strategic KPI	Definition
Predictive accuracy	Clinical reliability in early detection or decision support
Patient-perceived outcomes	Subjective impact on safety, control, clarity and health journey
Cost reduction	Reduction in unnecessary utilisation, such as ED visits or readmissions
Inclusion metrics	Usage across diverse populations, including underserved or low-literacy groups
Adherence over time	Sustained engagement and avoidance of drop-off
Provider uptake	Degree of clinician trust and integration into care processes.
Standards compliance	Alignment with FHIR, GDPR and interoperability protocols

Table 2. Strategic KPI Accounting for Digital Self-Care Initiatives Implementation

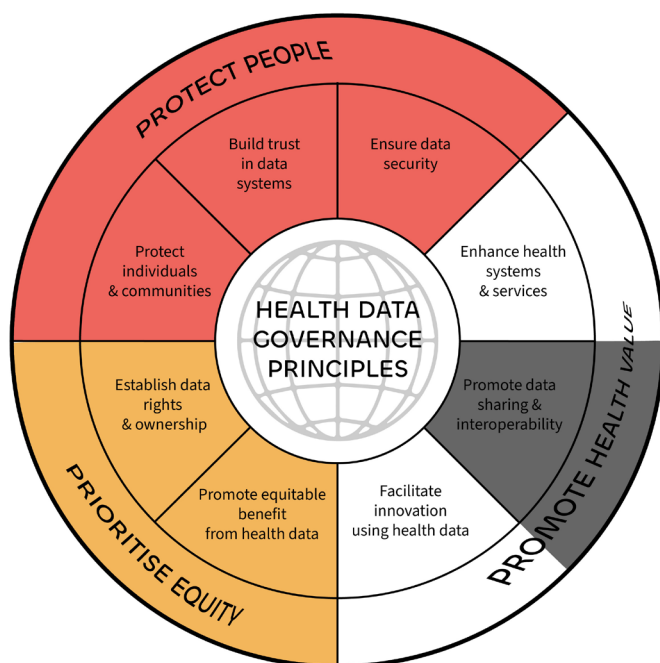


Figure 2. Health Data Governance Principles.

tied to outcomes that matter to patients, not to the volume of services delivered.

“You can’t improve health by paying for services—you improve health by paying for outcomes.” Porter & Kaplan, *Harvard Business Review*

This concept is particularly relevant in the digital self-care domain, where success cannot be measured by downloads or time spent in an app, but by improved well-being, avoided complications and reduced system strain.

Porter and Kaplan propose bundled payments that cover the full cycle of care, rewarding providers for prevention and sustained outcomes. Digital self-care fits naturally into this framework. When a chatbot prevents a clinic visit or a remote-monitoring tool flags early deterioration, that digital intervention deserves recognition and funding. However, this only works when governance, reimbursement and infrastructure align.

Bundled payments reward continuity, prevention and impact—not volume. That’s where digital self-care belongs.

If digital self-care is to become a foundation of future health systems, it must be governed accordingly. Governance is about more than cybersecurity—it’s about establishing legitimacy and accountability. This includes:

- Clear compliance with GDPR, national health laws and the EU AI Act.

- Transparent policies on data ownership and consent.
- Alignment with value-based purchasing: no outcome, no payment.

Trust is not just a user sentiment—it’s a system requirement.

From Pilot to Practice: Strategic Recommendations

Here are some recommendations to move a digital health pilot beyond experimentation:

- **Governance first:** Treat regulation as an enabler, not a constraint.
- **Co-create with users:** Build solutions with those they’re meant to serve.
- **Tie funding to outcomes:** Align budgets with measurable system gains.
- **Design for equity:** Make inclusion and accessibility design imperatives.
- **Use common standards:** Require FHIR for every scalable solution.
- **Embed in national policy:** Elevate digital self-care from pilot to infrastructure.

“
Value-Based Healthcare is about improving the right outcomes for patients.

MICHAEL E. PORTER

“
Value-Based Healthcare delivery requires bundled payments covering the full care cycle.

ROBERT S. KAPLAN

Figure 3. Quotes from Porter & Kaplan highlighting the transition from volume to value in healthcare. Image courtesy of Erasmus MC / Richard Dasselaar.

Ultimately, digital self-care should empower users without burdening them with poorly integrated technology. It should facilitate individuals through ethically designed, system-supported, and value-aligned pathways. My work at the intersection of AI, cardiology, and global health strategy aims to champion this vision.

To close the gap, we must reframe digital self-care not as a wellness product but as an integral part of health system infrastructure. That means focusing on regulation, reimbursement and interoperability. It requires finding a shared language, establishing common goals and using shared data.

“You can’t improve health by paying for services—you improve health by paying for outcomes.”

Conclusion: From Buzzword to Building Block

Digital self-care has the potential to alleviate system pressure, increase access and empower patients. However, potential alone does not equate to impact.

For health leaders, the mandate is clear: transition from applications to architecture, from hype to health equity and from digital noise to systemic change.

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The plasma volume status of a patient is one of the top priorities in evaluating and treating critical illness including CHF, ARDS, AKI, and Sepsis.²⁻⁴

Ionized Magnesium (iMg)

Hypomagnesemia is a frequent finding in critically ill patients.⁵ Magnesium therapy guided by real time ionized magnesium monitoring has been shown to improve outcome in these patients.⁶

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Advances in Imaging



Smart Cardiac MRI Solutions from United Imaging

Cardiac MRI plays a crucial role in diagnosing complex heart conditions with high precision and safety. United Imaging's MRI platforms support detailed, radiation-free imaging, offering fast, consistent results even in challenging cases. Their systems enhance patient comfort and streamline workflows through advanced technology and AI features. Designed for long-term value, they align with institutional goals in quality care, efficiency and strategic growth.

CHRISTIAN
MAROLT



Executive & Editorial Director |
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key points

- Cardiac MRI enables precise, radiation-free diagnosis of complex heart conditions.
- United Imaging systems deliver high-resolution images quickly and consistently.
- AI-supported workflows improve efficiency and reduce scan and reporting times.
- Patient-centred design enhances comfort during demanding cardiac MRI exams.
- Scalable platforms align with strategic goals and support multidisciplinary care.

Magnetic resonance imaging, or MRI, has become one of the most important tools in cardiac diagnostics. Its ability to visualise the heart's structure, tissue composition and function in great detail without exposing patients to ionising radiation offers clinical accuracy and patient safety. With cardiovascular disease remaining a leading cause of death globally, timely, precise imaging is essential to improving outcomes, guiding therapeutic decisions and enhancing long-term care planning.

Cardiac MRI is particularly valuable in evaluating complex heart conditions where conventional methods may offer limited insight. In cases of suspected myocarditis, cardiomyopathies, ischaemic heart disease, congenital defects or complications following surgery, MRI provides information that cannot be captured by echocardiography or computed tomography. In this context, the choice of imaging system has significant implications for diagnostic performance as well as for patient experience, workflow efficiency and institutional strategy.

A Versatile Tool in Cardiovascular Diagnostics

The diagnostic versatility of cardiac MRI lies in its ability to assess multiple dimensions of cardiac health within a single examination. Morphology, wall motion, blood flow, myocardial perfusion, fibrosis and viability can all be evaluated non-invasively. This makes it especially useful in differential diagnosis, treatment selection and post-treatment evaluation.

Late gadolinium enhancement (LGE) imaging has become a cornerstone of tissue characterisation. By identifying scarring or inflammation in the myocardium, LGE enables clinicians to distinguish between viable and non-viable tissue—crucial in managing conditions such as myocardial infarction, sarcoidosis, or inflammatory cardiomyopathy. In addition, cardiac MRI offers reliable quantification of ventricular volumes and ejection fraction, which are key indicators in heart failure management.

Cardiac MRI is also used to evaluate vascular abnormalities, pericardial effusion and cardiac masses. It plays a central role in monitoring the progression



of disease and detecting complications following interventions such as bypass grafting, stent placement, or device implantation. Because the examination can be repeated without risk of radiation exposure, it supports safe and consistent follow-up, particularly in younger or high-risk populations.

Technology That Elevates Precision and Efficiency

The diagnostic value of cardiac MRI is heavily dependent on the capabilities of the scanner itself. Modern systems must not only deliver excellent image quality but also ensure speed, consistency and adaptability to complex clinical requirements. In this regard, United Imaging's MRI platforms are designed to meet the growing demands of cardiac imaging with

lengths (150 cm or 170 cm), and quiet scanning modes increase comfort and reduce anxiety—an important consideration in cardiac MRI, which can be physically and emotionally demanding for some patients. Real-time image display, AI-supported reconstruction and intelligent system management streamline the work of technologists and radiologists for consistent quality and faster reporting.

Aligning Imaging Investment with Strategic Goals

For healthcare leaders, the decision to invest in cardiac MRI systems involves more than technical specifications: it also affects diagnostic capacity, care quality workforce engagement and institutional reputation.

“Cardiac MRI is increasingly seen as a frontline diagnostic tool, offering insights that inform care across the entire continuum.”

systems that combine technical innovation, intelligent workflow, and patient-centred design.

United Imaging offers a broad range of MRI scanners tailored to different clinical and operational needs. The systems use strong magnetic fields and advanced imaging technology to deliver high-resolution images quickly, contributing to accurate diagnostics across a range of clinical situations. Features such as synchronisation with heart rhythm and techniques to reduce the impact of chest movement help ensure consistent imaging, even in patients with arrhythmias or difficulty holding their breath.

At the heart of United Imaging's approach is the uCS platform, which significantly reduces scan and reconstruction times without compromising image quality. Acceleration rates of up to 36 times allow cardiac imaging to be performed more efficiently, improving departmental throughput and reducing patient waiting times. In time-sensitive settings, this speed translates directly into improved care delivery and operational flexibility.

Beyond performance, attention to ergonomics and system design further enhances the overall examination experience. Options such as wide gantry diameters (65 cm, 70 cm or 75 cm), short magnet

Cardiac MRI results are essential to cardiologists, radiologists, electrophysiologists and cardiac surgeons alike. By equipping imaging departments with scalable, future-ready platforms, institutions can strengthen multidisciplinary collaboration and build integrated care pathways around high-quality diagnostic information. The ability to produce standardised, reproducible data improves decision-making and reduces the risk of diagnostic variability.

The flexibility of United Imaging's solutions allows institutions to tailor configurations to their specific context—whether focused on high-volume service delivery, specialised cardiac centres or academic research environments. Features such as field of view homogeneity, real-time adjustments and comprehensive cardiac software packages ensure that the system evolves alongside clinical needs.

The sustainability of imaging operations also depends on durability, ease of maintenance and support services. United Imaging's systems are engineered for long-term reliability, with service and upgrade options that reduce lifecycle costs and protect institutional investment.



Meeting the Demands of Contemporary Cardiology

Cardiac MRI is increasingly seen as a frontline diagnostic tool, offering insights that inform care across the entire continuum—from early detection and risk stratification to intervention planning and chronic disease monitoring. With growing expectations for speed, accuracy and patient-centred care, imaging departments must be equipped with systems that can keep pace.

United Imaging's advanced MRI platforms are designed to meet these needs, combining clinical precision with operational efficiency. For hospitals aiming to lead in quality and outcomes, investing in next-generation cardiac imaging is a clear step forward.

Conflict of Interest

Spotlight articles are the sole opinion of the author(s), and they are part of the HealthManagement.org Corporate Engagement or Educational Community Programme.



Robotic Scanning and Phantom Design: Ultrasound Imaging Advances in Moscow

Moscow researchers have developed advanced medical phantoms to enhance ultrasound and MRI training, including liver, prostate, foetal and spinal models. Backed by the MosMedMaterial materials database, these phantoms improve diagnostic accuracy and procedural skills. International collaborations support AI development and protocol optimisation. The initiative strengthens medical education, clinical research and digital healthcare innovation.

YURI VASILEV



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key points

- Moscow developed realistic phantoms to improve ultrasound and MRI diagnostic training.
- The liver phantom helps distinguish benign from malignant lesions and guide procedures.
- MosMedMaterial offers materials data for building accurate, multimodal imaging phantoms.
- International collaboration supports AI algorithm development using these phantoms.
- The initiative enhances clinical skills, protocol design and scientific self-sufficiency.

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Phantom-Based Training for Ultrasound Imaging

Researchers in Moscow have created a liver phantom encased in soft tissue to assist in training physicians in ultrasound. The phantom includes reconstructed blood vessels and 18 inclusions representing cysts, malignant tumours and adenomas. This setup generates realistic ultrasound images, helping doctors improve their ability to identify liver diseases and perform medical procedures.

Anastasia Rakova, Deputy Mayor of Moscow for Social Development, reported on this advancement, emphasising that training on phantoms is a vital factor in significantly improving the quality of medical care in Moscow. She noted that doctors who practice on test-objects until their skills become automatic demonstrate greater confidence and precision when performing procedures on patients. Russian-developed ultrasound phantoms now provide images

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closely resembling real organs, thereby enhancing the effectiveness of medical training. According to Rakova's report, scientists in Moscow have created 12 phantoms. The latest liver phantom allows practitioners to distinguish between benign and malignant liver lesions and perform ultrasound-guided interventions.

Development of Phantom Models for MRI Applications

Each of the models has unique properties. The prostate phantom improves magnetic resonance imaging (MRI) accessibility, particularly for patients with metal-on-metal hip implant systems. Previously, scanner configuration required patient participation, but the phantom now enables pre-scan setup, reducing errors and streamlining the process. Additionally, developing new scanning protocols for patients with implants was time-consuming, prolonging procedure times and disrupting clinic schedules. The phantom mitigates these issues by allowing advance calibration, enhancing study accuracy.

Another model, the foetal phantom, optimises imaging protocols for foetal MRI. MRI provides high-resolution, high-contrast imaging of the foetus, abdomen and pelvis without ionising radiation, making it a valuable adjunct to ultrasound for detecting various pathologies. However, foetal MRI protocol is challenging. Given its critical role in pregnancy management and planning of intrauterine interventions, optimising imaging protocols is essential. The foetal phantom facilitates this process, enhancing diagnostic precision and clinical decision-making.

To optimise MRI scanning protocols, clinicians often rely on pregnant volunteers. Although safe for both mother and foetus, prolonged scanning in uncomfortable positions is required due to foetal movement and the mother's breath, which degrade image quality and reduce diagnostic value. To address these challenges, a foetal phantom was developed in collaboration with the Kulakov National Medical Research Center for Obstetrics, Gynaecology and Perinatology, enabling protocol refinement without patient burden.

The lumbosacral phantom is an anatomically accurate simulation model designed to enhance ultrasound-guided needle insertion skills for anaesthesiologists, particularly in chronic pain management. Derived from anonymised human CT data, the phantom replicates two vertebrae, the coccyx, iliac bones and surrounding soft tissues using durable materials. Its inclusion of the sacrum enables training for specialised procedures, such as caudal anaesthesia. Additionally, this phantom aids preoperative planning and, when combined with augmented reality (AR), improves visualisation of critical structures (eg blood vessels, nerves and tumours), refining procedural accuracy.





International Collaborations and AI Integration

Phantoms developed by Moscow researchers represent advanced simulation models that have garnered significant international interest. Notably, a breast phantom designed to enhance ultrasound-guided diagnostic and biopsy training for breast

the Center for Diagnostics and Telemedicine of the Moscow Healthcare Department. The Center has established Russia's first database – MosMedMaterial – containing information on 23 solid and 19 liquid materials suitable for phantom creation. This database is regularly updated as new materials and data become available, supporting the advancement of medical training simulators.

“Doctors who practice on test-objects until their skills become automatic demonstrate greater confidence and precision when performing procedures on patients.”

neoplasms has demonstrated its utility in a collaborative study between Russian and Chinese scientists. This research focuses on improving early breast cancer detection.

In April 2025, the Center for Diagnostics and Telemedicine and Beijing University of Technology (BJUT) initiated a strategic partnership to develop AI-based algorithms aimed at optimising ultrasound image quality and diagnostic precision, further validating the clinical relevance of these phantom models.

Zhuhuang Zhou, Ph.D., Associate Professor, Dept. of Biomedical Engineering College of Chemistry and Life Science at Beijing University of Technology, noted the value of this collaboration: “We are pleased to work with the Center for Diagnostics and Telemedicine. We share a common scientific goal—to develop algorithms that enhance ultrasound diagnostics. The experience of our Moscow colleagues, particularly in creating medical phantoms, is of great interest to us. We plan to use these phantoms to test and refine new artificial intelligence algorithms before proceeding to clinical trials. The accuracy and realism of these models are vital to the validity of our research. We are confident that this scientific partnership will enable significant progress in healthcare innovation.”

Yuri Vasilev, Chief Consultant for Radiology of the Moscow Healthcare Department, reported the MosMedMaterial database as a valuable practical resource for clinicians and researchers. It consolidates information on materials appropriate for creating medical phantoms, enabling even small research teams to independently produce realistic organ models for their studies. Vasilev highlighted this as a significant step toward advancing medical education and research.

The developers systematically evaluated each material included in the database for its capacity to mimic specific organs or tissues across various imaging modalities, including computed tomography magnetic resonance imaging and ultrasound. For solid materials, mechanical properties were also thoroughly characterised. To enhance user accessibility, software with a search function based on organ type or material parameters has been developed. Additionally, an interactive atlas is currently under development,

MosMedMaterial: Russia's Phantom Material Database

The development of medical imaging phantoms has been ongoing for seven years at the Laboratory of





systematising data on materials and their biological counterparts, with visual search capabilities using a three-dimensional human model. This atlas will allow users to visually explore a three-dimensional model of the human body, streamlining the identification and selection of suitable materials for biomedical and imaging purposes.

research on blood flow modeling in diagnostic imaging. The technology accurately replicates vascular biomechanical, hydrodynamic and visual characteristics, enabling simulation of diverse vessel states.

Data from the MosMedMaterial database has already facilitated the rapid development of a forearm tissue

“The accuracy and realism of these models are vital to the validity of our research.”

Anton Vladzymirskyy, Dr. Sc. in Medicine, MD, Deputy Director for Research at the Center for Diagnostics and Telemedicine, noted that most phantom developers traditionally rely on experimental researches to select materials, a process that is both time-consuming and resource-intensive. The Center’s systematic evaluation ensures that materials not only match the imaging characteristics of biological tissues but also replicate their mechanical properties, which is critical for effective medical training.

The established database enables a more technological approach to phantom development. Researchers in Moscow are optimising this process by utilising substances that replicate various human tissue types, allowing rapid modelling of organs and systems through combinations of existing materials.

The Center’s approach also revealed that some materials exhibit multimodal properties, suggesting promising potential for developing phantoms suitable for complex, multimodal diagnostic training.

model for scientific research conducted at the Department of Medical and Technical Information Technologies, Bauman Moscow State Technical University. Specifically, a model with predefined dimensions was required to validate the accuracy of a novel ultrasound-based method for assessing muscle function. The use of human volunteers was not feasible, as precise measurements of tissue dimensions in vivo are unattainable, thereby precluding rigorous method validation. In the absence of such control data, the reliability of the verification process would be compromised. The successful use of this phantom was reported in a scientific article published by MDPI (Kapravchuk et al. 2025).

Olga Omelyanskaya, CAO of the Research and Development Department at the Center for Diagnostics and Telemedicine, remarked that the creation of a soft tissue phantom of the forearm exemplified effective collaboration between two leading scientific teams in Moscow. She emphasised that the partnership between the Center for

“Such comprehensive, full-cycle projects form the foundation of scientific and technological independence.”

Multimodal Phantom and Research Integration

The Center has developed the first multimodal arterial vessel phantom. This innovation forms part of a comprehensive pulsation simulation system designed for vascular imaging studies using both computed tomography and ultrasound. This innovation supports the refinement of imaging protocols, serves as a simulation tool for medical education and facilitates

Diagnostics and Telemedicine and Bauman Moscow State Technical University not only highlighted the development of advanced technologies by Moscow-based specialists but also demonstrated their capability to independently design and implement robust testing tools utilising an in-house database of materials for radiology diagnostics. Omelyanskaya further noted that such comprehensive, full-cycle projects form the foundation of scientific and technological independence.



Scientific Leadership and Output

The Center for Diagnostics and Telemedicine is a leading scientific and practical institution within the Moscow Healthcare Department. It oversees the management of radiology departments, drives digital healthcare transformation, implements AI technologies in clinical practice, conducts scientific research and trains medical professionals. Since 2013, the Center's

staff have produced over 800 scientific publications—including articles, methodological guidelines, monographs and training manuals,—registered more than 200 intellectual property results and developed 12 medical phantoms.

Conflict of Interest

None.

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Digitally Driven Care: Integrating AI in Breast Diagnostics Across Europe

Affidea and b-rayZ are partnering to integrate modular AI tools into breast diagnostics across Europe. With a focus on clinical support, workflow efficiency and standardisation, the collaboration adapts to local needs while aligning with Affidea's ESG and innovation goals. Pilots in Switzerland, Spain and Lithuania show how tailored AI solutions can enhance care quality and operational performance.

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key points

- Affidea and b-rayZ are partnering to enhance breast diagnostics with AI solutions.
- The AI platform of b-rayZ supports image quality, lesion detection and BI-RADS classification and identification of women at higher risk of developing breast cancer.
- b-rayZ technology DANAI can adapt to the clinical setting collecting the feedback of the users on the AI classification.
- Thanks to the real-time feedback to the clinical team, AI contributes to a continuous improvement of quality performance.
- The initiative aligns with Affidea's ESG goals, improving quality, efficiency and sustainability.

PROF. CRISTINA
ROSSI



CEO/Co-Founder | b-rayZ AG |
Schlieren, Switzerland

Building Innovation into Clinical Strategy

Affidea, a leading European provider of community-based polyclinics, advanced diagnostics and specialist healthcare services, is expanding its commitment to digital innovation through a partnership with the Swiss health tech company b-rayZ. Together, the two organisations are introducing artificial intelligence solutions into breast diagnostics to support clinical teams, improve workflow efficiency and enhance the quality of patient care.

With a growing network of >410 centres across 15 countries, Affidea delivers 20 million scans and receives 14 million patient visits annually, operating over 1,750 pieces of diagnostic equipment. Its scale and consistent governance standards make it well-positioned to integrate advanced technologies, adapting them to local contexts while maintaining internationally benchmarked quality of care. Each country brings a unique healthcare environment, requiring a tailored approach to ensure that technology delivers on its potential without disrupting the consistency of care.

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Breast imaging plays a central role in Affidea's clinical service strategy. It is embedded within broader oncology and prevention programmes and often delivered in outpatient settings. These services respond to increasing clinical demand and expectations from both patients and referrers for timely, precise and safe diagnostic outcomes. Breast imaging is also an area where the application of digital tools has shown particular promise, not only in detection but in operational support and standardisation. AI tools offer an opportunity to ensure sustainable, high-quality services that are scalable and aligned with evolving standards of care.

Tailored Solutions for Diverse Contexts

b-rayZ, co-founded by Professor Cristina Rossi, has developed a connected suite of solutions specifically designed for breast imaging, ranging from acquisition quality checks to lesion detection and risk-based triage. Their adaptive AI framework, DANAI (Dynamic Adapting Neural AI), is MDR-certified as a medical device and has been built to integrate into diverse radiological environments.

whether part of a national screening programme or a diagnostic outpatient unit. The system can be scaled and reconfigured as local regulations, clinical teams or infrastructure evolve—an important factor in supporting long-term digital transformation.

Initial implementation of AI tools began several years ago. At that time, integration was gradual, and acceptance from clinical teams varied. Training and validation were essential to ensure safe deployment. Over time, however, experience with AI tools led to broader use. Today, Affidea uses ten AI solutions across more than 150 centres in ten countries. The AI tools are now embedded into daily routines, contributing to both clinical accuracy and workflow efficiency. In several locations, these tools have become an expected part of the radiology toolkit, reflecting their integration into broader clinical culture.

In Switzerland, Affidea's breast care centre, Brust Zentrum Zurich, provided an early test case for the integration of b-rayZ tools. This centre operates a comprehensive model, connecting screening, diagnosis, treatment and follow-up in a single location. AI modules were introduced here to support triage

“Breast imaging an area where the application of digital tools has shown particular promise.”

“Our AI is not simply an AI useful for tumour detection, but a digital space which is completely dedicated to breast diagnostics.”

Prof. Cristina Rossi, CEO and Co-founder, b-rayZ AG

b-rayZ offers five core modules:

- b-Quality, which verifies the correct positioning of the breast during image acquisition;
- b-Density, assessing breast density as both a risk and masking factor;
- b-Diagnose, supporting lesion and calcification identification, as well as BI-RADS classification;
- b-Smart, an analytics dashboard providing performance monitoring for imaging units;
- and the DANAI framework, that continuously monitors AI performances and adjusts it to the clinical setting.

This modular approach allows Affidea to tailor the implementation according to the needs of each site,

processes and ensure consistent image quality, particularly valuable in a country without a national breast screening programme. The experience in Brust Zentrum Zurich served as a model for other sites, showing how digital solutions could be aligned with clinical processes.

In contrast, countries such as Lithuania posed different operational challenges and opportunities. Affidea's network there is composed of multiple outpatient polyclinic centres. The b-rayZ platform was adjusted accordingly, offering site-specific configurations and support mechanisms. In both cases, the focus remained on ensuring that digital tools were not disruptive, but complementary. This flexibility is particularly important as Affidea navigates different healthcare systems, reimbursement models and levels of AI readiness across its European footprint.



From Deployment to Continuous Improvement

The partnership is structured around long-term collaboration rather than one-time deployment. Affidea treats its technology partnerships as iterative engagements, where tools are refined based on clinician feedback, operational experience and evolving clinical standards. This responsiveness is built into the way the tools are managed. Updates to the platform are shaped through regular interaction with field professionals. This cycle of feedback and refinement helps ensure that tools remain aligned with the needs of clinical staff and relevant to patients across different health contexts.

b-rayZ's willingness to engage in co-development has helped ensure that its tools meet Affidea's operational goals and patient-centred mission.

from energy efficiency and digitisation to data privacy and workforce development. Clinical innovation is aligned with these values and contribute to their achievement.

Looking Ahead

The partnership between Affidea and b-rayZ is ongoing. Future developments may include deeper integration of AI into multidisciplinary workflows, extended analytics capabilities and broader clinical applications beyond mammography. Both organisations are committed to ensuring that progress is shaped by clinical needs and operational realities rather than technical novelty alone. There is a plan underway regarding how the platform might support breast MRI and ultrasound interpretation, and how dashboard analytics could help regional managers visualise key quality metrics in real time.

“The aim is to offer radiologists better tools to support their decisions, simplify their tasks and improve the experience of care for our patients.”

Contributing to Broader Strategic Goals

The benefits of AI integration are not limited to diagnostic accuracy. By supporting image quality and workflow standardisation, the tools contribute to patient safety and reduce the likelihood of unnecessary recalls. BI-RADS support and risk-based triage also allow for more consistent and equitable care. The operational data captured by the tools helps site managers compare performance across regions and implement quality improvement initiatives. For example, local managers can benchmark triage effectiveness, turnaround times and radiologist workloads against regional targets. This level of oversight supports ongoing operational planning and allows resources to be adjusted more accurately.

These efforts complement Affidea's broader commitment to sustainability, transparency and governance. Since 2023, ESG (Environmental, Social and Governance) objectives have been integrated into management strategy. A dedicated ESG Director and cross-functional task force oversee initiatives ranging

The aim is to offer radiologists better tools to support their decisions, simplify their tasks and improve the experience of care for patients. In this regard, the partnership serves as a model for responsible and effective digital transformation. It shows how technology can be integrated gradually, thoughtfully and with measurable impact. For Affidea, this project is not an isolated initiative but part of a broader effort to offer high-quality medical services with best-in-class patient experience across its network. Through this approach, Affidea is helping set a standard for the adoption of AI in healthcare. It is not just investing in tools, but in systems of care that are safe, responsive and resilient.

Conflict of Interest

Spotlight articles are the sole opinion of the author(s), and they are part of the HealthManagement.org Corporate Engagement or Educational Community Programme.

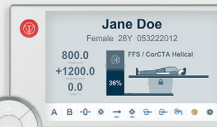
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Digital Transformation

From Fragmentation to Flow: Unlocking the Full Potential of Health Data

Fragmentation continues to limit the full potential of health data across systems. Progress depends on establishing interoperability, aligning regulations and investing in sustainable digital infrastructure. Strategic actions include enforcing open standards, financing ongoing digital operations, developing workforce skills and empowering patients as active data stewards. With quality data and structured access, healthcare can transition from silos to intelligent, connected care.

JENS KÖGLER



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key points

- Health data remains underused due to fragmentation and lack of interoperability.
- Open standards and regulatory support are vital for connected digital health systems.
- AI in healthcare needs quality data, clear governance and inclusive access models.
- Patients must be empowered as active data stewards through better consent tools.
- Sustainable change requires financing, training, smart regulation and coordination.

Introduction

Health systems today generate vast volumes of data; however, much of it remains underutilised. Fragmented IT landscapes, siloed infrastructures and multi-layered regulations continue to obstruct the path to a data-driven healthcare model. With demographic pressures, rising expectations and workforce shortages mounting, the key question is no longer whether to use health data, but how.

The insights in this article are based on a whitepaper authored by Jens Kögler, developed in collaboration with healthcare executives, digital health experts and policy leaders from the German-speaking healthcare ecosystem. A broad-based expert consultation identified the primary enablers of meaningful digital transformation. While technologies are available, the core issues lie in structural and cultural barriers that hinder implementation. Achieving intelligent use of health

data requires more than digitisation; it calls for integrated strategies that span interoperability, governance, financing and patient participation.

Interoperability First: The Cornerstone of Digital Health

The lack of interoperability continues to be one of the most pressing barriers to digital health. Despite the existence of established standards such as HL7 FHIR, SNOMED CT and LOINC, healthcare providers often operate with incompatible systems, disconnected interfaces and historically grown data silos. This fragmentation hinders the seamless exchange of information, creating inefficiencies and missed opportunities across sectors.

The absence of binding implementation requirements allows proprietary systems to persist. Experts emphasise



the need for a regulatory push towards open standards and for procurement policies to prioritise interoperable architectures. Interoperability is not merely a technical concern—it is foundational to coordinated care, efficient workflows and the sustainable integration of innovations such as artificial intelligence.

Strategic models such as federated data spaces, data lakes and Clinical Data Repositories (CDRs) can help enable secure and structured data sharing. These must be backed by clear responsibilities, standardised data formats and support mechanisms for medical and administrative

Patients as Data Stewards, Not Just Subjects

Empowering patients to manage their own health data is another key enabler of transformation. Many individuals remain unaware of how their data is used—or why it matters. Simplified and transparent consent frameworks can strengthen trust while reducing bureaucratic hurdles. Broad Consent, allowing individuals to approve data use for predefined research or care purposes, is widely viewed as a practical compromise between autonomy and efficiency.

“The key question is no longer whether to use health data, but how.”

personnel to boost digital competence. Without a cultural shift and a common understanding of shared responsibilities, true interoperability will remain elusive.

AI-Readiness Depends on Data Quality and Access

Artificial intelligence is widely seen as a game-changer for clinical decision-making, diagnostics and operational efficiency. However, its deployment depends critically on the availability of structured, high-quality, longitudinal datasets. In most healthcare systems, these remain scarce or are held in formats unsuitable for algorithmic training and analysis.

Regulatory frameworks such as the European AI Act currently classify most clinical AI systems as high-risk, imposing stringent documentation and approval requirements. While important for patient safety, this creates high barriers for smaller organisations and limits experimentation. There is growing support for differentiated risk assessment, sandbox environments for testing, and access structures based on neutral data trustees that preserve privacy while enabling innovation.

Without pragmatic governance models, including consent frameworks like Broad Consent and mechanisms for pseudonymised data access, AI will remain confined to isolated pilot projects. Standardisation of data quality is equally essential—poor input data invariably leads to flawed models. Collaborative partnerships between providers, researchers and developers can create a more inclusive and adaptive ecosystem for AI in healthcare.

The availability of secure digital identities will be a crucial step forward. Current registration procedures for services such as electronic health records remain cumbersome and often exclude less digitally literate groups. Streamlined authentication protocols based on national electronic IDs could unlock everyday use while maintaining data protection and sovereignty.

The electronic patient record (ePA) in Germany offers an instructive case. Despite political support and regulatory momentum, it has struggled to gain broad adoption due to limited usability and unclear added value for users. The inclusion of patient-generated data—such as symptom tracking, wearables or therapy feedback—alongside incentives for clinical use, could improve uptake. However, integration must be seamless, structured and supported by compensation schemes to be sustainable.

System-Wide Enablers: What Needs to Happen Now

Health data cannot be unlocked through isolated projects or pilot schemes. Systemic change is required—grounded in structural investment, human capability and strategic oversight. Based on expert consultations, four strategic enablers were identified:

- **Sustainable financing:** Digital infrastructure must be financed as a long-term operational component, not just through time-limited project funding. Recurrent costs for cloud services, platform maintenance and innovation should be integrated into routine financing mechanisms, including DRG-based systems.
- **Skills development:** Medical, administrative and IT professionals alike need access to targeted training



in digital tools and data governance. Interdisciplinary teams and updated curricula are essential. The discontinuation of qualifications such as medical informatics risks exacerbating the digital talent gap.

- **Governance and oversight:** Responsibilities for digital transformation remain fragmented. National

Conclusion

Unlocking health data is both an opportunity and a necessity. More than just technological infrastructure, it requires trust, collaboration and strategic intent. By building systems that are interoperable, inclusive and accountable, healthcare can move from data

“Interoperability is not merely a technical concern—it is foundational to coordinated care.”

agencies or agile coordination bodies could help steer implementation, define clear priorities and ensure alignment across sectors. Institutions like Gematik should focus on standard-setting and enforcement, not product development.

- **Smart regulation:** Legal frameworks should include sunset clauses or periodic impact assessments. If policies fail to deliver demonstrable improvements in care, access or efficiency, they must be revised. Data protection remains vital, but it must be reconciled with innovation through harmonised interpretation and practical application.

fragmentation to data flow. This shift underpins digital transformation, but also sustainability and resilience of future care delivery.

Conflict of Interest

None.

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Zero Click Health: Redefining Medical Interaction in the Digital Age

Healthcare professionals are confronted with increasing administrative burdens due to inefficient EHR systems, which lead to burnout and diminished patient interaction. The Zero Click paradigm proposes integrating AI, automation and intuitive interfaces to minimise digital friction. The model aims to reclaim clinical time, reduce stress and improve care quality in an overstretched global workforce by streamlining tasks like data entry and scheduling.

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key points

- EHR systems increase administrative tasks and reduce time spent with patients.
- Excessive clicking and data entry contribute to clinician stress and burnout.
- Zero Click Health uses AI and automation to streamline routine medical tasks.
- Smart interfaces and virtual assistants can reduce documentation workload.
- Reclaiming clinical time improves care quality and supports healthcare sustainability.

The Administrative Dilemma in Modern Healthcare

In 21st-century medicine, healthcare professionals face growing challenges beyond clinical complexity. One of the most significant burdens comes not from patients but from the systems meant to support their care, such as Electronic Health Records (EHRs). Though their promise once lay in optimising medical information, their real-world implementation has contributed heavily to administrative overload.

The history of EHRs traces back to the 1960s, with pioneering efforts from institutions like the Mayo Clinic, which aimed to create more effective ways to store, retrieve and manage patient data. During the 1970s, further advancements emerged, including significant work from the Regenstrief Institute in Indianapolis, led by Clement McDonald. This system addressed the complex database design issues and the challenge of linking healthcare organisations through digital infrastructure. By the 1980s, EHRs became more affordable and accessible. In the 1990s, efforts were made to standardise platforms and integrate internet capabilities,

further transforming how data could be shared and used across clinical settings. Widespread adoption accelerated in the 2010s, particularly in countries like the United States, where government incentives helped establish EHRs as a cornerstone of clinical practice. This period marked a turning point, as the healthcare community increasingly recognised the potential of EHRs to improve quality, safety and efficiency. Yet, these benefits came with a cost that has become increasingly apparent to those who use the systems daily.

The Current Reality: Thousands of Clicks and Less Time for Patients

The implementation of EHRs, though well-intentioned, has led to unintended consequences. A study conducted by the Mayo Clinic revealed that a significant proportion of physicians—63%—believed EHRs had made their work less efficient. Furthermore, 44% expressed dissatisfaction with the systems. These sentiments are echoed across multiple healthcare settings, where digital documentation often dominates clinicians' time.



Similarly, a systematic review has highlighted a troubling trend: usability issues and excessive interaction with EHRs are major contributors to stress and burnout among healthcare professionals. In particular, physicians are subject to a constant demand for documentation in emergency departments. One study found that during a 10-hour shift, an emergency physician may perform as many as 4,000 clicks. In this same timeframe, nearly half of their working hours, about 44%, are spent on

Several strategies can support this transition:

- **Smart Automation:** Deploy systems capable of automatically collecting and processing data, reducing the need for manual input. This could simplify the creation of discharge summaries, emergency department reports or surgical notes. Tools like Nabla or Abridge are examples of providers working in this line.

“Reclaiming time from bureaucratic systems enables more human-centred care.”

data entry, while only 28% is allocated to direct patient interaction. This imbalance not only hampers efficiency, but also exacerbates professional burnout.

Proposals for a Click-Free Healthcare Model

The advent of generative artificial intelligence has facilitated the simplification of information retrieval and generation across various sectors. One of the more disruptive innovations has been the emergence of the “zero-click search” experience. This refers to a model in which users receive relevant information immediately

- **Optimised User Interface:** Design EHR systems with more intuitive, user-centred interfaces. For example, Llamalitica enables conversational interaction with the medical record, allowing clinicians to request past results—potentially through speech—from the patient’s file.
- **AI Integration:** Use artificial intelligence to predict and perform routine tasks like prescription renewals or appointment scheduling. Microsoft’s Nuance DAX-Copilot, Suki AI or Babylon Health allow these options.

“It is time to move from the paradigm of ‘we need more doctors’ to the one of ‘we need more useful doctor time.’”

without opening additional links or navigating through layers of content. Originally a feature of search engines like Google, zero-click search has begun influencing how users engage with information across digital environments.

According to a recent survey conducted by Bain & Company, around 80% of consumers trust zero-click results for at least 40% of their searches. This shift has already had measurable effects, with organic web traffic reportedly declining by 15–25% due to this trend. In healthcare, the “Zero Click Health” concept draws inspiration from this model, proposing a future in which clinical data and support tools are delivered seamlessly to providers without demanding time-consuming interaction.

- **Administrative Support:** Assign virtual assistants to handle administrative duties, allowing healthcare professionals to devote more time to patient care. Examples include chatbots, integrated messaging and other digital tools. Olive AI or Sensely as many others are working in this way.

Reducing Friction, Restoring Focus

The ambition behind Zero Click Health is not simply to eliminate clicks but to reduce friction across all points of medical interaction. By applying emerging technologies in meaningful, user-centred ways, the healthcare sector can alleviate administrative overload and restore balance



to clinical work. The model advocates for a healthcare environment where tools adapt to people, not vice versa.

The promise of such a shift is profound for physicians and care teams. Reclaiming time from bureaucratic systems enables more human-centred care, fostering stronger relationships between caregivers and patients. It also contributes directly to professional well-being. In an era where clinician burnout is reaching critical levels, such improvements are more than technical—they are necessary safeguards for the profession's future.

The global context only sharpens this urgency. According to the World Health Organisation, there is a shortage of 10 million healthcare professionals. Rather than focusing exclusively on producing more clinicians, ensuring that existing professionals can use their time more effectively may be more effective. In other words, it is time to move from the paradigm of “we need more doctors” to “we need more useful doctor time.” The Zero Click Health approach could deliver up to 30% more effective medical time, directly addressing this imbalance and unlocking new efficiencies in care delivery.

Conclusion: Enabling Time for What Matters Most

Zero Click Health represents a vision of healthcare where technology serves as a silent partner—efficient, intelligent and unobtrusive. It offers an antidote to the digital exhaustion many clinicians experience and proposes a path toward more intelligent, more compassionate systems.

By adopting this approach, healthcare systems can reduce burnout and enhance the quality of care. The technology to make this possible already exists; it is now up to policymakers and healthcare leaders to act.

Conflict of Interest

The author is cofounder and partner at Llamalitica (llamalitica.com), a start-up dedicated to Ambient AI and mentioned in the piece.

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Treating Catecholamine Refractory Hypotension in Septic Shock



 **Increase mean arterial pressure**
in catecholamine refractory septic shock^{1,3}

 **Reduce Norepinephrine Infusion**
while maintaining mean arterial pressure^{1,2}

 **Increase Chances of Survival**
for patients with less severe septic shock
($<15 \mu\text{m/min NE}$)⁵ and patients at risk
of AKI (increased serum creatinine $\times 1.5$)⁴

Empressin 40 I.U./2 ml concentrate for solution for infusion. Active substance: Argipressin. **Composition:** One ampoule with 2 ml solution for injection contains argipressin, standardised to 40 I.U. (equates 133 microgram). 1 ml concentrate for solution for infusion contains argipressin acetate corresponding to 20 I.U. argipressin (equating 66.5 microgram). **List of excipients:** Sodium chloride, glacial acid for pH adjustment, water for injections. **Therapeutic indication:** Empressin is indicated for the treatment of catecholamine refractory hypotension following septic shock in patients older than 18 years. A catecholamine refractory hypotension is present if the mean arterial blood pressure cannot be stabilised to target despite adequate volume substitution and application of catecholamines. **Contraindications:** Hypersensitivity to the active substance or to any of the excipients. **Undesirable effects:** **Metabolism and nutrition disorders:** Uncommon: hyponatremia Unknown: Water intoxication, diabetes insipidus after discontinuation. **Nervous system disorders:** Uncommon: tremor, vertigo, headache. **Cardiac disorders:** Common: arrhythmia, angina pectoris, myocardial ischaemia. Uncommon: reduced cardiac output, life threatening arrhythmia, cardiac arrest. **Vascular disorders:** Common: peripheral vasoconstriction, necrosis, perioral paleness. **Respiratory, thoracic and mediastinal disorders:** Uncommon: bronchial constriction. **Gastrointestinal disorders:** Common: abdominal cramps, intestinal ischaemia Uncommon: nausea, vomiting, flatulence, gut necrosis. **Skin and subcutaneous tissue disorders:** Common: skin necrosis, digital ischaemia (may require surgical intervention in single patients) Uncommon: sweating, urticaria. **General disorders and administration site conditions:** Rare: anaphylaxis (cardiac arrest and / or shock) has been observed shortly after injection of argipressin. **Investigations:** Uncommon: in two clinical trials some patients with vasodilatory shock showed increased bilirubin and transaminase plasma levels and decreased thrombocyte counts during therapy with argipressin **Warning:** less than 23 mg sodium per ml. **Prescription only. Marketing authorisation holder:** OrphaDevel Handels und Vertriebs GmbH, Wintergasse 85/1B; 3002 Purkersdorf; Austria. **Date of revision of the text:** 02/2022

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Sustainability

Hacking Forward: CHI-FLYING Hackathon Shaping Tomorrow's Solutions

The Centre for Healthcare Innovation's Future Leaders and Young Innovators Guild (CHI-FLYING) developed a new hackathon model to drive system-level healthcare innovation, led and driven by healthcare professionals within the organisation. Targeting in-service healthcare professionals, it focuses on real-world problem validation, solution development and project sustainment. Case studies like the Healthcare Sustainability Innovation Challenge demonstrate its success in fostering ground-up, cross-sector collaboration and lasting change.

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key points

- The CHI-FLYING Hackathon model drives system-level healthcare innovation.
- It targets in-service healthcare professionals to solve real-world problems.
- Participants validate challenges, develop solutions and test prototypes.
- Teams receive mentorship and support to sustain and expand their projects.
- A healthcare sustainability challenge demonstrated the model's effectiveness.

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An Imperative for System-Level Change

Healthcare organisations around the globe face a convergence of complex healthcare needs, arising from several factors such as a rapidly ageing population, an increase in non-communicable diseases and growing health inequities (OECD & WHO 2020; WHO 2019; WHO 2021). The challenges faced are becoming increasingly multifaceted, requiring a vast array of services across multiple levels, ranging from preventative care to acute specialist and long-term care (Figuerola et al. 2019).

Although there is an urgent need for change, these healthcare systems often struggle to adapt, especially in terms of reorientation necessary to address new challenges such as climate change and a declining workforce capable of caring for older, sicker patients (Braithwaite et al. 2018). This struggle has been attributed to ongoing fragmentation in the planning,

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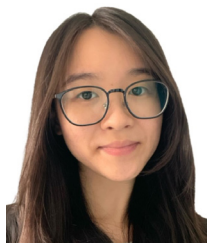


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Thirumalai et al. 2024). To navigate these challenges, healthcare professionals will need to develop collaborative structures and behaviours. This approach can facilitate the creation of solutions through cross-disciplinary innovations, allowing successful tools and solutions from one setting to be adapted for use in another. This will help minimise duplication of efforts and reduce resource waste (Best et al. 2020; Borgwardt et al. 2019; Woiceshyn et al. 2022).

Re-engineering Hackathons for Healthcare Professionals through CHI-FLYING

Hackathons have been growing in prominence and interest as accessible channels for rapid, intense solutions to wide-ranging problems (Falk Olesen et al. 2020; Heller et al. 2023). While first conceptualised and delivered in the realm of computer science, bringing individuals together to create software solutions over a short time span, this concept of accelerated design and problem-solving has grown and demonstrated strong potential in the corporate, research, scientific and healthcare sector (Nolte et al. 2020; Rooholamini et al. 2024; Wang et al. 2018). Such hackathons are often organised to enhance an organisation's innovation processes, develop and prototype new solutions and increase employee motivation to remain engaged and contribute to the organisation through collaborative problem-solving (Herala et al. 2019).

A recent literature review demonstrated hackathons' potential in the healthcare sector, showing that they are providing opportunities for healthcare professionals to collaborate with non-healthcare experts, leading to innovative solutions in both public health and healthcare education (Leary et al. 2022; Muñoz-Leija et al. 2021; Rooholamini et al. 2024). However, the focus and value of hackathons in healthcare have often been limited to educational settings and higher education institutions as a means to engage students and improve their learning experience (Rooholamini et al. 2024). This demonstrates a gap and a potential for in-service healthcare staff to participate in and drive such short-term problem-solving efforts during hackathons.

In Singapore, we fill this gap through the Centre for Healthcare Innovation-Future Leaders and Young Innovators Guild (CHI-FLYING). A unique network of over 150 young leaders below 40 years of age in the health and social care sector across the nation, our ethos is to go “across professions and across siloes” to solve cross-cutting health issues. With such a wide-ranging group of individuals with unique experiences

investment and operation of healthcare systems, which hinders their ability to evolve to meet these needs (WHO 2021).

Some cases, such as the COVID-19 pandemic, demonstrated that healthcare systems can radically reorient in the face of crisis. However, it may be difficult to mobilise such an intense effort when faced with increased complexities necessitating new tools and solutions, like digital innovations. These innovations can help reduce the need for manpower while ensuring equitable resource distribution and compliance with regulations and protocols (Braithwaite et al. 2024; Cernega et al. 2024; Kasula 2023; Niaz et al. 2023;

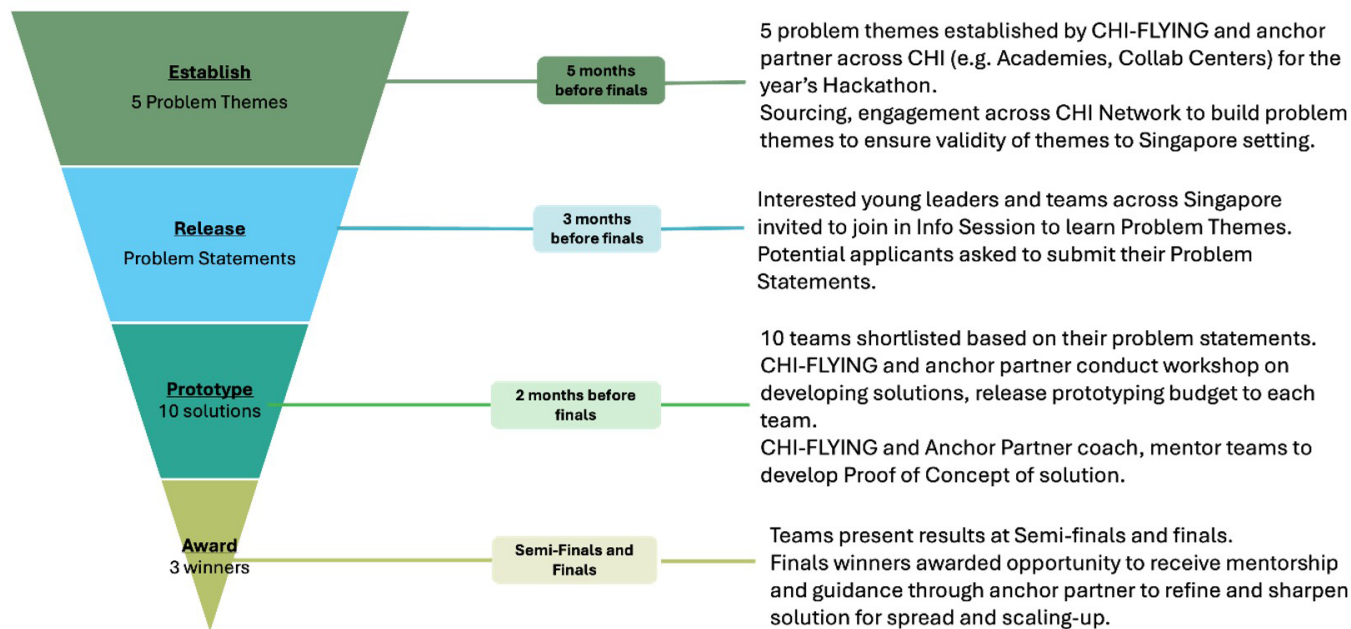


Figure 1. Timeframe Guide of the CHI-FLYING Hackathon Model

and skillsets, all driven by a common goal to solve pressing health challenges, we chose to harness the hackathon concept as a platform for a systematic, rapid validation of problems and the development of quick, iterative solutions to address them.

Unlike technology-oriented hackathons aiming on the development of new software or technological products to improve patient outcomes, our hackathons are issue-oriented, addressing broader issues and social problems (Briscoe 2014; Wang et al. 2018). For example, one

“CHI-FLYING’s ethos is to go ‘across professions and across siloes’ to solve cross-cutting health issues.”

While healthcare students are willing to participate, our hackathons primarily target in-service healthcare professionals who are directly involved in patient care and operations. This is essential as these professionals possess the specific knowledge needed to address the real-world issues they encounter. They also have the opportunity to test and validate the problems they face.

One key benefit of this approach is that participants are encouraged to actively solve the problems they encounter, promoting a culture of innovation within the healthcare organisation. In addition, this method ensures the development of concrete and effective solutions, as they are created by individuals who can implement them in their specific setting and environments (Huppenkothen et al. 2018). Participants are grouped into teams of three to six members to ensure that everyone has a voice and can contribute actively (Day et al. 2018).

hackathon we conducted in 2023 focused on the needs of older adults, specifically on solutions to either maintain their level of independence, such as an innovative ‘buddying’ system among aged neighbours, or to assist families of seniors approaching the end of life. By accommodating both technology-focused solutions, such as mobile health apps, and social-focused solutions, such as resident networks, we enable participants to apply their full range of professional and technical skills and knowledge to generate appropriate solutions.

Our Hackathon Model

Our approach and flow of hackathons are adapted from the Massachusetts Institute of Technology (MIT)’s Hackathon model, a proven, scalable and practical approach to hackathons, integrating the principles of

interdisciplinary collaboration and rapid innovation techniques (Gubin et al. 2017). We have split it into five components:

1. Defining the problem,
2. Validating the problem,
3. Development of testing of a solution,
4. Presentation and judging of findings,
5. Support and sustainment of the project.

Based on the scope of the hackathon and the intended ‘end-product’, we have organised one-day hackathons intended to rapidly identify solutions akin to ‘traditional’ weekend-based hackathons, as well as three-month hackathons to allow sufficient time for validating the problem and developing and testing the proposed solution (Falk Olesen et al. 2020). Throughout each step of the process, teams are mentored by both CHI-FLYING members, who have expertise in hackathons, and

potentially radical solutions that can lead to impactful outcomes (Wilson 2013). The timeframe guide of our hackathon model, which illustrates our journey from identifying problem themes to developing solutions and final judging within a five-month timeframe, is shown in Figure 1.

Throughout the hackathon, teams are evaluated based on the following criteria to determine their readiness to progress to the next stage:

1. If their solution effectively addresses the identified problem,
2. If their solution clearly demonstrates benefits to public healthcare and aligns with the challenge statement,
3. If the solution shows potential for sustainability and longevity, with the capacity to continue beyond the hackathon,
4. If the solution can be scaled to other locations.

“Hackathons have been growing in prominence and interest as accessible channels for rapid, intense solutions.”

relevant subject matter experts from the Centre for Healthcare Innovation (CHI). This ensures that at each step of the process, teams are facilitated through their brainstorming, ideation and execution process, encouraging the flow of ideas and the tolerance of

The judging process consists of four phases: one for “Validating the Problem,” one for “Developing and Testing the Solution,” and two for “Presentation of Findings.” The specific aspects that will be assessed are illustrated in Figure 2.

Defining the Problem

Our initial Problem theme focuses on an area of interest to CHI, ensuring alignment with the organisation’s strategic needs while providing resources, capacity and access to expert advice. By collaborating with subject matter experts from CHI and its associate partners in relevant industries and academia, we establish clearly defined themes with sufficient latitude for teams to develop appropriate problem statements that are both precise and realistic (Heller et al. 2023). This collaboration also allows us to identify suitable subject matter experts to serve as mentors, offering specific technical skillsets and expertise to properly advise the team (Franco et al. 2022).

Next, we organise an information session open to all potential participants in order to communicate the theme and its relevance to the current and future healthcare landscape. A deliberate in-person gathering at CHI

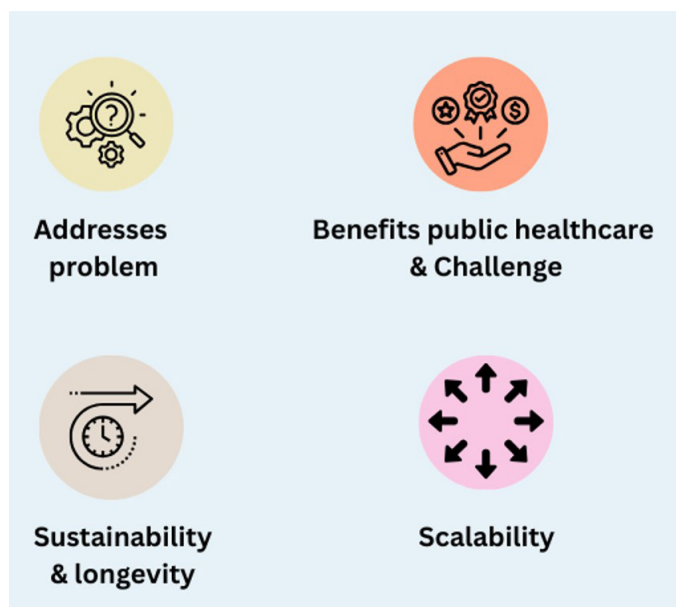


Figure 2. Project Aspects Assessed

facilitates clear communication of the objective and focus of the hackathon, while also providing networking opportunities for potential participants to connect with mentors and experts. This interaction allows them to brainstorm ideas and explore potential approaches to their problem statements (Nolte et al. 2018). Afterwards, potential participants proceed to identify potential problem statements aligned with the theme and validate them appropriately.

Validating the Problem

Teams return to their workplace to collect data around the identified problem statement, examining whether the problem is relevant to public healthcare institutions in Singapore. This step allows teams to confirm that their proposed problem is pressing and aligns with the goals of their organisation. This is typically achieved through rapid focus groups with peers and staff surveys, demonstrating the extent of the issue and the need for action (Gubin et al. 2017).

Following this, teams submit their problem statement and associated data to CHI-FLYING and a panel of external judges assembled for the hackathon. This marks the first-cut review of the applications (Judging Phase 1). During this phase, the judges evaluate whether the teams' proposed problems are suitable for the hackathon and if they meet the goals of the Problem theme (Kitsios et al. 2019).

Development and Testing of a Solution

Shortlisted teams are invited to CHI for a workshop designed to guide them on the fundamentals of solution development. During this workshop, teams learn how to identify the most valuable aspects of their intervention, which helps to improve outcomes for patients and the general population while reducing environmental, social and financial impacts. This approach ensures that both the solution they developed and the processes established to create the solution will build a cycle of positive change (Gubin et al. 2017; Senge 2006).

After the workshop, teams submit the first draft of their proposal for review by CHI-FLYING. An external panel of judges is then assembled to review the proposals for their relevance to the problem statement and their feasibility for completion during the hackathon (Judging Phase 2). Successful teams are awarded a start-up sum to proceed with the prototype of their solution.

Teams receive guidance throughout their prototyping process and are informed about the expected prototype necessary for testing their ideas. They collaborate with a suitable mentor who has expertise in the relevant field, such as a software engineer for digital solutions or a manufacturing expert for new fabric production. This ensures the prototype developed

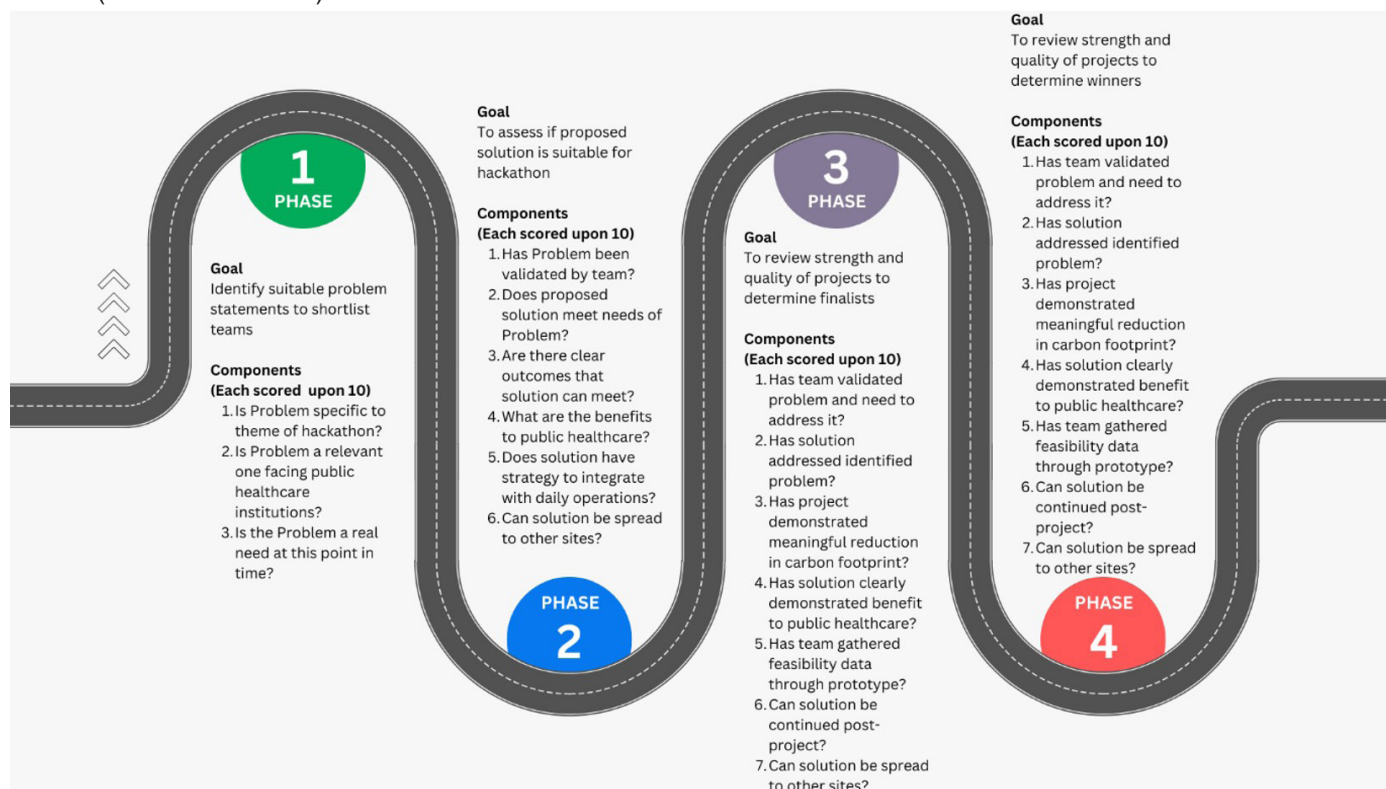


Figure 3. Judging Phases

can be effectively produced for testing purposes (Heller et al. 2023).

Once the teams have developed their solutions, they test them within their specific settings. Due to the time constraints of the hackathon, the testing is limited to Proof of Concept (POC) demonstrations. During this phase, teams evaluate their solution's feasibility, effectiveness and overall value proposition in comparison to existing approaches. Over a brief testing period, the team assess whether their solutions adequately address the identified problem, are capable of being operationalised in their setting and have the potential for making a meaningful impact (Rabinowitz et al. 2013). With their solutions developed and tested, the teams are now ready for judging.

Presentation and Judgement of Findings

The teams present their findings from the POC and their recommendations for adaptation and expansion of their prototyped solutions to a panel of expert judges selected by CHI-FLYING and CHI. We aim to include judges from both the healthcare sector and beyond, ensuring they have the necessary subject matter expertise related to the topics addressed during the Hackathon. This approach guarantees that the judges possess the appropriate knowledge and experience to assess the solutions and their applicability in healthcare settings (De Winne et al. 2020; Kitsios et al. 2019). Through this judging process, we aim to identify the highest quality solutions, which will subsequently receive institutional support to help them mature and move forward.

partnered with their home institutions to further refine and mature their solutions before wider implementation. An overview of the judging phases throughout the project is summarised in Figure 3.

Support and Sustainment of the Project

Once the best solutions are identified and funding is awarded, we proceed to ensure the project teams receive the organisational support to continue and expand their solution within their healthcare organisation. To achieve this, we partner the teams with relevant subject matter experts from CHI, including the CHI Academies Office, which provides expertise in areas such as healthcare sustainability and socially-focused healthcare.

We hope to deliver some of the key ingredients needed for the successful continuation of Hackathon projects. This includes access to expertise-focused learning through CHI, as well as funds and resources from the prize money to further enhance or develop their solutions. Additionally, this support may be supplemented through further start-up grants from CHI (Nolte et al. 2020).

In addition, throughout the entire coaching and development process, we aim to identify and bring out team members who demonstrate the drive, motivation and commitment to see their project through. These qualities have been recognised as strong predictors of a team's ability to sustain their project after the hackathon (Cobham et al., 2017a; Cobham et al. 2017b; Nolte et al. 2018).

Hence, the CHI-FLYING Hackathon approach has a structured, logical flow. It effectively guides teams to focus on a designated problem, validate it and develop

“Participants are encouraged to actively solve the problems they encounter, promoting a culture of innovation.”

Although the Hackathon is designed to foster collaboration, we chose to include a competitive atmosphere towards the end to encourage teams to present unique solutions and innovative findings to their judges (Nolte et al. 2020). Each team is allocated five minutes to present their solution, explain how they validated the need for it and share the findings of their POC before the judging panel (Judging Phases 3 and 4 represent semi-finals and finals, respectively). The top three teams are awarded €2,636 (\$3,000) each to support the continued development of their solutions and are

solutions to address it. Teams then test their effect, present their findings and, if successful, seek a potential 'home' to further refine and develop their ideas before deploying them in a healthcare setting.

Case Study: Healthcare Sustainability Hackathon

We applied the CHI-FLYING Hackathon model to raise sustainability efforts across the healthcare settings through the Centre for Healthcare Innovation-Singapore Institute of Technology (CHI x SIT)

Healthcare Sustainability Innovation Challenge. Our focus was on environmental sustainability in healthcare, as climate change poses a growing concern for the Singaporean healthcare system. A recent systematic review by Aik et al. (2023) found a positive correlation between rising temperatures and heat-related as well as enteric illnesses. This indicates an increased risk for Singaporeans facing heatwaves and heatstroke as temperatures rise. While national measures are being implemented to reduce carbon emissions, with a net-zero target set for 2050, we sought to initiate local initiatives within the public healthcare sector (National Climate Change Secretariat 2023).

Earlier research has shown that even slight changes can have both environmental and clinical impact. For example, raising the temperature in the operating theatre to a still clinically appropriate level has led to a significant reduction in electricity consumption, while also reducing the risk of patient hypothermia and related complications (Tee et al. 2024). However, with so many departments and areas needing to initiate such change, we sought to

use the Healthcare Sustainability Innovation Challenge as a single unifying platform for the ideation and prototyping of sustainability efforts across institutions and departments.

Working alongside sustainability experts at SIT, we defined our hackathon into clear, actionable areas. We developed five problems that participants could use to frame their problem statements:

1. **Points of Care:** examining how healthcare services are assessed, accessed, consumed and delivered.
2. **Rethinking Efficiency:** analysing how processes, infrastructure and environment are designed and used.
3. **Rethinking Impact in Supply Chain:** ensuring that we receive what we need when it is needed.
4. **Rethinking Pharmaceuticals:** evaluating how medications are produced, delivered and managed.
5. **Rethinking What We Throw:** investigating how we manage our waste.

Team	Project
National Healthcare Group Community Health Team, Cross-Cluster Pharmacy (Formed from the merger of 2 teams into 1)	Matching patients' donated unused medications to patients willing to use them
National Cancer Centre Singapore	Managing the upstream demand of nurse uniforms, recycling of old nurse uniforms and prototyping of uniforms from recycled materials
National Cancer Centre Singapore	Developing a Smart Calculator to project and reduce the wastage of cytotoxic drugs
Tan Tock Seng Hospital's Ang Mo Kio Specialist Centre Day Surgery, Rethink Good, PlasPulp Union, Semula	Redesigning the process and consumables to reduce disposable waste and setting up the OT infrastructure for recycling and upcycling of surgical waste
Tan Tock Seng Hospital Intensive Care Unit	Segregation of clean plastics in the ICU to facilitate recycling
Agency of Logistics and Procurement Services	Dashboard to track the environmental impact of the supply chain
Tan Tock Seng Hospital Hematology, Tan Tock Seng Hospital Nursing, Zevero	Prioritising the usage of soon-to-expire phlebotomy vials
National Trade Union Congress Health, National Healthcare Group Diagnostics	Smart switches to reduce electricity wastage in the wards and the lab
Tan Tock Seng Hospital Pharmacy	Redesigning the medication package to facilitate recycling

Table 1. List of CHI x SIT Healthcare Sustainability Innovation Challenge Projects



This framework allowed participating teams to examine sustainability efforts across the entire healthcare delivery process, from re-evaluating the coordination and procurement of healthcare products to the consumption of electricity needed for department operations and waste disposal. With this comprehensive range of opportunities, 34 teams submitted their problem statements in April 2024, with the majority (14) being centred around Rethinking What We Throw.

three major public healthcare groups in Singapore, the presenting teams had the opportunity to demonstrate their problem-solving skills and their ability to establish effective solutions. This could potentially open the door to more opportunities for collaboration with their home public healthcare institutions following the event (Nolte et al. 2020).

Using the judging criteria outlined above in Figure 3, we selected five teams of 30 participants

“Hackathons using our model have the potential to kick-start solutions that could address immediate, pressing problems.”

Using our assessment criteria, we narrowed down the problem statements to select 11 teams of 50 participants who had the most appropriate problem statements. We invited them to our workshop in May 2024 to introduce them to context-based problem-solving skills, which would help them better analyse their problems and generate solutions. Teams received guidance on the application of Sustainability in Quality Improvement (SusQI) and the principles of Sustainable Clinical Practice – prevention, patient-empowerment and self-care, lean clinical pathways and low carbon alternatives – developed at the Centre for Sustainable Healthcare (CSH) (Mortimer 2010). This instruction provided valuable ideation support for enhancing and sustainably delivering healthcare.

Throughout the workshop, two teams identified a shared challenge regarding the recycling of unused medications and the redistribution of these medications to underserved patients in the community, which led to their merger. 10 teams were formed, each of which received €1,318 (\$1,500) in seed funding to prototype and test their solutions. Additionally, they were matched with suitable experts from SIT, including specialists in materials development and engineering for teams focused on reusing plastics.

In July 2024, nine teams presented their solutions and findings during the semi-finals. The judging panel consisted of Chief Sustainability Officers from Singapore's three public healthcare clusters, who had the expertise and knowledge to evaluate whether the proposed solutions could be implemented in their institutions (Kitsios & Kamariotou 2019). In addition, as the judges were leaders in sustainability efforts across the

to compete in the finals, which took place on the following day. They presented their solutions and findings to a panel of sustainability experts who further assessed the solutions and plans based on their experience of implementing and supporting sustainability initiatives in their own settings. Through this process, three winning teams were identified, each awarded €2,636 (\$3,000) to continue developing and refining their solution. In addition, these teams are now receiving expert coaching and guidance from professionals in innovation and sustainability at the CHI Sustainability Academy. This support will assist them in redesigning their solutions and delivery models to improve the quality and longevity of their projects.

Overall, the Challenge provided comprehensive support for ideation, prototyping and solution testing through the CHI-FLYING Hackathon model. A summary of the nine teams that reached the semi-finals is provided in Table 1, with the top three winners highlighted.

FLYING into a Hackable Future

Our Hackathon model offers an end-to-end framework for guiding the ideation, prototyping and solution testing of innovative ideas and processes. This approach has demonstrated its effectiveness through case studies, such as the CHI x SIT Healthcare Sustainability Innovation Challenge. We demonstrated how this model allows healthcare professionals ‘in the trenches’ to better manage the complexities of healthcare systems and develop multifaceted solutions together. It has the potential to connect and unite a fragmented healthcare



ecosystem to better solve various interconnected challenges across sectors.

While this method will not resolve all issues, especially deep-seated problems like poor health outcomes stemming from generational poverty, hackathons using our model have the potential to kick-start solutions that could address immediate, pressing problems.

Now we are exporting the model to various settings and environments to showcase its versatility. One example is a Research Hackathon held within Singapore's National Healthcare Group, focusing on its nursing workforce. It intends to both initiate new research in identified priority areas and to identify the next generation of clinician-scientist talents. Through this model, we hope to encourage and inspire healthcare leaders to build more platforms for ground-up innovation and pilot projects, allowing the clinicians and administrators to have a stake in shaping the future of their organisations.

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Conflict of Interest

None.



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Talent Management

Extended Reality in Medical Education

Extended Reality (XR)—including Virtual, Augmented and Mixed Reality—is reshaping medical education by providing immersive, interactive tools for anatomy, surgical training, clinical skills and emergency preparedness. These technologies enhance learning, improve outcomes and foster collaboration. Despite challenges like high costs, limited access and lack of standardisation, XR shows strong global growth and potential for personalised, efficient medical training.

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key points

- XR enables immersive simulations that improve medical skill development and clinical competence.
- VR, AR and MR tools are widely used in anatomy, surgical training and emergency preparedness.
- Studies show XR shortens learning curves and boosts confidence in complex medical procedures.
- Cost, access, standardisation and user resistance hinder widespread XR integration in education.
- XR supports personalised, interactive and collaborative learning across healthcare professions.

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in various fields, such as healthcare, education and crisis management, indicates that immersive technology can significantly improve learning experiences, promote cooperation and foster creativity among learners.

Current Landscape of Extended Reality in Medical Education

The analysis of existing research reveals that VR is the most frequently discussed immersive technology, followed by AR and MR. VR's prominence in simulation and training contexts is well-established, while AR and MR are gaining importance, particularly in surgical training. The focus on medical students and surgeons highlights the relevance of immersive technologies in educational and professional development. However, there is a notable gap in studies addressing medical specialities such as orthopaedics and neurosurgery, suggesting a need for further exploration of these areas.

The Promise of Extended Reality

XR technologies have shown significant potential in revolutionising medical training. VR creates fully

Introduction

Medical knowledge is evolving at an unprecedented pace, creating a growing need for innovative tools that enhance both medical education and practice. Extended Reality (XR), encompassing Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and other immersive technologies, represents a cutting-edge approach to simulation-based training. Research

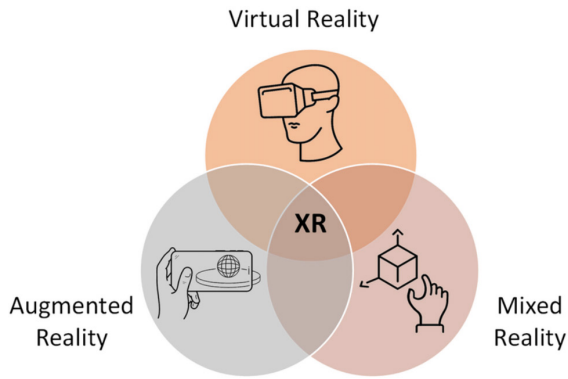


Figure 1. Definition of realities. Source: Janiszewski et al., 2021.

immersive environments where medical students can practice procedures repetitively, refining their skills without the risk of harming patients. AR overlays digital information onto the real world, aiding in the visualisation of anatomical structures and surgical procedures. MR combines elements of both VR and AR, allowing for interaction with both physical and digital objects in real time, which is particularly useful in surgical simulations.

- **Clinical Skills Development:** XR is also used to develop clinical skills, such as patient interaction and diagnostic procedures. Simulations can recreate various clinical scenarios, allowing students to practice and refine their skills in a controlled setting. This is particularly beneficial for developing soft skills, such as communication and empathy, which are crucial for patient care.
- **Emergency Medicine:** In emergency medicine, XR simulations prepare medical first responders for crisis situations. These simulations can replicate high-stress environments, helping responders develop the necessary skills to manage real-life emergencies effectively. By practicing in a virtual environment, responders can improve their decision-making and procedural skills, which are critical in emergency situations.

Challenges and Limitations

Despite its potential, the integration of XR in medical education faces several challenges:

“Immersive technology can significantly improve learning experiences, promote cooperation and foster creativity among learners.”

Current Applications and Benefits of XR Technologies in Medical Education

- **Anatomy Education:** XR technologies, especially AR, have been widely adopted in anatomy education. Tools like Microsoft's HoloLens allow students to visualise and interact with 3D models of the human body, enhancing their understanding of complex anatomical structures. This interactive approach helps bridge the gap between theoretical knowledge and practical application, making learning more engaging and effective.
- **Surgical Training:** VR simulators provide a risk-free environment for surgical training. Surgeons can practice intricate procedures, such as laparoscopic and neurosurgery, improving their precision and confidence. Studies have shown that VR training can significantly reduce the learning curve and improve surgical outcomes. For instance, VR platforms can simulate various surgical scenarios, allowing trainees to develop their skills in a controlled setting and receive immediate feedback on their performance.
- **Technical Limitations:** High-quality XR experiences require advanced hardware and software, which can be expensive and technically demanding. Ensuring smooth and realistic simulations is crucial for effective training. Technical issues, such as latency and motion sickness, can also affect the user experience and limit the effectiveness of XR training.
- **Accessibility:** The cost and availability of XR technologies can limit their widespread adoption, particularly in resource-constrained settings. Efforts are needed to make these technologies more accessible to a broader audience. This includes developing cost-effective solutions and providing training and support to educators and students.
- **Standardisation:** There is a lack of standardised protocols and guidelines for the use of XR in medical education. Establishing best practices and ensuring consistency across different training programmes is essential. This will help ensure that XR technologies are used effectively and that the training provided is of high quality.

- **User Acceptance:** Resistance to new technologies can be a barrier. Educators and students need to be convinced of the benefits of XR and trained to use these tools effectively. Overcoming this resistance requires demonstrating the effectiveness of XR in improving learning outcomes and providing ongoing support and training.

To support the discussion of XR's potential and limitations, a bibliometric analysis was conducted to assess how systematic reviews have addressed the integration of XR technologies into medical education. The study aimed to synthesise findings from multiple systematic reviews to provide a comprehensive overview of the current state of research, identifying trends, gaps and potential areas for future investigation.

Bibliometric Study of Systematic Reviews on XR in Medical Education

Methodology

The analysis followed the PRISMA guidelines for systematic reviews, ensuring a rigorous and transparent selection process. The search strategy involved combining key terms related to XR technologies and medical education across several databases, including PubMed, Web of Science, EBSCO, ScienceDirect and Embase. The inclusion criteria were strictly defined to

focus on systematic reviews involving medical students, surgeons and other relevant healthcare professionals. 44 articles were included.

Results

- **Publication Trends:** The study identified a significant increase in the number of systematic reviews on XR in medical education from 2016 onwards, with a peak in 2021. This surge is attributed to the COVID-19 pandemic, which necessitated innovative educational solutions.
- **Populations Studied:** The majority of the reviews focused on medical students (54.5%) and surgeons (29.5%), highlighting the importance of XR technologies in both initial training and ongoing professional development.
- **Areas of Focus:** Surgery was the most frequently studied area, followed by medical education and anatomy. This indicates a strong interest in using XR for surgical training and anatomical education.
- **Technologies Used:** Virtual reality (VR) was the predominant technology discussed in the reviews (75%), followed by augmented reality (AR) (36%). Mixed reality (MR) and extended reality (XR) were less frequently mentioned, suggesting these technologies are still emerging in the field.

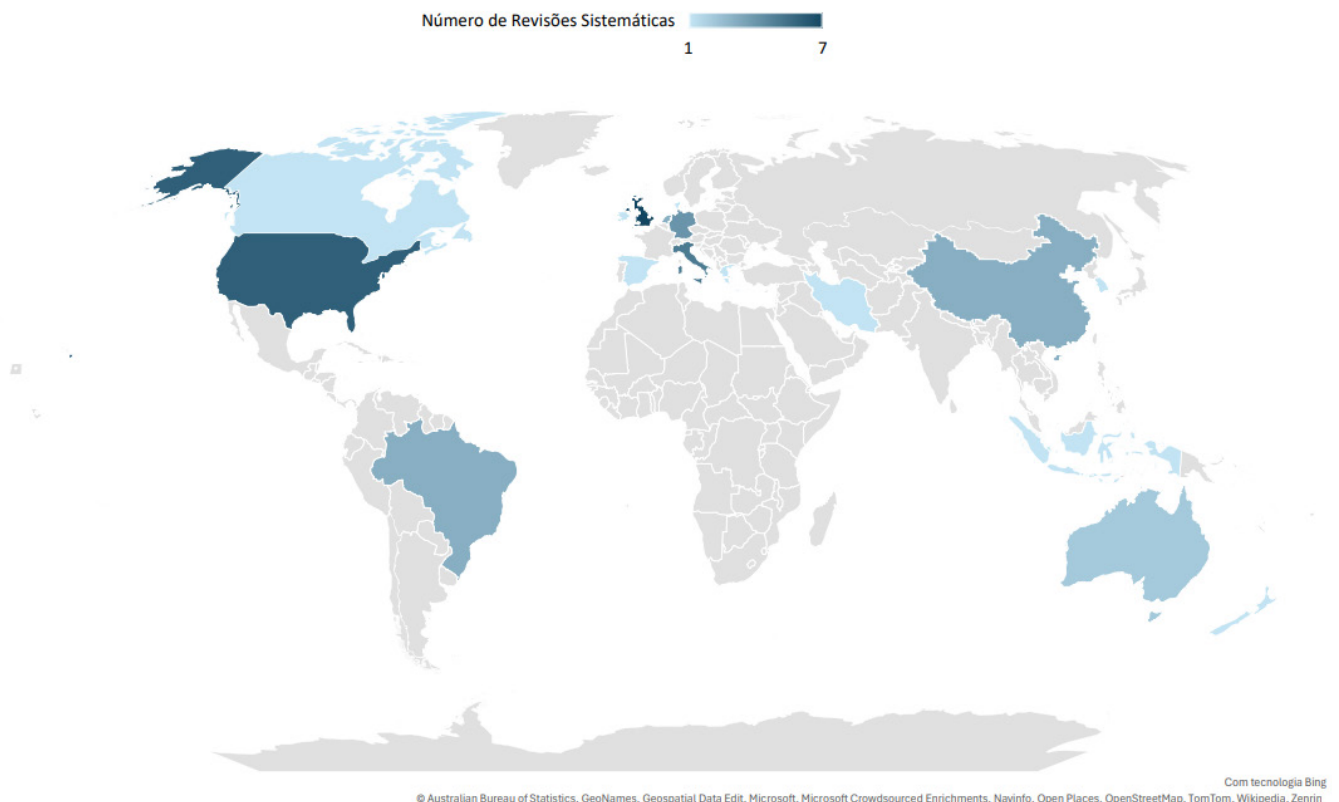


Figure 2. Geographic distribution of the included systematic reviews

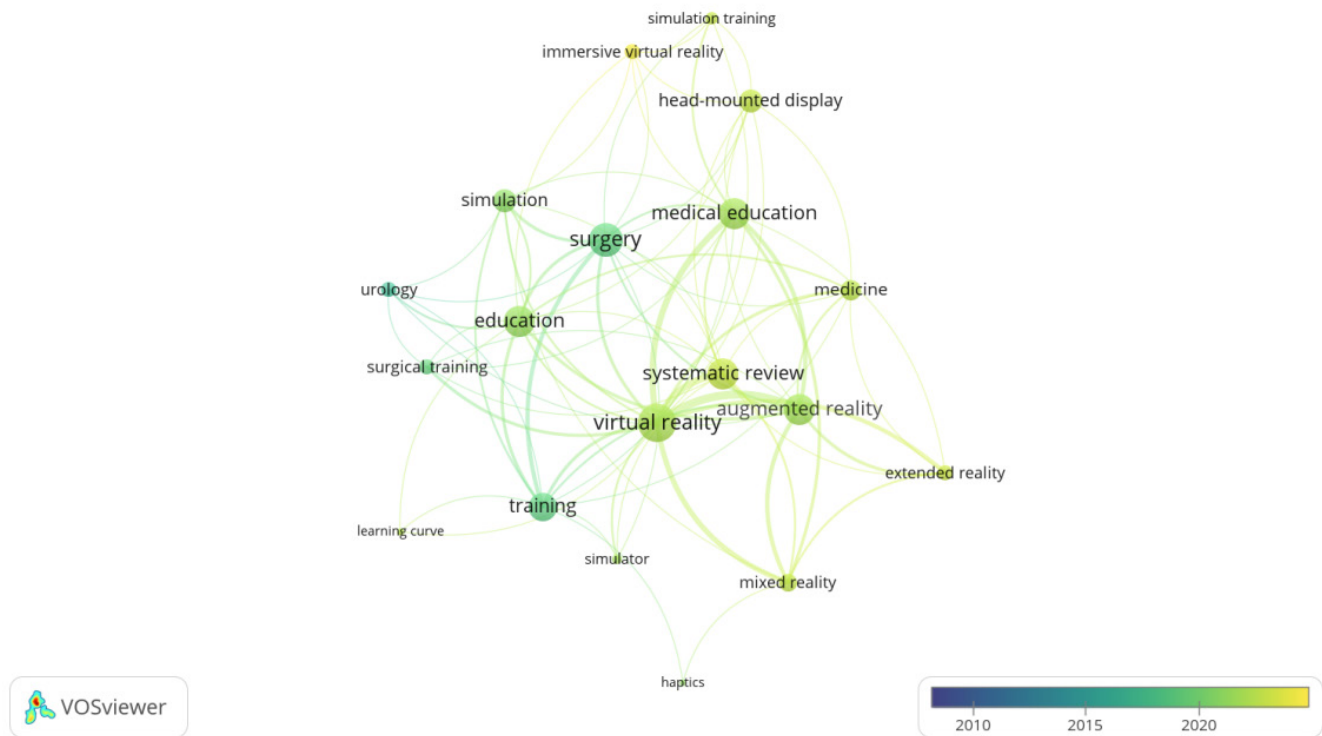


Figure 3. Chronological network of VOSviewer keyword co-occurrences with at least 2 occurrences in the set of studied publications.

- **Geographical Distribution:** The United Kingdom, the United States and Italy were the leading countries in terms of the number of publications. This reflects substantial investment and interest in XR technologies in these regions.
- **Meta-Analysis:** Only 14% of the systematic reviews included a meta-analysis, indicating a need for more rigorous statistical synthesis in future research.

Evaluation of XR Tools: An Essay

Extended Reality (XR) technologies, encompassing Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR), have emerged as transformative tools in medical education. These technologies offer immersive and interactive environments that enhance learning experiences, promote cooperation and foster creativity among learners. This essay critically evaluates various

“VR training can significantly reduce the learning curve and improve surgical outcomes.”

The analysis reveals a growing interest in XR technologies for medical education, particularly in surgical training and anatomy. However, there are notable gaps in research on specific medical specialties and the use of MR and XR technologies. Future studies should explore these areas to provide a more comprehensive understanding of the potential applications and benefits of XR in medical education.

In addition to reviewing the existing literature, a practical evaluation was carried out to examine the functionality and usability of selected XR applications currently used in medical education settings.

XR tools designed for medical education, focusing on their features, specifications and potential impact on medical training and practice.

Overview of XR Tools

The integration of XR in medical education represents a cutting-edge approach to simulation-based training. A comprehensive evaluation of XR tools reveals a predominance of functional software compatible with Microsoft HoloLens and Meta Quest devices, which account for 62% of the market. Apple Vision Pro and

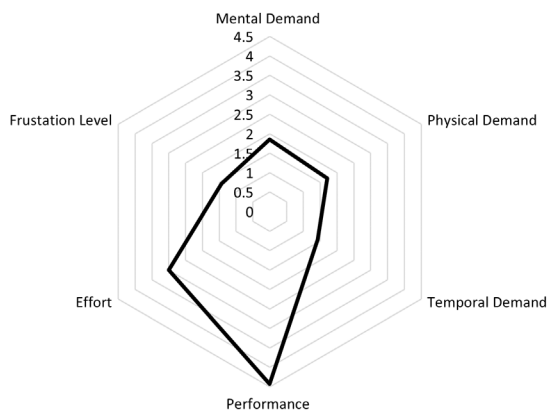


Figure 4. Radar chart summarising NASA-TLX results.

Magic Leap devices have a lower compatibility with the applications studied, each representing 13% of the market.

Medical Fields Targeted

Anatomy is the most targeted medical field, with 44% of applications focused on this area, followed by 26% dedicated to surgical purposes. The emphasis on anatomy-related software underscores its fundamental role in medical education, while the significant presence

Belgium, the United Kingdom and Switzerland, each represent 4-5%, reflecting global interest in the development of these technologies.

Software Launch Timeline

From 2016 to 2024, the highest number of software launches occurred in 2019, representing 28% of the applications studied. There was a significant increase in new applications from 2016 to 2019, followed by a sharp decline in 2020 and 2021, likely due to the onset of the pandemic and reduced productivity. A recovery was observed in 2022, with 14% of the applications introduced, followed by a decrease in 2023 and 2024.

Testing of XR Tools

Seven applications offering a free trial period were selected for testing on HoloLens 2 or Meta Quest 3 devices. The evaluation focused on user interface intuitiveness, available functionalities, realism, task efficiency and user fatigue.

Virtual Reality Applications

- **Human Anatomy VR:** Enables manipulation of anatomical structures with detailed captions and descriptions. Its immersive nature may lead to user fatigue with prolonged use.

“The future of XR in medical education looks promising, with ongoing advancements aimed at overcoming current limitations.”

of surgical applications highlights the necessity for simulation and planning tools to enhance surgeons' skills and improve patient safety. Orthopaedics accounts for 15% of applications, benefiting from 3D visualisation and simulation for diagnosis and treatment planning.

Technologies Used

The technologies used in the studied software predominantly fall into virtual reality (37%) and mixed reality (36%), indicating a strong preference for immersive virtual experiences and interactive environments. Augmented reality also has a significant presence (27%), proving useful in simulation and teaching.

Geographical Distribution

The United States dominates the market, accounting for 62% of the tools developed, likely due to substantial investment in research and development. Germany follows with 9%, making it the second-largest contributor. Other countries, including Canada, Slovenia, Japan,

- **Body Map:** Features an intuitive interface and detailed descriptions, including insertions and innervations of anatomical structures. Allows assessments and analysis of CT scans, X-ray images and real anatomical images.
- **Oxford Medical Simulation:** Provides patient communication training and diagnostic assessments using virtual patients. Lacks high realism; prolonged use can lead to significant fatigue.

Augmented Reality Applications

- **OpenSight:** Excels in clinical utility, particularly for visualising patient data. Uses patented technology to overlay holograms on patients for preoperative surgical planning.
- **Medicalholodeck:** Creates immersive medical scans for manipulation and study from various angles. Facilitates direct comparisons between medical images and anatomical models.

Mixed Reality Applications

- **Mimics Viewer XR:** Provides 3D model visualisation for surgical planning, enhancing depth perception for personalised treatments. Offers broad functionality with minimal fatigue.
- **HoloAnatomy:** Innovative experience for exploring human anatomy without cadavers, featuring over 8,500 anatomical models. Promotes collaboration among students.

Comparative Analysis of HMD Devices

Both HoloLens 2 and Meta Quest 3 headsets were assessed for their effectiveness in manipulating virtual objects. Meta Quest was found to be easier to learn, more responsive and more efficient than HoloLens, leading to superior visualisation and faster task performance. This advantage stems from Meta Quest's motion controllers, which offer greater precision compared to HoloLens's gesture controls.

Evaluation of HoloAnatomy

To evaluate the feasibility of HoloAnatomy using HoloLens 2, seven healthcare professionals completed two questionnaires assessing its effectiveness in teaching anatomy. The NASA-TLX methodology was used to measure subjective mental workload, revealing generally low mental and physical effort. A second questionnaire provided a detailed analysis of user experience, indicating that the tool was intuitive, user-friendly and efficient for anatomy-related tasks.

The evaluation of the HoloAnatomy software assessed both cognitive and physical demands, revealing a generally low mental effort, as 43% of respondents rated mental demand as very low (1). Physical demand was similarly minimal, with 85.8% of participants rating it as 1 or 2. Most respondents perceived the pace of tasks as relaxed, and performance feedback was overwhelmingly positive, with 57.1% rating the application's efficiency at 4 or 5.

Subsequently, the evaluation of HoloAnatomy revealed that it features an intuitive interface, requiring minimal physical and mental effort from users, resulting in excellent performance in the study of anatomy. However, it is more suitable for individual study rather than classroom application, offering a valuable complement to practical classes in anatomical theatres. The high cost of HoloLens 2 presents a barrier to its application in education.

Future Directions

The future of XR in medical education looks promising, with ongoing advancements aimed at overcoming current limitations. Key areas of focus include:

- **Enhanced Realism:** Improving the realism of XR simulations through better graphics, haptic feedback and AI-driven interactions will make training more effective and engaging. Advances in technology will enable more realistic and immersive simulations, enhancing the learning experience.
- **Interoperability:** Developing interoperable XR systems that can integrate with existing medical education platforms and electronic health records will streamline training processes and enhance learning outcomes. This will enable seamless integration of XR technologies into the existing educational infrastructure.
- **Personalised Learning:** Leveraging data analytics and AI, XR can offer personalised learning experiences tailored to individual student needs, tracking progress and providing targeted feedback. This will help ensure that each student receives the support and training they need to succeed.
- **Collaborative Learning:** XR can facilitate collaborative learning experiences, allowing students and professionals from different locations to interact and learn together in a shared virtual environment. This will enable more effective teamwork and communication, which are essential skills in healthcare.

Taken together, the findings from both the literature review and empirical evaluation demonstrate that XR technologies offer substantial promise for enhancing medical education. While their effectiveness is well supported in areas such as anatomy and surgical training, challenges related to access, standardisation and cost remain critical factors to be addressed with the development of these tools.

Conflict of Interest

None

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Healing the Healers: A Technological Revolution to End the Nurse Staffing Crisis

Healthcare faces a mounting nurse staffing crisis, intensified by burnout, ageing populations and rigid systems. AI-driven workforce tools are helping healthcare providers create responsive, equitable staffing strategies, reducing administrative burden and improving retention. Success requires leadership, policy support and cultural change to ensure technology serves caregivers, not the other way around.

JEFF RICHARDS



CSO and Cofounder | SnapCare |
Atlanta, Georgia, USA

key points

- Nurse shortages threaten care quality and require urgent structural solutions.
- AI tools enable smarter, faster and more equitable staffing decisions.
- Predictive scheduling reduces burnout and improves staff retention.
- Leadership must prioritise innovation, empathy and system-wide collaboration.
- Policy changes are needed to scale AI solutions and support workforce resilience.

A Nation at a Crossroads

Let's begin not with systems or spreadsheets, but with people.

A nurse in Philadelphia wakes before sunrise. She kisses her children goodbye and enters a hospital knowing she'll face another shift with more patients than hands. A scheduler in Birmingham stares at a screen full of holes—shifts nobody wants, hours that can't be filled. An elderly patient in Phoenix waits longer than they should, because the nurse assigned has burned out.

Now imagine these scenes multiplied across thousands of facilities, in America and beyond. This is not an isolated challenge—it is a national emergency that affects safety, equity and human dignity.

And yet, even in the middle of this storm, one powerful truth remains:

We have the tools. We have the technology. And we still have time to turn this around.

Understanding the Storm: The Nurse Staffing Crisis

The COVID-19 pandemic did not cause this crisis—it revealed it. Like floodwaters exposing cracks in a foundation, it peeled back years of underinvestment and inflexibility in healthcare labour management.

The statistics speak for themselves:

- Over 1 million nurses are projected to leave the profession by 2030.
- Turnover rates are costing individual facilities up to €1.4 million (\$1.5 million) annually.
- Between 12–15% of beds remain unstaffed in long-term care, leading to unmet care needs and lost revenue.
- Meanwhile, the “Silver Tsunami” is cresting—over 80 million Americans will be over 65 by 2040.

The maths is clear: without a shift in how healthcare workforce is managed and supported, demand will continue to exceed supply.

The AI-Powered Workforce: What It Really Looks Like

There is good news: we are not powerless. Across regions and disciplines, innovators are stepping forward—not just to heal patients, but to repair the systems themselves.

Technologies such as artificial intelligence, machine learning, predictive scheduling and smart workforce platforms are already being implemented to stabilise healthcare delivery. These are not speculative

Redesigning the Norms of Staffing

Various innovators are developing AI-driven platforms designed to address healthcare staffing challenges, offering smarter, human-centred workforce solutions. These systems embed rules that reduce unnecessary overtime, protect staff wellbeing and prioritise internal talent. In a system calling for speed, flexibility and compassion, these tools are setting a new operational benchmark.

“We have the tools. We have the technology. And we still have time to turn this around.”

solutions—they are practical tools helping organisations to do more with less, restoring control and structure to the frontline.

These innovations function like digital PPE: helping protect staff from overload, enabling better decisions and making it more likely that professionals will return the next day.

An AI-powered staffing solution does more than fill shifts. It takes into account:

- Patient acuity and census
- Labour costs and budget ceilings
- Credentialing and compliance
- Overtime limits
- Staff preferences and burnout indicators

Such systems build schedules in minutes, notify internal staff before turning to external sources, predict needs in advance and offer real-time performance insights. Crucially, they allow caregivers to spend more time at the bedside instead of managing logistics through

Facilities using such systems have reported:

- 20–30% lower agency spending
- 50% less administrative time spent on scheduling
- Over 90% fill rates on critical shifts
- Notable improvements in staff retention and satisfaction

But this is not just about metrics. It's about restoring time, trust and purpose to caregiving. As AI capabilities grow, patterns emerge—understaffed nights, uneven skill distribution or credentialing bottlenecks—all of which can now be addressed proactively.

This is not just efficiency—it's foresight.

Bridging the Gap: Post-Acute and Long-Term Care

The nurse staffing crisis extends beyond hospitals to SNFs, rehab centres and assisted living communities, where consistent relationships and long-term staffing are vital.

“The technology adapts to the human—not the other way around.”

apps and mass messages. They support administrators with clear data on coverage and cost.

The technology adapts to the human—not the other way around. And behind the digital upgrade lies a cultural shift: trusting and supporting staff not through heroic effort, but thoughtful systems.

Intelligent platforms are being adapted for these settings too—factoring in regulatory rules, resident preferences and risk signals. When staff can choose shifts that fit their lives, when risks are visible in real time and when residents see familiar faces, care improves, and stability returns.

The technology is ready. The moment requires the policy and leadership to match.

A Policy Blueprint for Sustainable Innovation

Solving the crisis demands structural change. Policymakers can act now by:

- **Incentivising cross-setting labour sharing:** In the USA, Medicare and Medicaid should reward organisations that maintain shared labour pools across settings—acute, post-acute and home health.
- **Funding interoperable workforce platforms,** especially for rural and under-resourced providers.
- **Establishing a national credentialing exchange:** like TSA PreCheck, create a fast, trusted, portable credentialing process for healthcare workers that spans states and settings.
- **Creating reimbursement pathways** for predictive, AI-driven staffing.
- **Including workforce tools in emergency preparedness planning** to handle crises rapidly and equitably.

The Ripple Effect: A Smarter System for All

When systems work better, so do people. Benefits extend far beyond the shift schedule:

- predictable schedules, reduced burnout, better work-life balance, respect and recognition—for clinicians;
- less time spent on logistics, lower labour costs, clear data decision-making—for administrators;
- improved continuity of care, better outcomes and deeper trust in the system—for patients.

This is about more than staffing: it's about rebuilding the social contract of care.

Beyond Staffing: A Cultural Renaissance

Stepping back, this shift is not just operational—it's philosophical. It raises the question:

- What if staffing became a strategy, not a crisis?
- What if nurses were stakeholders, not just shift-fillers?
- What if operational excellence and human dignity were not opposing forces, but two sides of the same coin?

“This is not just efficiency—it's foresight.”

Leadership in Action: From Crisis to Resilience

This is a call for new models of leadership—ones that favour innovation over inertia and design centred on the end user: be it a nurse, a scheduler or a patient.

Effective leadership today means:

- **Courage to innovate,** even if it means letting go of legacy systems.
- **Designing with empathy,** making sure every solution starts with the user—whether it's a nurse, a scheduler, a resident or a patient;
- **Prioritising collaboration over competition,** integrating systems and partners across facilities, regions and disciplines;
- **Ensuring equitable access** to modern tools for rural and underserved communities.

With the right leadership, healthcare can shift from reactive firefighting to proactive foresight.

This is the potential of human-centred innovation: not patching old problems, but rethinking the entire system.

Looking Ahead: What Comes Next?

This is just the beginning. As technology continues to mature, so will its applications in workforce management:

- Predictive analytics for outbreaks or seasonal surges;
- Credential-aware scheduling, including languages and qualifications;
- Dynamic, responsive pay models;
- Integrated, AI-driven platforms connecting clinicians and facilities directly.

But even as we look to the future, we must stay grounded in one eternal truth: **Technology is only as good as the heart behind it.** It must serve the mother on night shift, the overwhelmed coordinator, the patient seeking comfort.

What Success Could Look Like: The Vision for 2030

By 2030, the vision is clear: schedules that build themselves, teams coordinated across systems, caregivers who feel valued and safe. In Europe, public health systems such as the NHS, France's Sécurité Sociale and Germany's GKV are well placed to lead this shift. With unified structures and aligned goals, they can deploy workforce technology quickly and inclusively.

We are already seeing progress. AI-driven staffing pilots in the NHS, deployment of machine learning for workforce planning in Germany and cross-border credential sharing in France and Italy all point to a new era of care delivery. It's not just possible—it's happening.

The infrastructure is ready. The technology is proven. The mandate is clear.

Now is the time to act—to protect the heart of healthcare by protecting those who provide it. The systems we build now will shape the care we deliver tomorrow. Let's make them worthy of the people at the centre of it all.

Conflict of Interest

None

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