EUROPEAN HOSPITAL & Healthcare MANAGEMENT

Issue 06 | 2025 | www.europeanhhm.com

Redefining Strategic Planning for Modern Healthcare

Max Grenz

Global Head of Value Creation,
Siemens Healthineers Consulting

SIEMENS Healthineers

Redefining the Pulse of Modern Healthcare

Welcome to this transformative edition of ***European Hospital & Healthcare Management,*** where we explore how innovation, strategy, and compassion are converging to redefine the future of care. As the industry navigates unprecedented challenges ranging from demographic shifts and workforce shortages to digital disruption and rising patient expectations, this issue offers an essential guide to transforming healthcare systems into resilient, patient-centered, and future-ready models of care.

This issue brings a panoramic view of healthcare's evolution at the intersection of technology, strategy, and humanity. From artificial intelligence revolutionising diagnostics to remote patient monitoring reshaping care delivery, we explore how digital tools are driving efficiency, accuracy, and accessibility across the healthcare continuum. Editorials such as **"The Healthcare Workforce in the Age of AI" and "How AI Is Shaping the Future of Diagnostic Accuracy in Real-World Care"** examine how technology can complement human expertise, reduce burnout, and empower clinicians to deliver more personalised care.

At the heart of this edition lies our exclusive feature with **Max Grenz,** Global Head of Value Creation at **Siemens Healthineers Consulting.** In an insightful discussion, Grenz demonstrates what effective strategic planning truly means when it is grounded in real-world challenges. From demand-driven infrastructure design to seamless post-opening operational readiness, his approach transforms vision into tangible value, closing the gap between boardroom strategy and bedside care. In an industry where too many plans remain theoretical, this strategy delivers results.

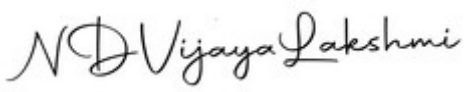
As you journey through these pages, you'll discover thought leaders, innovators, and clinicians pushing boundaries from **Dr. Daniel Morillo,** exploring the promise of liquid biopsy in lymphoma care, to **Bruno Virieux,** detailing how AI-powered digital twins are transforming vascular interventions. **Dr. Aravind Kumar Radhakrishnan's** insights on nationwide tele-ECG monitoring and Simos **Kedikoglou's** exploration of diagnostic precision further highlight how innovation is making care more proactive, predictive, and patient-centered.

Patient-centricity runs as a unifying thread through this edition. Features like **"A Patient-Centric Bridge"** and **"Digital Strategy for Healthcare Organisations"** underscore how digital transformation must remain rooted in empathy, ethics, and accessibility. As Diaa ElDin Helmy of Oracle reminds us, patient care must evolve without losing the human touch, a balance that defines the most successful healthcare systems of tomorrow.

This edition is a roadmap for building adaptable, data-driven, and compassionate healthcare systems that serve both patients and practitioners alike. It highlights how the thoughtful integration of technology, strategic planning, and human-centered care can come together to create resilient networks capable of meeting the complex challenges of today and tomorrow. Ultimately, the future of healthcare will be defined by coordinated, intelligent actions that bring lasting value and improved outcomes for all.

We invite you to engage with these insights and join us in shaping a healthier, more connected future.

Stay connected!



N D Vijaya Lakshmi
Editor

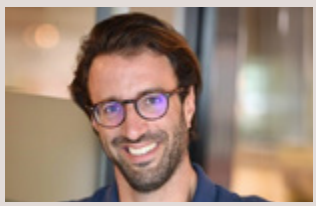
CONTENTS

CoverStory

36 Redefining Strategic Planning for Modern Healthcare

Max Grenz,
Global Head of Value Creation,
Siemens Healthineers Consulting

ExpertTalk



EUROPEAN HOSPITAL **& HEALTHCARE** MANAGEMENT

EUROPEANHHM with its keen interest across the length and breadth of the healthcare world aims to provide premium, cutting-edge & reliable healthcare content to its subscribes base in the European region.

Ochremedia

HEALTHCARE MANAGEMENT
These days, healthcare management is in extremely high demand

MEDICAL SCIENCES
As a result of the development of medial sciences, we are now enjoying better and long lives.

SURGICAL SPECIALITY
Patients are treated for greater health in the surgical discipline of medicine

DIAGNOSTICS
One of the most valuable markets in the world is the diagnostics sector.

TECHNOLOGY EQUIPMENT
Healthcare providers have been compelled to look for cutting-edge technologies

FACILITIES OPERATIONS
It's crucial to have a wide range of operations & facilities to give patients better treatments.

INFORMATION TECHNOLOGY
With its Healthcare IT Solutions, information technology has propelled the healthcare sector.

EUROPEAN HOSPITAL & Healthcare MANAGEMENT

www.europeanhhm.com

EUROPEAN HOSPITAL & Healthcare MANAGEMENT

EDITOR
Vijaya Lakshmi N D

EDITORIAL TEAM
Sarah Richards
Debi Jones
Harry Callum
Supraja BR
Samatha CH
Santhosh CH

ART DIRECTOR
M Abdul Hannan

PRODUCT MANAGER
Jeff Kenney

SENIOR PRODUCT ASSOCIATES
Santhosh Gaddam
David Nelson
Peter Thomas

BUSINESS EVENTS
Sussane Vincent

CIRCULATION TEAM
Sam Smith

SUBSCRIPTIONS IN-CHARGE
Vijay Kumar Gaddam

HEAD-OPERATIONS
Sivala VNR

EUROPEAN HOSPITAL & Healthcare MANAGEMENT
www.europeanhhm.com

Ochremedia®
Ochre Digi Media
www.ochre-media.com

Magazine Subscribe

LinkedIn

The Healthcare Workforce in the Age of AI

Healthcare faces unprecedented workforce shortages, which are worsened by burnout and systemic inefficiencies. AI has the potential to help mitigate some of these challenges. This article explores how AI can serve as a catalyst to reimagine roles, workflows, and leadership. It urges leaders to be brave and act decisively to redesign a system for the healthcare teams of tomorrow

Dr. Dipu Patel

DMSc, ABAIM, MPAS, PA-C, Department of PA Studies, University of Pittsburgh

Dr. David C. Beck

Jr., EdD, MPAS, PA-C, DFAAPA, School of Health and Rehabilitation Sciences, University of Pittsburgh

Healthcare is at an intersection of complexity and urgency. Technology, hybrid care models, global instability, rising costs, and workforce shortages are forces that are rapidly shaping our tomorrow. Systems that were designed for stability are being tested by technology and innovation. Clinicians are confronted with outdated infrastructure and evolving patient expectations. And the pressure to do more and care more is driving burnout at exponential rates. How do we address these challenges?

Healthcare leadership today means being brave enough to redesign and rethink what we once fought hard to build.

The current system is not only no longer sustainable; it doesn't work for anybody-not the patients, not the clinicians, not the educators, not the payors, not public health, and not the health systems.

Artificial Intelligence (AI) is here, and it is changing how we do everything. It has become the catalyst for changes in our workflows, diagnostics, and our clinical decisions. The emergence and adoption of AI demands that we reimagine roles, rethink leadership, and redesign education for a workforce that must adapt faster than ever before.

This article aims to explore the future of the healthcare workforce through the lens of education, technology, emerging interdisciplinary teams, talent and leadership development, and the evolving roles of the next generation of healthcare professionals. Healthcare has evolved to recognise the experiences and expertise of team members as essential to delivering safe, equitable, and patient-centered care. This progress is continuing as current and future generations of clinicians not only have to be collaborative and agile, but they will have to increasingly thrive in a world where humanity and AI must not compete but

complement care delivery. We need leaders bold enough to ask, What must we unlearn to learn again?

Rising costs of healthcare increase pressure on the workforce to be more efficient and productive. The most pressing issues in healthcare fall into several areas, as noted by Sandeep Reddy in a HIMSS article,

"Shortage of healthcare professionals: Many countries face a shortage of doctors, nurses, and other healthcare workers, leading to increased workload and burnout.

Uneven distribution of healthcare resources: Rural and underserved areas often struggle to attract and retain healthcare professionals.

Rising healthcare costs: The increasing cost of healthcare puts pressure on the workforce to become more efficient and productive.

Administrative burden: Healthcare professionals spend a significant amount of time on paperwork and administrative tasks, thereby reducing the time available for patient care."

According to the Association of American Medical Colleges, the healthcare workforce is slated to have a shortage of up to 124,000 physicians by 2034. The American Nurses Association estimates that it needs more than 1.1 million new nurses by 2030. These shortages are particularly acute in rural communities where the need is the greatest. The COVID-19 pandemic not only revealed these fractures in access to care but also increased burnout among clinicians.

A McKinsey article noted that 20% of a nurse's shift could potentially be freed up through the use of technology.

While clinicians are not engineers, we will need to collaborate with each other as part of our healthcare teams. Therefore, a mutual understanding of language, goals, and functions of each team member will be crucial to successful patient outcomes

Administrative burden is one of the most significant contributors to healthcare workforce attrition. Healthcare professionals feel overworked and overwhelmed by administrative tasks. They spend a significant amount of time documenting, making phone calls for authorisations, or coordinating care, which takes away from direct patient care. These administrative tasks diminish job satisfaction and increase turnover.

To address some of these issues, we have to embrace technology as a tool to inform us on how to leverage human skills while mitigating risk. In short, we must look at new ways of building the entire talent pipeline. This requires a fundamental shift in how we recruit, educate, and mentor. Organisations need to consider alternative pathways like apprenticeships, stackable credentials, and community-based programs to "meet the learners where they are." Furthermore, leaders need to identify skills gaps and upskill based on the needs of the organisation, but also for the various health professions. The integration of AI demands new skills, the need for tailored training and development opportunities based on profession, skill set, and preferences. Employees are ready to utilise AI. According to AI in the workplace: A report for 2025 by McKinsey, almost half of the survey respondents want more formal training, yet more than a fifth reported receiving minimal to no support. In addition to identifying skill gaps, AI can aid in providing customised professional development, such as coaching for teams and individuals, AI-powered simulations for procedural training, and providing feedback for various medical tasks.

Medical education should incorporate AI into the curriculum so that students are well prepared and the workforce is ready to use AI tools and technologies in a strategic and educated manner. While clinicians are not engineers, we will need to collaborate with each other as part of our healthcare teams. Therefore, a mutual understanding of language, goals, and functions of each team member will be crucial to successful patient outcomes. Just as we have expanded our definition of healthcare teams in practice, we will once again need to redefine the healthcare teams of the future to include computer scientists, data scientists, and data engineers. ▶

Digital platforms and AI are vital to scaling training initiatives. This is particularly important as the World Health Organisation (WHO) predicts that there will be a global shortage of 4.3 million physicians, nurses, and health professionals by 2030. The urgency of this workforce gap should be an alarm bell to think of how technology can support education. While some organisations currently lack the infrastructure and expertise for AI implementation, the use of AI in education is evolving, and attention should be paid to addressing and advancing this shifting ecosystem. The digital healthcare ecosystem will bring about new workforce roles such as AI navigators, digital scribes, and virtual care coordinators. The streamlining of traditional roles like administrative assistants, appointment schedulers, and data entry will be replaced by AI-powered tools. This will open up new opportunities for innovation that will complement human expertise, rather than replace it. Human expertise and human touch will be more important in the era of AI and digital healthcare.

Furthermore, clinical workflows enhanced by AI will improve patient outcomes and the delivery of precision medicine. AI algorithms are already being used in certain specialities to improve diagnostic accuracy, such as X-rays and CT scans to detect more minute abnormalities and in colonoscopies to detect polyps. These algorithms don't replace the specialists but rather help triage urgency and improve accuracy, augmenting human expertise.

Perhaps the greatest impact of AI in the immediate future will be risk prediction. For example, by reviewing large datasets, algorithms can identify patients at high risk of developing sepsis or opioid dependency after surgery. Another area of research is stroke classification. One study published in 2023 by Miyamoto et al. showed that a trained AI algorithm was able to classify the type of stroke with high accuracy. This has the potential to decrease time to treatment and

AUTHOR BIO

Dipu Patel, DHSc, PA-C is Vice Chair for Innovation and Professor at the University of Pittsburgh, bringing over 24 years of experience in medical education and healthcare innovation. Her leadership spans academic institutions and health tech startups, where she has led provider-driven, patient-centered clinical pathway initiatives. At the University of Pittsburgh, she focuses on quality improvement, digital health, innovation, and the integration of artificial intelligence in clinical practice and education. Dr. Patel is ABAIM-certified and passionate about bridging clinical expertise with technology to enhance patient care and education—while preserving the human touch at the heart of healthcare.

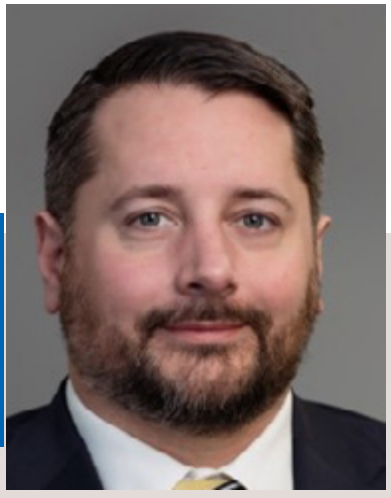
improve patient outcomes. Additionally, AI can assist in developing personalised treatment plans based on a patient's medical history and genetic information. As noted by Saeed et al., "Implementation of AI-driven decision-support tools led to decreased medical errors by 20% together with enhanced treatment efficiency reaching up to 15% thus proving their value in workforce performance optimisation."

The time and cognitive burden saved by AI will enable healthcare professionals to focus on higher-order, strategic, and human-centric work. This will allow for professionals to provide more attention, guidance, and coaching for patients; the reason we all got into healthcare in the first place.

Healthcare leaders should encourage and foster a culture of AI use, where AI is viewed as a tool to augment work rather than replace human expertise. Concerns of job displacement will remain; emphasis on enabling humans to engage in impactful and meaningful work is the key to balancing the success of AI implementation and scaling. The "human in the loop" is crucial. Many studies have shown a positive correlation between the quality of the provider-patient relationship and health outcomes, and AI is one tool that can be used to improve upon those trends.

In conclusion, the healthcare systems of tomorrow will need a workforce that is not only AI-ready but also AI-agile and able to flex their human capabilities by leveraging AI tools for true human-centered care. Leaders of health systems and educators need to ensure that current and future clinicians are prepared for this new ecosystem. Building the AI-healthcare talent pipeline for the future requires a multi-pronged and human-centered approach. This includes using AI to streamline recruitment and retention, but also personalised and continuous education and upskilling for all members of the healthcare team. AI can help us deliver high-quality, patient-centered care while enhancing clinician well-being. We just have to be brave enough to reimagine the system. ■

References are available at www.europeanhhm.com



AUTHOR BIO

David Beck, MD, MPH is a clinician, educator, and healthcare leader with over 20 years of experience dedicated to advancing health professions education and driving healthcare innovation. An award-winning and internationally recognized expert, his work focuses on quality improvement, interprofessional collaboration, and professional development. Dr. Beck is committed to transforming healthcare education through evidence-based strategies and team-based approaches to care.

Patient-Centric Healthcare Delivery

Blending Technology with a Human Touch

Inspired by The Future of Care and brought to life through the ConsultCare app, this article shows how smart, connected healthcare can put patients first. From real-time medical access and global emergency help to seamless record sharing, it's about making care faster, safer, and more personal—anytime, anywhere.

Diaa ElDin Helmy
Sales Director & Advisor at Oracle, Saudi Arabia

Healthcare has never been more advanced and yet, paradoxically, never more fragmented. Across Europe, we can perform robotic-assisted surgeries, use AI to detect early cancers, and carry out genetic sequencing that personalises therapies. But for many patients, the day-to-day experience still involves long waiting times, incomplete records, and a sense of being lost in the system.

Take the story of an elderly woman who rushed to the hospital in a foreign country for a cardiac procedure. The local clinicians, skilled and well-intentioned, were prepared to operate. What they lacked was her complete history. Unknown to them, a prior diagnosis meant the procedure could put her life at risk. By sheer persistence, her family managed to provide the missing records, changing the care pathway and averting harm.

This case highlights a painful truth: healthcare too often works around patients, not with them. At a time when people move freely across European borders for work, study, or travel, and when digital innovation is at our fingertips, it is unacceptable that critical information is trapped in silos.

Patient-centric healthcare delivery offers a way forward. It is about more than apps or portals—it is about rethinking healthcare systems so that patients are partners, not bystanders, in their own care. That vision underpins both the book The Future of Care: A Digital Roadmap for Healthcare Systems and the ConsultCare platform, a digital health companion designed to restore humanity and safety in healthcare delivery.

The Problem Context: Why Fragmentation Hurts

Across Europe, healthcare systems face three interlinked crises: rising demand, workforce shortages, and unsustainable costs. However, underlying these is an information problem: fragmented, siloed, and inconsistent patient data.

From the patient's perspective

Imagine being a diabetic living in Paris, travelling to Lisbon for work. Your health record, labs, prescriptions, and imaging are stored in French systems, formatted for local use, and often inaccessible to Portuguese doctors. If you fall ill abroad, clinicians may treat you without crucial knowledge of your condition.

The stress of repeating histories, undergoing duplicate tests, or worrying about whether doctors know your allergies adds to the burden of illness. For many patients, especially migrants, expatriates, or frequent travellers, this is a daily anxiety.

From the provider's perspective

Clinicians face their own frustrations. Studies show doctors in Europe can spend up to 40% of their time on documentation and coordination tasks—time that could be spent with patients. When systems do not "talk" to each other, tests are repeated, prescriptions duplicated, and workflows disrupted.

This administrative overload contributes directly to burnout, a growing crisis across Europe. According to the European Hospital and Healthcare Federation (HOPE), nearly one in three healthcare professionals reports symptoms of exhaustion. The lack of integrated tools is not just inefficient, it is harmful to those delivering care.

From the system perspective

Fragmentation is also expensive. A 2019 OECD report estimated that 20% of healthcare

spending is wasted on inefficiencies such as unnecessary tests, avoidable hospitalisations, and administrative duplication. For governments already under financial strain, this is unsustainable.

Put simply: fragmentation undermines safety, drains resources, and erodes trust.

ConsultCare: A Patient-Centric Bridge

ConsultCare was designed as a direct response to these challenges. Unlike many health apps that target only one slice of the patient journey, ConsultCare is built as a comprehensive, patient-first ecosystem.

Its guiding principle is simple yet transformative: the patient should never be strangers in their own healthcare story.

ConsultCare was co-developed with input from clinicians, technologists, and patients themselves. Its design emphasises accessibility, security, and cultural sensitivity, recognising Europe's diversity. More than a digital record, it is a companion—an intelligent, mobile, and adaptable platform that empowers patients while reducing the burden on providers.

Core Features and Human Impact

ConsultCare's features go beyond technology; they reflect real-life needs. Each addresses a challenge that patients and providers face daily.

1. **AI Health Assistant**

   What it does: Provides 24/7 multilingual support, offering symptom triage, medication reminders, and tailored guidance.

   Human impact: A mother in Berlin, unsure about her child's fever at night, can receive reassurance or advice on whether to seek urgent care—without waiting until morning.

2. **Global Emergency Toolkit**

   What it does: Stores a secure offline health summary, integrates local emergency numbers, and uses GPS to navigate to nearby hospitals.

   Human impact: A traveller in Rome collapses from a chronic condition. First responders instantly access her allergy and medication details via ConsultCare, ensuring safe, informed treatment.

3. **Interoperability with EHRs**

   What it does: Built on HL7 FHIR standards, it integrates with major European health record systems.

   Human impact: A diabetic patient moving from Warsaw to Amsterdam can carry their entire medical history seamlessly, ensuring continuity of care.

> Fragmentation undermines safety, drains resources, and erodes trust; connected care is no longer optional, it is imperative.

4. **AI-Powered Documentation**
   What it does: Generates structured notes during consultations, integrating them into EHRs.
   Human impact: A GP in Madrid spends less time typing and more time listening, restoring the personal connection that patients crave.
5. **Patient-Reported Outcomes (PROs)**
   What it does: Collects ongoing well-being data directly from patients, feeding it back into care pathways.

   Human impact: A cancer survivor in Copenhagen can log fatigue levels weekly, enabling early intervention before hospitalisation becomes necessary.
6. **Multilingual and Culturally Adapted UX**
   What it does: Offers interfaces and health information tailored to language and culture.
   Human impact: A Syrian refugee in Athens can understand treatment plans in Arabic, improving adherence and trust.
   What it does: Offers interfaces and health information tailored to language and culture.
   Human impact: A Syrian refugee in Athens can understand treatment plans in Arabic, improving adherence and trust.

Each of these features embodies the philosophy that healthcare should adapt to the patient—not the other way around.

Strategic Relevance for European Healthcare

Europe has long championed universal access and equity in healthcare, but the reality of fragmented records undermines these ideals. The European Health Data Space (EHDS), currently under development, aims to fix this by enabling secure, cross-border sharing of health data, and ConsultCare is perfectly aligned with this agenda. By ensuring patients can carry their health summaries anywhere, ConsultCare enhances safety across borders so that, no matter where in the EU a person falls ill, critical data is available immediately. At the same time, automation within the platform reduces administrative load on clinicians,

helping to address workforce burnout in a sector already facing critical shortages. This efficiency directly translates into more time for meaningful patient interactions. Furthermore, ConsultCare's multilingual interfaces and culturally adapted education tools promote equity and inclusion by ensuring vulnerable groups—such as migrants, refugees, and minority communities—are not left behind. This approach reflects EU values of inclusivity and solidarity. Finally, by enabling systems to respond quickly and flexibly, ConsultCare strengthens preparedness. From pandemics to migration crises, European health systems must be resilient, and digital innovation of this kind enhances both agility and public trust.

Lessons for European Leaders

For policymakers, hospital managers, and investors, several lessons can be drawn from the ConsultCare approach. Technology must always serve humanity, and the most successful innovations are those that make care safer, easier, and more compassionate. Empowerment also drives adoption, since patients are far more likely to embrace platforms when they see tangible benefits such as safer travel or easier communication with their providers. Interoperability is equally essential; no platform can succeed in isolation, and collaboration across standards and systems must be prioritised if Europe is to achieve a truly connected healthcare ecosystem. Equity should be treated as a strategic imperative, as Europe's diversity is its strength and digital health must reflect it by ensuring access and usability for all communities. Finally, preparedness must be viewed as both an ethical and operational responsibility. Whether responding to health crises such as pandemics or supporting routine cross-border care, systems need to be ready to deliver safe, patient-first solutions. Together, these lessons highlight the path towards building more resilient, inclusive, and human-centred healthcare systems across Europe.

Conclusion: Towards 2030

Europe stands at a pivotal moment. With the EHDS, digital health innovation, and a renewed commitment to equity, the continent has the opportunity to create the most patient-centric health system in the world.

Imagine the year 2030: a patient in Brussels, travelling to Prague for work, collapses with a chronic condition. Within seconds, paramedics access her complete health history through a secure, patient-controlled platform. Doctors treat her with full context, avoiding errors. Her family, notified through the app, feels reassured. Meanwhile, her clinicians at home receive real-time updates.

This is not science fiction—it is the logical outcome of combining technology with human-centred design. ConsultCare offers a glimpse of this future.

Patient-centric healthcare delivery is no longer a slogan; it is a moral and operational

imperative. By embracing platforms that bridge gaps, empower patients, and support providers, Europe can set a global standard for safe, inclusive, and sustainable care.

The future of care is not about replacing doctors with machines. It is about giving both doctors and patients the tools they need to make healthcare more humane. ConsultCare is one such tool. The responsibility now lies with leaders, innovators, and investors to ensure that every European can say, with confidence: my health system sees me, knows me, and cares for me. ■

References are available at www.europeanhhm.com

AUTHOR BIO

Diaa ElDin Helmy is a digital transformation strategist with over 23 years of experience delivering innovative solutions in healthcare and public services. As Sales Director for Consulting at Oracle Saudi Arabia, he specializes in AI, cloud, and ERP technologies. Passionate about improving healthcare outcomes, Diaa holds an MBA and advanced certifications in healthcare IT.

Liquid Biopsy in Lymphoma

Promise, Pitfalls, and the Path Ahead

Liquid biopsy is redefining cancer diagnostics by enabling non-invasive molecular profiling and real-time monitoring through circulating tumor DNA (ctDNA) analysis. Its role in hematological malignancies—including lymphomas—is increasing due to its transformative potential.

In lymphomas, liquid biopsy offers distinct advantages over traditional methods such as lymph node and bone marrow biopsies, which are invasive and can be limited by sample accessibility. Its potential to detect minimal residual disease (MRD), guide treatment decisions, and predict relapse is particularly relevant for diseases with aggressive or heterogeneous behavior.

This article examines the emerging role of liquid biopsy in lymphoma and clinical trials. It also highlights the operational, technical, and regulatory hurdles that must be addressed for broader adoption.

Dr. Daniel Morillo

Hematologist and Clinical Investigator at START Madrid-FJD

Liquid Biopsy in Hematological Malignancies: A Growing Opportunity

Liquid biopsy refers to the detection of tumor-derived genetic material—primarily ctDNA—in body fluids, most commonly blood. In hematological malignancies, this technique holds promise for disease characterization, monitoring, and therapeutic decision-making without the need for repeated invasive procedures.

Compared to standard methods such as lymph node excision or bone marrow aspiration, liquid biopsy is less burdensome for patients and allows for serial sampling over time. This opens the door to dynamic disease tracking, which is critical in fast-evolving conditions like lymphoma. Furthermore, ctDNA levels have been shown to correlate with tumor burden and treatment response, and in some subtypes, offer earlier signals of relapse than imaging alone.

As technologies improve and data accumulates, liquid biopsy is increasingly being positioned not just as a research tool but as a clinically actionable adjunct in lymphoma care.

Clinical Applications in Lymphoma

In clinical practice, liquid biopsy is being increasingly explored in the management of B-cell lymphomas, particularly diffuse large B-cell lymphoma (DLBCL) and follicular lymphoma. In addition, ctDNA assays are in use in clinical practice for both response assessment and disease surveillance in these subtypes, where they complement—but do not replace—conventional imaging.

Studies have demonstrated that ctDNA dynamics—such as early molecular response or persistent ctDNA after initial therapy—can offer prognostic value beyond conventional imaging. In particular, liquid biopsy may aid in distinguishing true progression from post-treatment inflammation, reducing the risk of overtreatment or unnecessary biopsies.

In DLBCL, ctDNA clearance within the first few treatment cycles has been associated with superior progression-free survival, suggesting its potential use as an early surrogate marker. Similarly, in follicular lymphoma, ctDNA levels can help monitor transformation risk and detect molecular relapse before clinical symptoms emerge.

Serial monitoring is particularly valuable. Liquid biopsy is being used to track disease evolution across cycles, offering clinicians a dynamic view of response over time. This supports timely decision-making and enhances

confidence in treatment continuation or escalation when imaging is ambiguous.

There is also growing interest in applying liquid biopsy to peripheral T-cell lymphoma (PTCL), a rare and clinically challenging group of lymphomas with limited treatment options and poor outcomes. Recognizing the urgent need for better monitoring tools in PTCL, a dedicated project is currently underway at START Madrid-FJD to develop and validate ctDNA panels specific to T-cell subtypes. These efforts aim to improve early response assessment and disease surveillance in a patient population that often lacks reliable biomarkers. By tailoring liquid biopsy applications to the molecular characteristics of PTCL, clinicians hope to enable earlier interventions and more precise treatment adaptation.

Although laboratory workflows sometimes result in delayed reporting due to sample batching, the clinical value of liquid biopsy remains clear—especially when paired with imaging for a more comprehensive assessment. As experience builds, these insights are shaping a more refined and proactive approach to lymphoma care across both B-cell and T-cell subtypes.

Use in Clinical Trials

While liquid biopsy is gaining traction in clinical practice, its integration into clinical trial design has lagged behind its potential. Many ongoing lymphoma trials include liquid biopsy as an exploratory endpoint, but ctDNA results are often used retrospectively rather than to guide real-time decision-making.

In most clinical trials, ctDNA data is typically collected, processed centrally, and reported back weeks later—well after key therapeutic decisions have already been made. This time lag limits the clinical utility of liquid biopsy within the trial context and misses opportunities to adapt treatment based on early molecular response. Nevertheless, its use in late-phase clinical trials is steadily increasing, with ctDNA beginning to inform treatment-driven decisions, marking a shift from retrospective analysis toward prospective clinical relevance.

An ideal trial design would incorporate liquid biopsy into predefined decision points—such as escalation or de-escalation of therapy based on ctDNA clearance. Adaptive trial frameworks that integrate molecular response as a trigger for randomisation or treatment change could improve precision and accelerate outcomes.

Moreover, liquid biopsy could aid in patient stratification, identifying high-risk molecular signatures that warrant alternative therapeutic approaches from the outset. Used this way, ctDNA would not only be a tool for monitoring but a lever for real-time personalisation.

These possibilities are increasingly supported by emerging trial data, yet adoption remains slow. For broader implementation, sponsors must be willing to invest in faster laboratory workflows, decentralised testing

models, and standardised interpretation protocols. As feedback from trial centers accumulates, there is growing recognition that liquid biopsy should evolve from a passive data collector to an active driver of trial decisions.

Clinical Decision-Making and the Case for Broader Adoption

Liquid biopsy has the potential to transform how clinicians evaluate remission, progression, and therapeutic response in lymphoma. One area of particular interest is its role in guiding treatment de-escalation. For patients who achieve ctDNA-negative remission, there may be an opportunity to reduce or avoid further cycles of chemotherapy or radiation, thereby minimising toxicity without compromising outcomes.

This concept mirrors the use of MRD as a decision-making tool in multiple myeloma and other hematologic malignancies. In lymphoma, especially for patients with deep metabolic responses on PET, ctDNA negativity could serve as an added layer of reassurance before scaling back therapy. Conversely, rising ctDNA levels may signal molecular relapse ahead of radiological evidence, enabling earlier intervention.

Clinicians are already exploring such scenarios, using liquid biopsy results to support or challenge treatment continuation in ambiguous cases. These insights help refine decisions in real-time, especially when imaging alone leaves clinical uncertainty. Importantly, liquid biopsy does not replace standard modalities but adds molecular precision to existing tools.

Broader adoption will likely depend on further validation of ctDNA thresholds, greater availability of rapid testing workflows, and integration into clinical guidelines. As use cases expand across lymphoma subtypes, liquid biopsy may evolve from an adjunct into a routine decision-support tool in frontline and relapsed/refractory settings alike.

Challenges to Implementation

Despite promising clinical applications, several barriers continue to limit the widespread integration of liquid biopsy into routine lymphoma care.

One major challenge is the lack of standardised gene panels and reporting thresholds. Currently, most hospitals and institutions develop in-house assays, leading to variability in test design and interpretation. This lack of harmonisation complicates data comparison across centers and hampers efforts to generate universally accepted clinical guidelines.

In addition, operational logistics remain a hurdle. Due to batching requirements for cost-efficiency, turnaround times are often delayed, reducing the value of liquid biopsy for real-time clinical decision-making. This issue is particularly relevant in public health systems where reimbursement policies may not yet accommodate regular testing required for serial monitoring. ▶

There is also a need for more consensus on what constitutes a clinically meaningful ctDNA signal. Without agreed-upon cutoffs for positivity, clinicians are left to interpret results in relative terms, which introduces subjectivity into treatment decisions.

Addressing these barriers will require multi-institutional collaboration, technical standardisation, and policy engagement. Initiatives such as the development of standardised panels for broader use (e.g., EuroClonality-NDC), which aim to align assay design, validation, and reporting practices across institutions, represent critical steps toward widespread clinical implementation.

Outlook and Conclusion

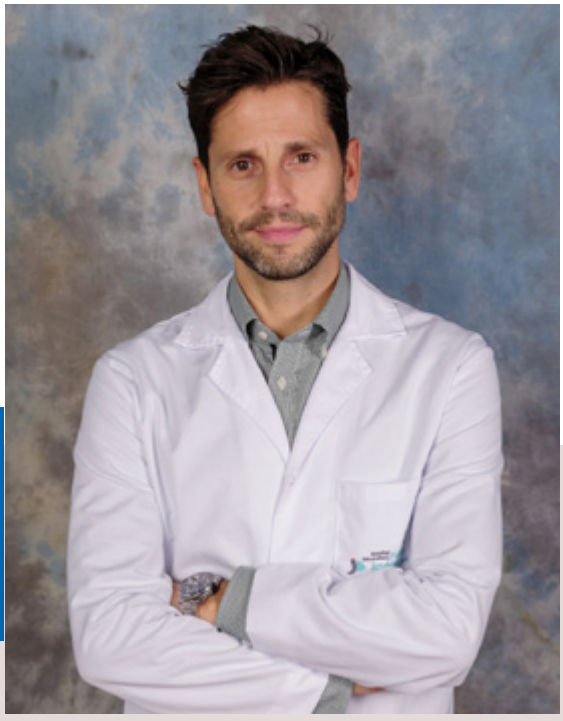
The promise of liquid biopsy in lymphoma is no longer theoretical. Its applications—from molecular monitoring and risk stratification to clinical trial design—are already demonstrating value in real-world settings. Ongoing work is helping to define best practices and uncover use cases that go beyond conventional endpoints.

Looking ahead, broader adoption will depend on standardisation, accessibility, and scale. As assay technology matures and costs decline, ctDNA testing could become a routine part of lymphoma management and in clinical trials to determine treatment endpoints, much like PET imaging or lymph node biopsies today. However, realising this vision will require coordinated efforts across oncologists, pathologists, regulators, and payers.

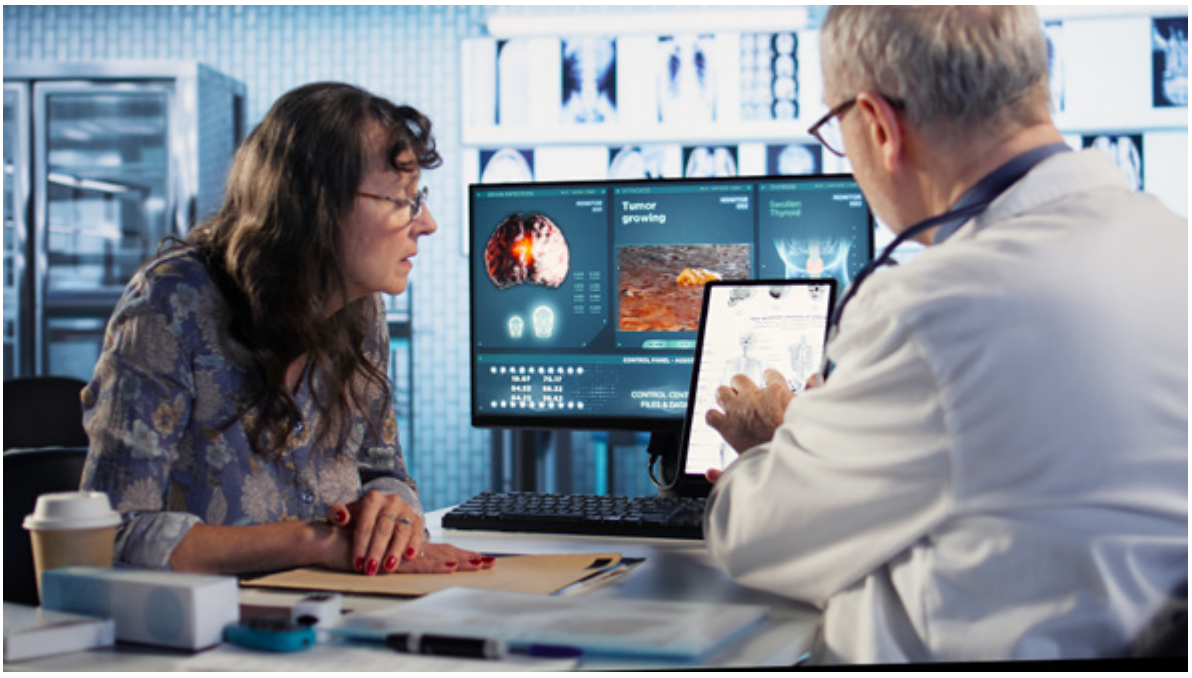
Crucially, liquid biopsy must be viewed not as a replacement but as a complementary layer of decision-making—one that brings molecular precision to the art of oncology. With the right infrastructure and frameworks, it has the potential to redefine remission, personalise therapy, and ultimately improve outcomes for patients with lymphoma. ■

References are available at www.europeanhhm.com

AUTHOR BIO



Daniel Morillo, MD, is a hematologist at START Madrid-FJD, dedicated to advancing new treatments for blood cancers. Since joining START in 2017, he has led more than 30 clinical trials aimed at bringing promising therapies to patients. His work offers hope to families today while contributing to the drug discoveries of tomorrow.



How AI Is Shaping the Future of Diagnostic Accuracy in Real-World Care

AI is transforming diagnostics by identifying subtle patterns, streamlining workflows, and accelerating time to diagnosis. This piece will explore how AI supports earlier and more accurate decision-making, the importance of clinical integration, and key considerations around trust, usability, and responsible deployment in real-world care settings.

Simos Kedikoglou

President and Chief Operating Officer, Anumana

Artificial intelligence (AI) has become one of the most closely watched developments in healthcare. By surfacing subtle patterns and providing immediate feedback, it can deliver clearer, faster insights that strengthen clinical decision-making and patient outcomes.

Nowhere is this impact more critical than in diagnostics. Many conditions are still missed or identified too late, contributing to unnecessary costs and preventable harm. AI offers a way to narrow these gaps by embedding predictive and diagnostic capabilities into tools clinicians already use every day. The aim is to reinforce medical judgment, helping physicians make

the right call earlier with greater confidence.

Realising this value requires more than technological breakthroughs. For AI to be trusted and adopted, it must integrate seamlessly into clinical workflows, be supported by rigorous evidence, and demonstrate value across varied clinical environments. Only then can it move from an experimental technology to a standard part of patient care.

The Challenge of Diagnostic Accuracy

Despite progress in imaging, lab testing, and clinical guidelines, and diagnostic errors remain among the most persistent challenges in medicine. In primary care, time constraints, incomplete histories, and overlapping symptoms contribute to missed or delayed diagnoses. In speciality care, the sheer volume and complexity of data—from imaging studies, lab panels, and patient records—can overwhelm even experienced providers.

These challenges have consequences. In cardiology, delayed detection of conditions such as heart failure can mean the difference between effective management and irreversible disease progression. Across oncology, neurology, and other specialties, the stakes are similarly high. As population's age and the burden of chronic disease grows, the demand for timely, more precise diagnoses will only intensify.

Why ECGs Demonstrate the Power of AI

Electrocardiograms (ECGs) provide a compelling case study for AI in diagnostics. They are simple, inexpensive, and ubiquitous, and are performed more than 200 million times annually in the United States alone. Yet, the richness of ECG data has historically been underutilized.

A human clinician can interpret rhythm disturbances or overt abnormalities, but an AI model can analyze tens of thousands of data points per recording, detecting patterns invisible to the human eye. For example, studies have shown that AI can flag signs of reduced ejection fraction, a marker of heart failure, even when the ECG appears normal to a trained cardiologist.

This capability transforms the ECG from a routine test into a powerful diagnostic tool. Instead of requiring multiple specialized exams, radiation exposure, or lengthy scheduling, AI-augmented ECGs can provide immediate insights in outpatient settings, such as primary care offices or rural clinics. This helps clinicians identify at-risk patients earlier, streamline referrals, and initiate treatment sooner.

Beyond clinical value, this approach has significant cost implications. Using a low-cost tool such as the ECG to guide which patients truly need advanced, invasive, or radiation-exposing confirmatory tests helps avoid unnecessary utilisation. At the population level, this lowers the overall cost of diagnosis while also driving savings by identifying disease earlier, when treatment is less intensive and less expensive.

Integrating AI into the Clinical Workflow

The success of AI in diagnostics depends on its ability to work within the natural rhythm of clinical care. A solution that requires physicians to step out of their normal process to access a separate system or manually upload data is unlikely to gain widespread adoption. The more friction there is, the more likely it is that even the most advanced tools will go unused.

Integration must be invisible. AI should surface insights within the systems clinicians are already using, whether that is an EHR, a diagnostic imaging viewer, or a laboratory-reporting interface. It should feel less like adding another step and more like enhancing an existing one. This approach not only improves adoption but also helps preserve trust. Clinicians remain in control of the decision-making process, with AI serving as a guide, not a replacement.

Equally important is speed and simplicity. Clinicians appreciate getting an output in seconds, which stands in contrast to the time it takes to gather multiple fragmented data points for traditional risk calculators. When something useful is that quick and straightforward, it is far more likely to be adopted into routine care.

Building Trust

Accuracy in diagnostics is not enough. AI must also be accessible, scalable, and most importantly, trusted.

For any new medical technology, credibility depends on evidence, and AI is no exception. AI solutions must undergo rigorous validation in diverse patient populations, across multiple care settings, and over extended time periods. This is essential not only for regulatory clearance but also for clinician confidence. It is not enough to demonstrate that an algorithm performs well in a retrospective dataset. We must show that it can improve outcomes when deployed in real-world settings, that it can reduce variability in care, and that it can be applied equitably across different demographic groups. Without this, AI risks becoming another promising technology that fails to leap from early adoption to standard practice.

Transparency is just as critical. Too often, AI is viewed as a "black box," producing results without clarity on how they are generated. Clinicians must be able to understand what the algorithm is analysing, where the data comes from, and how conclusions are reached. With clarity and evidence, AI can become ▶

> (AI) must show that it can improve outcomes when deployed in real-world settings, that it can reduce variability in care, and that it can be applied equitably across different demographic groups.

more than a technical achievement; it can be a reliable partner in clinical decision-making, one that strengthens the relationship between physician and patient.

Addressing Equity and Access

One of the most powerful aspects of AI is its potential to democratize access to high-quality diagnostics. In many parts of the world, access to specialist expertise is limited. Primary care providers often face the difficult task of managing complex cases without the benefit of timely specialist input. AI can help close this gap by embedding expert-level diagnostic capabilities directly into primary care tools.

However, this promise will only be realised if AI solutions are developed with equity in mind. Algorithms trained predominantly on data from well-resourced, urban populations may not perform as well in underserved or rural settings. This is why representative data is critical, not only to ensure fairness but also to maximise the clinical utility of AI for all patients.

From Prediction to Prevention

AI is beginning to change how medicine approaches disease, moving the focus from reacting to illness toward anticipating it. By detecting subtle changes in clinical data, this technology can highlight risks long before symptoms appear, giving physicians a window of opportunity to act earlier.

In cardiology, ECG-based algorithms have shown the ability to detect signals of heart failure years before conventional testing would detect them. Similar models are being developed in oncology to predict recurrence, or in nephrology to flag early kidney decline. These applications illustrate how prediction can inform care strategies across multiple specialties.

Most importantly, AI's ability to mine vast datasets for predictive signals has the potential to change the trajectory of many diseases. Earlier detection reduces the need for hospitalisations, intensive therapies, and late-stage interventions, helping health systems manage resources more effectively. Conditions that would have been diagnosed only at advanced stages can now be addressed proactively, turning potential crises into opportunities for timely intervention and shifting care toward prevention at scale.

The Path to Adoption

AI that works in the clinic, not just in the lab, is the AI that will define the future of diagnostics. However, long-lasting adoption depends on how well new tools fit into existing

roles, responsibilities, and systems of care. Some specialists express concern that shifting diagnostic capabilities upstream to primary care could reduce referrals. In practice, however, earlier detection often expands the need for speciality involvement, allowing experts to intervene at stages when treatment is most effective.

Health systems are also cautious, and rightly so. Any technology that informs clinical decisions must meet rigorous standards for safety, privacy, and effectiveness. Clear regulatory frameworks help balance innovation with patient protection, while ongoing validation ensures tools remain reliable across clinical settings. Transparency about how algorithms are developed, trained, and updated is equally important in building confidence among clinicians and patients.

Operational readiness is another determinant of success. Even the most intuitive solutions require training and change management to ensure they are applied consistently and appropriately. Supporting clinicians with the resources to integrate AI smoothly into their routines is essential. When regulatory, clinical, and operational requirements align, AI has the potential to move from early adoption to a lasting role in modern diagnostics

Looking Ahead

AI in diagnostics is beginning to move from promise to practice. The real measure of progress will be whether it can demonstrate consistent value across health systems, support clinicians without adding complexity, and reach patients in every setting where care is delivered.

If those conditions are met, AI will not change the role of physicians but strengthen it. By surfacing signals that would otherwise go undetected, it can help clinicians make decisions earlier, intervene more effectively, and manage disease before it advances. For health systems, this means more efficient use of resources; for patients, it means more years lived in better health.

True innovation is measured by its ability to improve patient outcomes at scale. With evidence, transparency, and thoughtful integration, AI can help create a healthcare model that is proactive rather than reactive, improving outcomes at both the individual and population level. ■

References are available at www.europeanhhm.com

AUTHOR BIO

Simos Kedikoglou is President and Chief Operating Officer at Anumana, an AI-driven health technology company pioneering ECG AI solutions for the early detection of heart failure. With extensive experience in medical device commercialization, healthcare strategy, and global operations, he leads Anumana's growth and strategic partnerships.

Telemedicine and Remote Monitoring for Nationwide ECG Network

Building a Scalable Cardiac Care Infrastructure in Liberia-West Africa

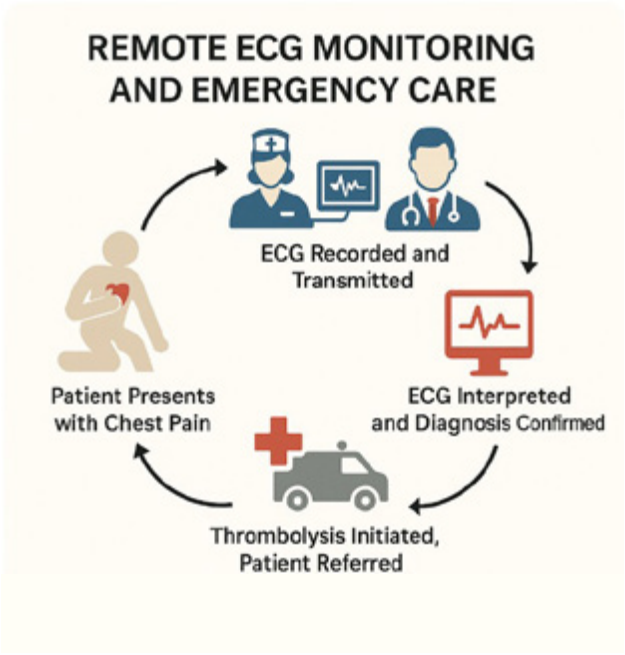
This article describes the development of a nationwide telemedicine-enabled ECG network linking all 15 Liberian counties to regional hubs and a tertiary cardiac center. By integrating remote monitoring, rapid ECG interpretation, and coordinated emergency response, the program enhances access to timely thrombolysis, builds capacity for cardiac services, and establishes the foundation for future catheterization laboratory infrastructure. This scalable model demonstrates how digital health and decentralized networks can transform cardiac care delivery in resource-constrained settings.

Dr. Aravind Kumar Radhakrishnan

Interventional Cardiologist & Associate, Mittal Institute at Harvard University

The Growing Burden of Cardiovascular Disease in Liberia

Cardiovascular disease (CVD) is a rapidly growing health challenge across Sub-Saharan Africa, yet most healthcare systems in the region remain underprepared for the increasing prevalence of ischemic heart disease. Liberia is no exception.



Emerging from years of civil conflict and the Ebola epidemic, the Liberian healthcare system has prioritised rebuilding primary care and infectious disease programs. However, non-communicable diseases such as hypertension, diabetes, and cardiovascular events now represent a significant—and growing—burden.

In acute myocardial infarction (AMI), early diagnosis and rapid treatment are critical. International guidelines emphasise the "golden hour," in which reperfusion therapy offers the greatest benefit. Yet in Liberia, the absence of routine ECG availability and limited cardiology expertise outside the capital has meant delayed diagnosis, late referrals, and preventable mortality. The challenge lies not only in the shortage of cardiologists but also in geography: Liberia's 15 counties include remote rural regions with poor transport and limited emergency services. This context makes a strong case for digital innovation and telemedicine-enabled cardiac care.

Why a Nationwide ECG Telemedicine Network?

Electrocardiography (ECG) is the cornerstone of cardiac diagnostics. An inexpensive, non-invasive test, the ECG can rapidly identify myocardial infarction, arrhythmias, and conduction disturbances. In high-resource settings, ECGs are ubiquitous, with near-instant access to cardiologists. In Liberia, however, the reality is starkly different: many county hospitals and clinics lack even a single functioning ECG machine, and few health workers are trained to interpret results.

A nationwide telemedicine ECG network aims to close this gap by connecting every county hospital in Liberia to centralised interpretation hubs staffed with trained personnel and supported by a tertiary referral center. This hub-and-spoke model ensures that even the most remote clinic can capture ECGs and transmit them digitally for expert review. The benefits are threefold: patients receive rapid diagnosis of acute coronary syndromes; county hospitals are guided to initiate thrombolysis before onward referral; and a centralised database allows long-term monitoring of chronic cardiac conditions for both clinical care and research.

Designing the System: Hub-and-Spoke Model

The proposed infrastructure links all 15 counties

into a three-tiered system. At the periphery, county hospitals and selected district health centers are equipped with portable digital ECG machines. These devices capture 12-lead ECGs, which can be uploaded securely using mobile or satellite internet. At the next level, designated regional hospitals serve as hubs, staffed with trained ECG technicians and general physicians who provide first-line reviews and coordinate patient transfers. Finally, the tertiary referral facility, ideally the John F. Kennedy Medical Center in Monrovia, acts as the national cardiac center. Staffed by cardiologists and emergency physicians, it is the final point of interpretation, treatment decision-making, and triage.

Data flows through a cloud-based telemedicine platform designed with redundancy and real-time feedback. Importantly, the system functions on an offline-first principle, automatically synchronising data once internet access becomes available in low-connectivity areas.

Remote Monitoring and Emergency Response Workflow

Consider a patient presenting to a county hospital with chest pain. The attending nurse records a 12-lead ECG within minutes, and the digital system uploads the tracing to the regional hub. A trained technician identifies a probable ST-elevation myocardial infarction (STEMI) and sends an alert to the tertiary center, where a cardiologist confirms the diagnosis. If the patient is eligible, thrombolysis can be initiated immediately at the county hospital—a

dramatic shift from the current system in which patients often wait hours or days for transfer. Once stabilised, the patient is referred onward to the tertiary hospital for advanced management.

This process transforms outcomes. A patient in remote Lofa County can access the same rapid diagnosis and life-saving treatment as one presenting directly to Monrovia. “Telemedicine transforms access to care, enabling rural clinics to deliver life-saving thrombolysis within the golden hour.”

Capacity Building: Training Healthcare Workers

Technology alone cannot achieve success; human capacity building is essential. A nationwide ECG program requires training for nurses, physician assistants, and general doctors. Modules include ECG acquisition and troubleshooting, recognition of acute coronary syndromes, protocol-driven administration of thrombolytics, and post-thrombolysis

monitoring with transfer procedures. Training combines in-person workshops with digital platforms and is structured in a "train-the-trainer" model. This ensures sustainability as local staff gradually take responsibility for training new cohorts, reducing dependence on external experts.

Digital Infrastructure and Data Security

The telemedicine platform operates on cloud-based servers with end-to-end encryption to ensure data privacy. Given the sensitive nature of health information, data sovereignty is prioritised, with hosting designed to comply with Liberian health regulations. The platform also creates a longitudinal patient registry. Every ECG and clinical note is stored, enabling long-term follow-up of patients with arrhythmias, heart failure, or recurrent ischemia. Over time, this registry will evolve into a valuable resource for epidemiological research and health policy planning.

Challenges and Solutions

Several obstacles threaten the success of this initiative. Connectivity remains a challenge, as many rural areas have poor mobile coverage, but offline-first technology and satellite backups mitigate the problem. Funding is another barrier, since the initial costs of equipment, training, and digital infrastructure are significant. Sustainability will rely on public-private partnerships and donor engagement. Workforce retention also presents difficulties, as training only delivers value if healthcare workers remain in their posts; therefore, incentive structures and career progression opportunities are necessary. Finally, access to medications such as thrombolytics must be guaranteed through stronger supply chains.

Despite these hurdles, pilot studies in neighboring countries show that tele-ECG networks are both feasible and impactful. "A nationwide ECG network can bridge geography and inequity, making early diagnosis of heart attacks possible in every Liberian county."

Future Directions: Toward Catheterisation Laboratories

While thrombolysis is the current standard in resource-limited settings, primary percutaneous coronary intervention (PCI) remains the gold standard. Establishing a tele-ECG network is ▶

therefore not the final step but a foundation for future expansion. The national registry of ECG-diagnosed STEMIs will provide data on disease burden and justify investments in catheterisation laboratories. Once PCI becomes available, the telemedicine system can seamlessly support triage to cath labs, reducing unnecessary delays.

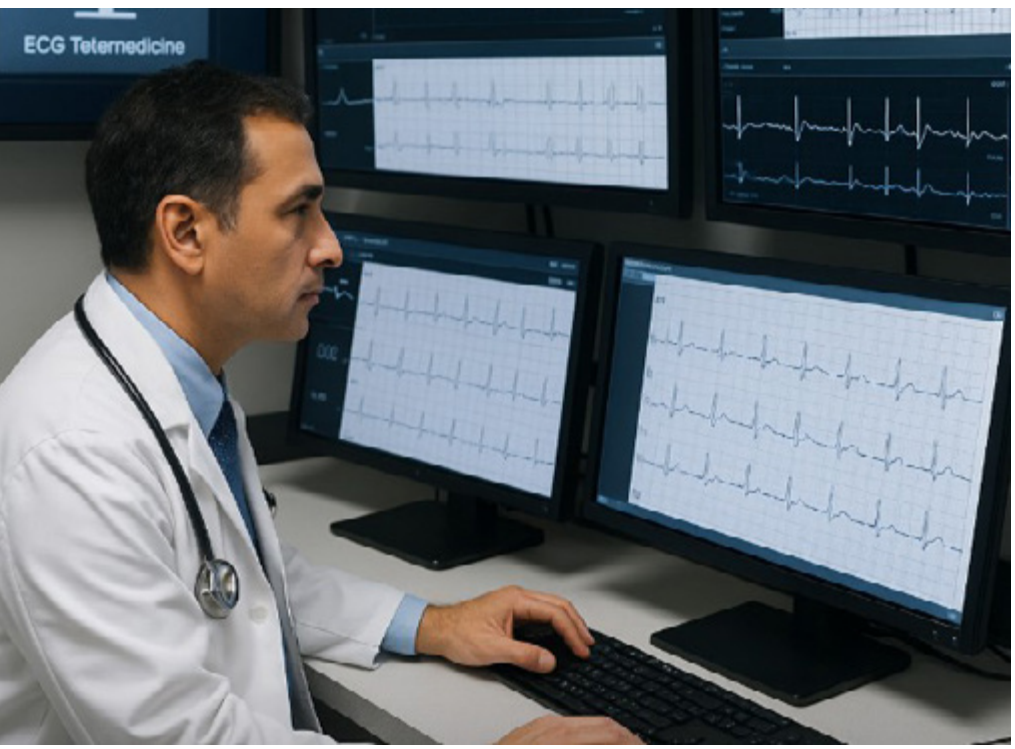
Beyond this, the infrastructure can evolve to support wearable ECG monitors for high-risk patients, artificial intelligence-assisted ECG interpretation, and even remote echocardiography and tele-ultrasound for more comprehensive cardiac imaging.

Global Relevance: Lessons for Other Low-Resource Countries

Liberia's journey reflects a broader challenge across Sub-Saharan Africa and other low-resource regions, where countries face the double burden of infectious disease and rising cardiovascular mortality. Telemedicine ECG networks provide a scalable and cost-effective solution adaptable to diverse healthcare settings.

Key lessons emerge: starting small with pilot counties before scaling nationwide; prioritising human capacity building alongside technology; fostering partnerships across government, NGOs, telecom providers, and academic institutions; and embedding monitoring and evaluation systems to measure impact continuously. Liberia's experience could ultimately serve as a model for a West African Cardiac Telemedicine Alliance.

"This initiative lays the foundation for future catheterisation laboratories and advanced cardiac interventions in Liberia."



Conclusion

The creation of a nationwide ECG telemedicine network in Liberia represents a transformative step toward equitable cardiac care. By linking rural clinics to cardiology expertise, enabling early thrombolysis, and establishing a robust digital backbone, Liberia can address the growing challenge of cardiovascular disease despite limited resources.

This initiative demonstrates how innovation, collaboration, and digital health can leapfrog infrastructural barriers. While challenges remain, the vision is clear: a future where no Liberian patient dies needlessly of a heart attack simply because they lived too far from a cardiologist.

Moreover, this model is not unique to Liberia alone. Its hub-and-spoke telemedicine framework can be readily adapted across West Africa and other African nations facing similar geographic, infrastructural, and workforce constraints. By leveraging regional partnerships and digital health platforms, the network approach offers a scalable blueprint for strengthening cardiovascular care systems continent-wide.

Global Outlook

The Liberian experience also carries lessons for the wider region. Cardiovascular disease is a rising public health challenge across West Africa and the broader African continent, where healthcare systems often face similar constraints in geography, workforce, and infrastructure.

The hub-and-spoke telemedicine framework demonstrated in Liberia provides a replicable and scalable model. By equipping peripheral hospitals with ECG capability, establishing regional hubs, and anchoring them to national or regional cardiac centers, other countries can rapidly build capacity for acute cardiac care. Importantly, such networks not only improve immediate outcomes but also create long-term data systems to guide investment in advanced services such as catheterisation laboratories and interventional cardiology.

If supported by regional cooperation, public–private partnerships, and sustained training, this model can evolve into a West African cardiac telemedicine alliance, extending lifesaving innovations across borders and paving the way for a stronger, continent-wide response to cardiovascular disease. ■

AUTHOR BIO

Dr. Aravind-Kumar Radhakrishnan is an interventional cardiologist and clinical researcher with expertise in telemedicine and digital health for cardiovascular disease management. He has developed scalable cardiac care models in low-resource settings and has led multiple initiatives to expand access to ECG-based diagnostics and emergency cardiac services. His research interests include remote monitoring, health systems innovation, and implementation science, with a focus on advancing cardiovascular health equity in Sub-Saharan Africa. He is driven by a mission to establish catheterisation laboratories across African countries and to strengthen cardiac care infrastructure across the continent.

Redefining Strategic Planning for Modern Healthcare

Siemens Healthineers Consulting combines global expertise with local insights to support healthcare providers in building resilient, patient-centric networks. From strategic planning and financial modeling to implementation and operational readiness, our integrated approach aligns CAPEX/OPEX with sustainability, mitigates execution risks, and leverages digital tools to accelerate high-quality, accessible care delivery.

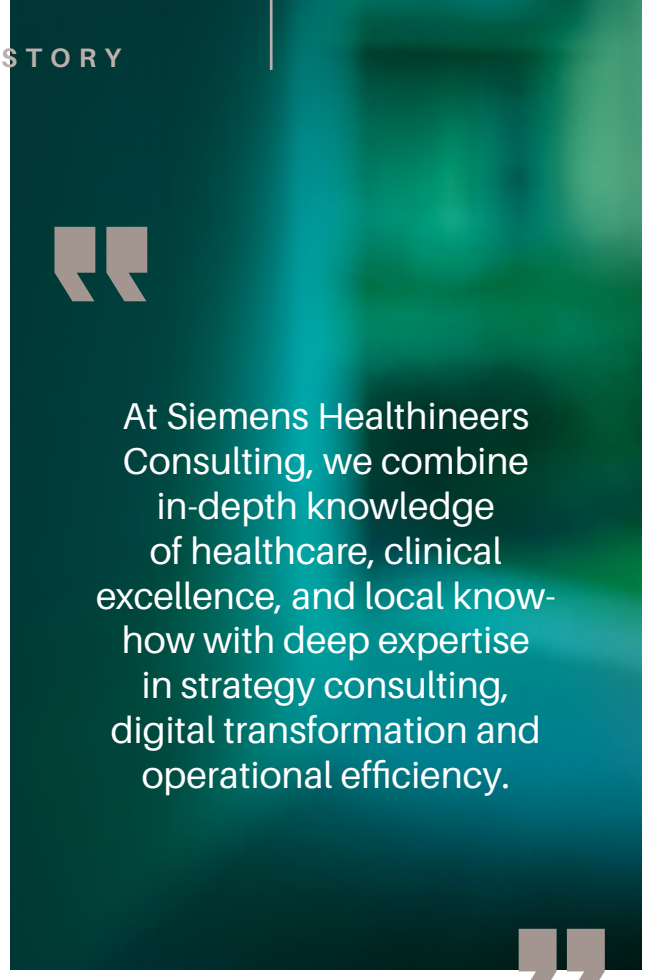
1. When engaging with both private providers and public health systems, how do you adapt your strategic planning approach to align with their distinct governance, funding, and operational frameworks?

Our approach leverages Siemens Healthineers presence in over 70 countries, where we have staff deeply embedded in both private and public healthcare systems. These colleagues talk to many different market players daily. This local presence provides up-to-date knowledge on regulatory changes, reimbursement frameworks, and governance structures. We combine this with global guidelines, international best practices, and access to our network of financiers, regulators, and implementation partners. Of course, our global team leverages similar education, profiles and databases as the leading consulting firms in the world. ▶

Max Grenz
Global Head of Value Creation
Siemens Healthineers Consulting

2. How do you ensure that early ideation translates seamlessly into practical, executable strategies that survive the transition from boardroom vision to patient-ready facilities?

Unlike pure-play consulting firms, we are part of a broader Siemens Healthineers ecosystem that spans from strategy to execution. This means early concepts are not left "on paper" but are continuously validated against real implementation capabilities, be it technology deployment, digital solutions, or workforce planning. Also, as we are part of Siemens Healthineers' larger business mission, we must take into account that while our consulting advice is fully independent of Siemens Healthineers' business motives, our colleagues will eventually be part of the implementation of the project.



3. Service-line positioning often determines long-term competitiveness. What frameworks or benchmarks do you apply to shape hub-and-spoke designs, referral flows, and clinical integration models effectively?

We use international benchmarks (e.g., CoE criteria, international referral benchmarks, and disease incidence/utilisation data) and adapt them to local realities. Our experience across Europe, MEA, and Asia provides a unique comparative database. For example, in the UAE, we designed a hub-and-spoke diagnostic model for a provider that drew on best practices from Singapore (specialty hubs) and Germany (integrated outpatient imaging centers) but tailored to the UAE's payer environment and mall-based clinics. Similarly, we see that many of our customers do not want to just follow THE one global best-practice but rather integrate different successful models. This is one of the most value-adding scenarios for us: as our work truly spans across the globe, we can conclude both real-world experience and data that many of our team members gathered first-hand in different countries.

4. In building demand scenarios and financial models, how do you balance market-driven

assumptions with clinical realities, especially in regions with volatile payer mixes?

We combine secondary data (epidemiology, insurance claims, and benchmarks) with local expert input (clinicians, payers, administrators) to validate assumptions. Every financial model is stress-tested with sensitivity and scenario analysis to account for volatile payer mixes and policy shifts. In Central Asia, for example, we modeled three demand scenarios (base, optimistic, and constrained) to account for currency fluctuations and uncertain insurance reforms. These scenarios are then further refined in the discussion with our customers, based on their experience, preference and the specific risks they want to take or avoid. As we stay part of the realization process, we are also able to adapt or update these models at a later stage, e.g. if financing institutions need more detail in specific areas.

5. Could you walk us through your methodology for aligning CAPEX/OPEX planning with long-term sustainability, while also maintaining clinical quality and patient accessibility?

For CAPEX, we start with a top-down view of incidence, prevalence, and competition to project demand, and combine it with a bottom-up assessment of workforce, infrastructure, and technology to ensure the system can realistically deliver against that demand. This prevents underutilised assets on one side and capacity bottlenecks on the other, keeping investments clinically relevant and financially sustainable. For OPEX, we anchor assumptions in local data to reflect true cost structures. For example, staffing costs make up a far higher share of operating expenses in high-income countries than in lower-income markets, ensuring projections remain both accurate and accessible for patients.

6. Many projects falter at the handover stage. How does your team ensure continuity when moving from strategic planning into pre-opening execution and operational readiness?

Our one-stop-shop model is a key differentiator: clients work with a single point of contact from ideation to implementation and long-term change management. We embed consulting into long-term partnerships, so-called Value Partnerships, ensuring the same team is accountable for pre-opening planning, operational readiness, and ongoing performance management. In practice, this avoids the “handover cliff” where strategy documents gather dust and ensures continuous accountability. We also find that this avoids inefficiencies in the consulting approach, as the team at each stage will be familiar with the discussions and assumptions that have been taken some time ago and therefore will not need to familiarize themselves with the models first. ▶

7. What are the biggest risks you see in misaligned medical equipment planning or room/ flow concepts, and how do you mitigate them early in the process?

The biggest risks are overinvestment in underutilised equipment (leading to financial strain) and bottlenecks in poorly designed patient flows. We mitigate this by combining robust demand forecasting with workflow simulation tools. For example, in Uzbekistan, we use patient-flow simulation for a new outpatient center to redesign the radiology reception area, avoiding future congestion and improving patient experience.

Here, our specialisation in healthcare really comes to play against generalist consulting firms: In a project in Mexico, the customer had planned a general hospital with a maternity ward for around 600 births/ year. From experience, we found this to be rather high and checked for competition. It turned out that the neighboring clinic, which specialises in births, delivered around 550 births/year. Moving ahead with the assumption of 600 clearly wouldn't have worked economically and capacity-wise.

8. In multi-vendor environments, what governance mechanisms do you implement to maintain accountability and integration across diverse stakeholders?

We establish structured program governance with a steering committee that includes all vendors, clinical stakeholders, and financial sponsors. We apply clear RACI matrices, standardised reporting, and performance dashboards. Independent "neutral facilitator" roles are often introduced to resolve conflicts. For instance, in PPP projects, we often chair multi-vendor governance forums, ensuring transparency across public partners, financiers, and technology providers. Being Siemens Healthineers as opposed to a generalist consultant makes it easier for us to play the role of integrator along the value-chain as we are used to dealing with a variety of different players within our complex projects.

9. How do you design ROI/NPV models that are robust enough for investors but still flexible enough to adapt to unexpected healthcare demand shifts?

We build ROI/NPV models on robust, clinically validated demand assumptions and complement them with sensitivity toggles for critical variables such as payer mix, utilisation rates, and price levels. This dual approach reassures investors by grounding projections in clinical reality, while also showing how margins and cash flows could evolve under different scenarios. In a project for an outpatient provider in Saudi, for example, we compared ROI across scenarios of in-house versus outsourced lab testing and imaging to see how capital intensity,

staffing requirements, and reimbursement models would affect long-term sustainability. Similarly, in hospital network planning we model variations in referral capture rates to assess the resilience of the investment case against shifts in patient flows.

10. Can you share how case learnings from regions like the Middle East, Central Asia, and the Baltics have influenced your approach to building scalable, resilient healthcare networks?

In the Middle East, cultural factors like gender-segregated care models shaped referral design and staffing ratios. In Central Asia, volatile payer systems required conservative base-case assumptions with flexible growth options. In the Baltics, cross-border patient flows drove us to design multi-country referral networks. However, these are just some examples of different insights gained in the different geographies. Healthcare delivery and accessibility vary greatly across the globe: in the UK, with its NHS-driven market, partnership models with the public sector will be required to succeed, while in Mexico, private investment and physician commitment will play a key role.

11. What role does cultural and regulatory context play in shaping referral flows and clinical integration across different geographies?

Regulatory frameworks strongly shape integration. For instance, bundled payments and value-based care in Sweden and the US incentivise coordinated pathways, DRGs in most high-income countries drive hospital efficiency, while fee-for-service models in parts of Asia reinforce volume-driven care. Cultural factors are equally important for example, gender-sensitive care and strong family involvement in the Middle East influence referral flows and facility design, whereas in Northern Europe, patient autonomy and transparency are central. Both elements must be considered to design referral networks that work in practice.

12. How do you measure success beyond financial performance - specifically in terms of patient access, system resilience, and quality of care?

We integrate financial metrics with broader measures of healthcare performance, focusing on access, quality, and resilience. Access is evaluated through patient volumes, wait times, and geographic reach; quality is assessed using PROMs, adherence to clinical guidelines, and outcome indicators; and resilience is measured by the system's ability to absorb shocks, such as pandemic readiness or workforce flexibility. For example, in Asia, oncology partnerships were evaluated not only on their return on investment but also on their success in reducing wait times for radiotherapy slots.

13. In your experience, what governance structures best support the "same team" model, where strategic planners remain engaged through implementation?

We establish joint steering committees to ensure the key point of contact stays the same from planning throughout the implementation phases. Escalation protocols, KPIs tied to both strategic and operational outcomes, and integrated PMO structures ensure transparency and continuity. In some cases, we embed consultants as interim PMO leads during hospital pre-opening phases, bridging the gap between planning and operations. This "same team" model not only secures consistent oversight but also builds trust with clinical and administrative leaders, reducing execution risk and accelerating time to readiness.

14. Finally, looking ahead, how do you see healthcare strategic planning evolving to reduce execution risk and accelerate time to service, particularly in emerging markets?

We see healthcare planning shifting toward comprehensive, end-to-end partnerships where execution risk is shared. Our value add is that Siemens Healthineers can combine strategy, technology, operations, and financing in one integrated offering, so hospitals don't have to manage a fragmented set of consultants and vendors. By putting the patient journey at the center, rather than the provider's internal structures, care models will be designed that are both clinically effective and financially sustainable. Leveraging digital tools such as AI-driven demand forecasting and workflow simulation further supports this approach, ensuring faster execution and reducing project risk.

AUTHOR BIO

Max Grenz is Global Head of Value Creation at Siemens Healthineers Consulting. An economist by background, he brings extensive experience in strategy, M&A, and digitalization across international healthcare systems, gained at leading global consulting firms. At Siemens Healthineers, he leads the global expansion of M&A advisory, greenfield development, and activation consulting, helping healthcare organizations translate strategic vision into scalable, sustainable, and patient-centered operations

Bridging the Gap

From National EMR Landscapes to the European Health Data Space

The European Health Data Space aims to unify health data exchange across EU Member States, yet faces challenges from fragmented EMR adoption, varying EHR definitions, interoperability gaps, legal inconsistencies, and cultural resistance. Bridging these requires technical upgrades, governance harmonisation, and clinician engagement to realise cross-border, patient-centred healthcare and research benefits.

Mariam Shokralla
Digital Health Strategist, Analytics- HIMSS - EMEA

The European Health Data Space (EHDS) stands as a monumental initiative in EU health policy, intending to establish a seamless, secure, and standardised framework for accessing, sharing, and reusing health data across Member States. This ambitious vision aims to enable the primary use of health data for continuity of care across borders and to facilitate its secondary use for research, innovation, policymaking, and AI development. However, the journey from the current state of Electronic Medical Record (EMR) adoption in Europe to the fully

realised EHDS is far from straightforward, shaped by deep variations in digital maturity, complex regulatory frameworks, and diverse interpretations of what constitutes an Electronic Health Record.

Fragmented EMR Adoption and Interoperability Gaps:

Across Europe, EMR adoption is highly fragmented. Nordic countries and Estonia enjoy near-universal digital health coverage with mature national interoperability frameworks. In contrast, many Southern and Eastern European countries have a more uneven landscape, where paper-based records still coexist with regional or hospital-specific systems. Even in countries with broad adoption, vendor lock-in and incompatible data models remain significant challenges. Interoperability is hindered by the inconsistent use of common terminologies such as SNOMED CT and LOINC, and by the varying maturity of HL7 FHIR implementations. In this context, the EHDS vision of effortless, cross-border data sharing will require setting standards and major investments in transforming legacy systems.

The Definition Challenge: EHDS EHR Definition Meet Real-World EMR Limitations

One of the most underestimated barriers to EHDS implementation lies in the gap between the **formal definition of the European Electronic Health Record** under the EHDS regulation and the **functional reality of existing EMR systems** deployed across Member States. While the EHDS requires a harmonised, structured, and semantically interoperable dataset including patient summaries, ePrescriptions, laboratory results, medical imaging, discharge reports, and eventually genomic data, many hospital EMRs were never designed with such pan-European interoperability in mind.

A key friction point is **data structure versus unstructured formats.** In many hospitals, clinical information exists as narrative text within scanned PDFs or free-text notes, especially in specialities such as oncology, psychiatry, or surgery. Although these documents may be sufficient for internal clinical workflows, they cannot be easily mapped to the structured and coded datasets mandated by the EHDS. This creates a major interoperability bottleneck: without structured formats linked to standard terminologies such as SNOMED CT, ICD-10/11, LOINC, or DICOM, automated cross-border data exchange is technically unfeasible.

Another challenge is the **selective or incomplete capture of the EHDS core dataset.** For example, ePrescription adoption is high in some countries like Finland or Estonia, but in others, prescriptions are still generated as printed or non-standardised digital forms. Similarly, laboratory data may be stored in separate LIS (Laboratory Information Systems) that are not fully integrated with the main EMR, leading to incomplete or delayed data availability. Imaging data is often held in PACS (Picture Archiving and Communication

Systems), which does not share metadata in EHDS-compliant formats, making cross-border retrieval cumbersome.

Semantic alignment is another area where theory and practice diverge. Even when EMRs store structured data, coding systems are often localised, inconsistent, or outdated. For example, lab results may use local code sets rather than LOINC, or diagnosis fields may combine free text with ICD-10 codes in a way that does not map cleanly to EHDS requirements. The EHDS's emphasis on semantic interoperability means hospitals will need to implement terminology services capable of mapping local codes to European standards in real time something few systems can currently do.

The EHDS also assumes a **patient-centric, longitudinal record,** whereas many EMRs are episode-based. In other words, a patient's history may be scattered across multiple encounters, facilities, or even vendors, with no unified, continuously updated record. This fragmentation is especially pronounced in countries with decentralised health systems, where regional EMRs do not automatically communicate with each other, let alone with a European-level infrastructure.

Lastly, the **workflow integration burden** should not be underestimated. EHDS compliance is not just about exporting data once; it requires real-time, bidirectional data exchange between local EMRs and the European framework. This will demand technical upgrades to interface engines, tighter cybersecurity controls, and robust consent management mechanisms all while ensuring minimal disruption to clinicians' daily routines.

> EHDS envisions a unified future for Europe's health data, yet today, its EHRs speak in different languages, both literal and metaphorical. The clarity and alignment we build now will shape tomorrow's patient-centred care and research for decades to come, let's harness this golden opportunity?.

Bridging these gaps will require **strategic investment and staged implementation.** Hospitals will need targeted funding to upgrade or replace legacy EMRs, deploy interoperability middleware, implement data mapping tools, and train staff in structured data entry. At the same time, Member States will need to establish national terminology services, provide clear technical guidance, and ensure that vendors deliver EHDS-compliant upgrades. Without addressing these technical and operational mismatches, the EHDS risks becoming a policy ambition that stalls at the point of real-world implementation.

Governance and Legal Alignment

Governance and legal alignment add another

layer of complexity. While the EHDS operates under the General Data Protection Regulation (GDPR), it also introduces new mechanisms for cross-border health data exchange. Member States will need to establish Health Data Access Bodies to govern both primary and secondary uses. Yet, interpretations of GDPR vary particularly regarding sensitive areas such as genomic or mental health data. Furthermore, consent management models differ across the EU, ranging from opt-in to opt-out systems, raising questions around patient autonomy, transparency, and trust. Achieving harmonised governance frameworks and clear, culturally adapted communication strategies for patients in all EU languages will be essential.

Technical Infrastructure and National Access Points

The EHDS also requires each Member State to set up a national access point to act as a technical gateway for data exchange. While some countries already have national health data hubs or health information exchanges, their existing architectures may not align with the EHDS's security, semantic, and

interoperability requirements. Smaller countries or those with decentralised health systems may struggle with the infrastructure, cybersecurity readiness, and operational capacity required to handle the scale of EHDS transactions. Investment in secure, scalable, and cloud-based environments ideally incorporating Trusted Research Environments (TREs), will be critical to making this vision a reality.

Cultural and Change Management Barriers

Even with the right technology and governance in place, cultural and change management barriers remain. Clinicians may see new interoperability mandates as bureaucratic burdens rather than clinical enablers, and hospital administrators may resist costly system upgrades if the benefits are not clear and immediate. Overcoming this resistance will require strong change management programmes, clinical leadership, and practical demonstrations of how EHDS adoption can improve patient care and health outcomes.

Ultimately, the European Health Data Space is not simply a technical standard to be implemented, but a catalyst for systemic transformation in healthcare. Moving from today's fragmented and inconsistent EMR environment to tomorrow's integrated, pan-European health data ecosystem will require modernising legacy systems to meet the EHDS core dataset definition, adopting common interoperability standards, harmonising legal and governance frameworks, and building the technical capacity to exchange health data securely and efficiently. Above all, success will depend on engaging clinicians and patients alike, fostering trust in the system, and demonstrating its value in improving care, advancing research, and strengthening public health across the continent. ■

AUTHOR BIO

Mariam Shokralla is a pharmacist and public health specialist based in the Netherlands. Since 2022, she has served as Digital Health Strategist at HIMSS, leading health analytics projects and evaluating hospital EMRs in the EMEA region. Mariam holds an MPH and a master's in Leadership and Governance in European Public Health. She has collaborated with European organizations and the WHO on national digital health strategies, focusing on policy and regulatory frameworks. With 12 years of experience in medical device regulation in the Middle East, Mariam now focuses on AI adoption, optimizing EMRs using AI, and implementing the European Health Data Space (EHDS).

The Coming Era of Contactless Core Temperature Monitoring

Why it matters for hospitals, field medicine, and the next wave of surgical automation

Contactless, autonomous temperature sensors are poised to reshape patient monitoring across hospitals, clinical trials, and field medicine. By delivering reliable, continuous core-temperature data without touching the patient, they can reduce staff workload, improve safety and regulatory compliance, and unlock new frontiers—from remote care to more automated, robot-assisted surgery.

Mustafa Ahmedov
Engineer, Co-founder, Thermo-i

Why core temperature still isn't "solved"

Temperature has been a foundational vital sign for more than a century, yet the way we measure and use it often lags behind clinical needs and modern workflows. In perioperative care, preventing inadvertent hypothermia

and maintaining normothermia are explicit guidelines; in emergency and critical care, early detection of fever or hypothermia can change outcomes; and in infectious disease control, rapid screening at scale can inform decisions in minutes. Still, conventional methods demand frequent manual checks, contact-based probes, and consumables—and in many care settings (busy wards, triage, home monitoring, or austere environments) that creates friction, gaps, and avoidable risk. NICE explicitly recommends frequent temperature measurement before, during, and after surgery to prevent complications, underscoring how central temperature is to routine, guideline-driven care.

A new generation of sensor systems—autonomous, contactless, and designed for continuous use—can help close these gaps. As an engineer and founder working on a sensor-based medical robot for core body temperature monitoring, I've seen how robust sensing, validation, and data integrity can transform temperature from a "snapshot" into a high-value signal stream that improves decisions, documentation, and automation.

The case for contactless & remote monitoring

Fewer touch points, less workload, more coverage: Contactless systems reduce the need for staff to place and replace probes, cutting interruptions and infection-control concerns while increasing measurement frequency. In real wards and ICUs, nurses routinely juggle dozens of tasks; automating temperature checks can reclaim time for higher-value care.

Better adherence to guidelines: Perioperative guidance calls for active maintenance of normothermia and frequent measurements around anesthesia and recovery. Continuous, automated sensing makes guideline adherence practical rather than aspirational.

Remote patient monitoring (RPM) that actually helps: Evidence syntheses suggest RPM can be feasible, acceptable, and associated with reductions in utilisation in select populations when implemented well. Temperature is a core input to early-warning algorithms and deterioration indices; capturing it continuously at home or step-down can enable earlier intervention. **(Agency for Clinical Innovation, WIRED)**

Built for scale—inside and outside the hospital: Field hospitals, humanitarian missions, and mass-casualty triage need low-touch, repeatable measurements that work when staff are constrained and PPE is heavy. Autonomous, contactless systems can extend monitoring to more patients with fewer people.

But is "contactless core temperature" real?

The reference ("gold standard") for true core temperature is pulmonary artery blood temperature—accurate but invasive and impractical for routine use. In practice, hospitals rely on clinically validated proxies such as esophageal, bladder, and rectal

measurements; rectal temperature is widely accepted as a reliable core proxy in many settings, but it remains contact-based and workflow-intensive. Non-contact forehead thermometers, by contrast, are convenient for screening, yet systematic reviews have highlighted accuracy variability versus core temperature, especially in fever detection, and even in ICU patients. Any contactless system that claims "core-level" performance must therefore demonstrate rigorous validation against accepted core proxies in the target setting (ICU, OR, ward).

Emerging approaches improve on traditional non-contact thermometry by combining:

- High-fidelity infrared sensing (calibrated optics, controlled distance/angle, ambient compensation),
- Physiological modeling (skin-to-core transfer functions that adapt to perfusion/vasoconstriction states), and
- Noise-reduction & data integrity layers (motion handling, outlier rejection, and tamper-evident logging).

This stack can bring contactless readings closer to the accuracy of rectal or esophageal probes—if and only if it's validated against those proxies in the same clinical environment and population. (Our own testing roadmap emphasises ICU and perioperative use precisely for that reason.) ▶

Workflow wins: from bedside to back office

Autonomous capture and charting. Temperature recorded on schedule (or continuously), cross-checked by algorithms, and pushed to the EHR using open standards (e.g., HL7® FHIR® Observation resources with LOINC® codes for body temperature) reduces omitted charting and manual entry errors. That's not just convenient; it underpins auditability, quality metrics, and research.

Tamper-evident data for trials and QA. Clinical trials demand source-verifiable, unaltered measurements. A device that signs data at capture, time-stamps it, and maintains an immutable audit trail provides confidence that temperature endpoints weren't mis-read, mis-timed, or transcribed incorrectly—advantages over paper logs and ad-hoc checks.

Perioperative value. Anesthesia societies call for ongoing evaluation of temperature when significant changes are anticipated (e.g., long cases, pediatric, large fluid shifts, cold environments). Automated sensing can reduce inadvertent hypothermia, a contributor to wound infection, coagulopathy, and prolonged recovery.

Field medicine and dual-use scenarios

Combat casualty care and hypothermia. Military protocols emphasise early prevention and monitoring of hypothermia to improve survival in trauma. In forward settings—where staffing and time are scarce—contactless, autonomous temperature monitoring can extend continuous surveillance without adding lines or probes.

CBRN and high-PPE environments. In chemical/biological incidents or infectious-disease isolation, minimising contact and donning/doffing cycles is critical. Temperature is both a screening and monitoring parameter; contactless collection helps preserve PPE and reduce exposure while maintaining frequency.

Mobile/temporary hospitals. When power and staff are limited, devices that operate autonomously, work at a short distance (e.g., bedside boom, gantry, or robot), and backhaul data over resilient links enable "ICU-like" observation density in tents or repurposed facilities.

The next frontier: enabling more automated, robot-assisted surgery

Robotic surgery and tele-surgery rely on a tightly integrated loop of sensing, decision support, and actuation. Core temperature is a key safety parameter during anesthesia: cooling, irrigation, insufflation gases, and ambient conditions can all drive patients toward hypothermia. Today, maintaining normothermia generally requires staff to place temperature probes and manually coordinate warming interventions. A validated, contactless temperature system integrated into the anesthetic and robotic stack could:

- Continuously feed core-equivalent estimates into the anesthesia record,
- Trigger automated warming protocols (forced-air blankets, warmed fluids), and

- Alert earlier to adverse shifts, even during remote or highly automated procedures.

To be clear, we are not claiming such systems are standard today; rather, we outline a credible path where validated, contactless core-temperature sensing becomes a building block for safer, more automated perioperative care.

Design pillars for trustworthy contactless temperature systems

1) Clinical accuracy with published validation: Benchmark against accepted core proxies in the exact settings of use (ICU, OR, ward). Publish bias/precision versus reference (e.g., Bland–Altman) across perfusion states, skin tones, age groups, and motion conditions. External, multi-site studies are especially important given prior limitations noted for off-the-shelf infrared devices.

2) Data integrity and security by design: Record measurements with cryptographic signatures, secure clocks, and audit trails. Encrypt at rest and in transit. Role-based access and immutable logs support clinical trials, QI audits, and medico-legal documentation.

3) Interoperability with open standards: Use HL7 FHIR Observation for temperature and IEEE 11073-20601/-10206, where applicabl,e for device communication and plug-and-play integration. This reduces integration cost and future-proofs the stack.

4) Human-factors and automation.

Design for near-zero workflow burden: self-positioning or fixed-mount devices that handle distance/angle, ambient compensation, and motion detection, with clear operator feedback when data quality is insufficient. Pair with rules/ML that translate readings into actionable prompts (e.g., “maintain forced-air warming,” “re-check in 5 minutes”).

5) Regulatory strategy aligned to use case: Positioning as a continuous monitoring device versus a screening tool changes evidence expectations. Align indications, validations, and risk controls to the target market (perioperative monitoring, ICU, clinical trials, field use).

Evidence snapshots and what they imply

- **Infrared/tympanic devices:** Convenient, but accuracy versus core varies by device, technique, and patient condition; caution is needed for fever detection in critical care. Translation: new contactless systems must prove accuracy head-to-head with core proxies, not infer it.
- **Zero-heat-flux sensors:** A non-invasive approach that can approximate the core with good accuracy in stable OR conditions. Translation: Non-invasive core estimation is possible; approach and context matter.
- **Perioperative guidance (NICE, ASA):** frequent monitoring and active warming improve outcomes; continuous data would make adherence easier and more reliable. Translation: automation aligns with existing standards.
- **RPM & Hospital-at-Home:** When implemented well, remote vital-sign

monitoring can be safe and associated with lower utilisation and high satisfaction. Translation: reliable temperature streams are valuable beyond the hospital's walls.

Field deployment: practical considerations

Ruggedisation & power. Field use requires devices that tolerate vibration, dust, and thermal extremes. Battery-backed operation and low-power modes keep monitoring active during generator swaps.

Distance and alignment. Optical sensors need predictable geometry. Fixed mounts over cots, rail-guided booms, or compact bedside robots can maintain the correct field of view without staff intervention.

Connectivity. Store-and-forward transmission with opportunistic sync is essential where connectivity is intermittent. On-device summaries (e.g., trend arrows, thresholds) help staff act even when offline.

Ethics & privacy. Continuous monitoring raises issues of consent and surveillance. Clear policies, visible indicators when active, and strict purpose limitation are essential—especially outside the hospital.

Looking ahead: temperature as a foundation signal for AI

Continuous, trustworthy temperature streams are a powerful feature for early-warning systems, sepsis detection, and post-op risk prediction when combined with heart rate, respiration, and blood pressure. AI models trained on clean, time-aligned data can detect subtle pattern shifts—if the inputs are accurate and untainted. Building that "sensor-to-insight" pipeline with device-level integrity, standard interfaces, and transparent performance reporting will define the winners in this space.

Contactless, autonomous temperature monitoring is more than convenience—it's a practical way to make guideline-driven care achievable, to extend monitoring to places and populations that lack staff or supplies, and to feed safer automation from the OR to the field. The technology is ready to matter, provided we insist on clinical-grade validation, interoperability, and integrity from sensor to system. ■

References are available at www.europeanhhm.com

AUTHOR BIO

Mustafa Ahmedov is an engineer and co-founder of Thermo-i, a sensor-based medical robotics startup focused on contactless core body temperature monitoring. He leads R&D and clinical validation partnerships across ICUs and perioperative care, with a mission to deliver autonomous, trustworthy vital-sign monitoring to hospitals and field medicine.

From Data to Decision

How AI-Powered Digital Twins Transform Vascular Interventions

Digital Twin technology combined with Artificial Intelligence is set to revolutionise vascular surgery by enabling patient-specific preoperative planning. Through precise simulations of vascular anatomy, surgeons can optimise device selection, reduce procedural risks, and enhance outcomes—ushering in a new era of personalized, data-driven intervention strategies.

Bruno VIRIEUX

CEO, PrediSurge, Guest lecturer, University of Dijon & GT Member, LyonBioPole

In the rapidly evolving landscape of vascular surgery, a silent revolution is taking place—one that shifts the paradigm from tradition-bound decision-making to a future where data and digital intelligence steer the course of patient care. The traditional reliance on the surgeon's experience and clinical intuition, while invaluable, is no longer sufficient to meet the growing demands for precision, safety, and personalisation. As Professor Robert Bruce Salter pertinently stated, "Decisions are more important than incisions." This philosophy is more relevant today ▶

than ever, as Artificial Intelligence (AI) and Digital Twin (DT) technologies reshape how vascular interventions are planned, executed, and evaluated.

At the same time, healthcare systems around the world are under increasing financial pressure, facing mounting costs and limited resources. There is a growing imperative to improve efficiency without compromising patient outcomes. In this context, leveraging AI and DT is not just a technological upgrade—it is a necessity to optimise workflows, reduce unnecessary procedures, and deliver value-based care.

> The integration of AI brings unprecedented power to the Digital Twin. Machine learning models, trained on thousands of previous cases, can recognise patterns, highlight risk factors, and predict procedural outcomes with increasing accuracy.

The Limits of Human-Centric Decision-Making

Historically, vascular interventions have been planned using a combination of anatomical imaging viewed through conventional medical imaging software, patient history, and the surgeon's personal expertise. While this method has served well, it is inherently limited. Even the most seasoned practitioners are constrained by human cognitive capacity when interpreting complex 3D vascular structures and predicting dynamic outcomes. Variability in patient anatomy, comorbidities, and procedural complexities introduces uncertainty that is often underestimated.

In this high-stakes environment, relying solely on surgical experience is no longer adequate. With rising patient expectations, the need for standardisation, and increasingly complex devices, surgeons must augment their skills with digital tools that reduce variability and improve outcomes. Moreover, such tools offer the ability to enhance the reproducibility of procedures across institutions and practitioners, ensuring that high standards of care are consistently maintained.

Enter the Digital Twin: Precision at a Patient-Specific Level

A Digital Twin in medicine is a virtual replica of a patient's anatomy, derived from high-resolution imaging data and enriched by real-time physiological and clinical information. When coupled with AI, these Digital Twins become predictive, allowing simulations of different procedural strategies and their likely outcomes.

In vascular interventions, this means simulating blood flow, stent-graft behavior, and potential complications such as endoleaks

(persistent blood flow outside the stent graft) or thrombosis—all before a single incision is made. This empowers clinicians to make data-backed decisions, optimise device sizing and positioning, and minimise intraoperative surprises. In addition, clinicians can test several treatment scenarios to find the optimal balance between risk and efficacy.

Digital Twin technology transforms preoperative planning into a dynamic, patient-specific process. Each decision becomes a calculated move, grounded in simulated outcomes and enriched with contextual data.

AI-Powered Insights and Predictive Indicators

The integration of AI brings unprecedented power to the Digital Twin. Machine learning models, trained on thousands of previous cases, can recognise patterns, highlight risk factors, and predict procedural outcomes with increasing accuracy.

A compelling example is the Endoleak Risk Index (ERI), which estimates the likelihood of an endoleak following an endovascular aneurysm repair (EVAR). EVAR is a minimally invasive procedure to repair abdominal aortic aneurysms. The ERI, calculated from the Digital Twin and powered by AI analytics, allows clinicians to address complications in advance by adjusting device selection or strategy.

These indicators embody the shift from reactive to proactive medicine—where the aim is not only to treat complications but also to anticipate and prevent them. Digital Twin and AI technologies enable prediction of adverse events, prevention through customised planning, and personalisation by tailoring interventions to each patient's unique anatomy and physiology.

Crucially, these tools are not a replacement for surgical judgment but a powerful augmentation—enhancing surgeons' capacity to make informed, patient-specific decisions. The surgeon remains at the center of the process but is now supported by a network of computational insights, transforming decision-making into a collaborative human-machine effort.

Generative AI and the Future of Preoperative Planning

Looking ahead, Generative AI holds transformative potential. Unlike traditional AI models that classify or predict, Generative AI creates, producing new hypotheses, simulating scenarios, and helping design personalised treatment pathways.

Generative agents synthesise clinical knowledge, imaging, and patient data to propose optimised procedures—reducing cognitive load and enhancing preoperative planning. For instance, while planning an EVAR, a generative AI assistant could calculate the ERI, recommend stent graft configurations, forecast the impact of alternative trajectories, and propose mitigation strategies for anatomical constraints.

These agents continuously learn from new cases, guidelines, and outcomes. They can ▶

serve as virtual planning assistants—reviewing imaging, flagging anomalies, summarising history, and generating personalised preoperative reports. This improves accuracy, consistency, and relieves cognitive burden on surgical teams.

Generative AI can also facilitate cross-disciplinary collaboration. By translating complex datasets into visual dashboards or natural language summaries, it empowers not only surgeons but also anesthesiologists, nurses, and even patients to better understand and engage with the treatment plan. This democratisation of data aligns perfectly with the participatory pillar of 4P medicine.

In essence, Generative AI helps turn complex data into actionable knowledge. It serves as a responsive co-pilot, ensuring every decision is grounded in evidence, simulation, and predictive intelligence.

Companion Algorithms: The Future of Medical Devices

The next frontier lies in merging hardware and software. Devices such as stent grafts and catheters are increasingly designed alongside companion algorithms—intelligent software that analyses anatomy and hemodynamics, recommends configurations, and predicts outcomes.

This hybrid approach turns passive medical hardware into active decision-making participants. Manufacturers, regulators, and clinicians alike now recognise that safety and efficacy depend on integrating data intelligence into device use. Regulatory bodies may soon require simulation-backed validation of devices, pushing the entire industry toward more intelligent, accountable designs.

A New Standard of Care: Digital Preoperative Planning

Digital preoperative planning is becoming a requirement, not a luxury. Hospitals worldwide are adopting simulation platforms that reconstruct vasculature from DICOM images (standard medical imaging format), simulate interventions, and offer risk assessments in secure, intuitive interfaces.

This enables reproducibility, reduces procedure time, lowers costs, and enhances patient experiences. From training to informed consent, digital planning adds value across the care continuum. It also supports more rigorous postoperative evaluation by enabling comparisons between predicted and actual outcomes, thereby closing the feedback loop.

Moreover, this approach supports the personalisation pillar of 4P medicine. Since no two anatomies are identical, procedures should be customised. Digital tools allow individualised planning that considers anatomy, comorbidities, and lifestyle. The result is not only a better clinical outcome but also improved patient satisfaction and trust.

> The next frontier lies in merging hardware and software. Devices such as stent grafts and catheters are increasingly designed alongside companion algorithms—intelligent software that analyses anatomy and hemodynamics, recommends configurations, and predicts outcomes.

Robotics: The Next Step in the Digital Evolution

As digitalisation deepens, robotics enters the scene. Robotic-assisted interventions, once limited to urology or orthopedics, are emerging in vascular procedures. But robotics alone is insufficient.

Robots require precise instructions, which Digital Twin simulations can provide. Combining AI, Digital Twins, and robotics creates an ecosystem where procedures are guided by real-time, patient-specific digital models.

Robotic systems can also improve dexterity, reduce fatigue, and offer new access pathways that would be challenging with manual instruments. As robotics becomes more integrated with planning software, it will further streamline the surgical workflow, reduce variability, and contribute to better long-term outcomes.

This intelligent fusion of human expertise and computational power promises safer, faster, and more effective interventions. It represents not a replacement of skill but an evolution of the surgical craft.

Barriers to Adoption and the Path Forward

Nevertheless, significant challenges remain.

In particular, regulatory frameworks are lagging behind the pace of innovation, and the upcoming AI Act in Europe is unlikely to resolve this gap. Validating AI and Digital Twin technologies requires access to large-scale datasets and long-term clinical trials. Additionally, integration with hospital IT systems is complex and demands secure, standardised communication protocols.

Training and cultural change are essential. Surgeons must view digital tools as allies that enhance their expertise, not as replacements. Institutions should invest in technology, change management, and digital literacy. Bridging the gap between engineers and clinicians is also critical to ensure that these tools are not only powerful but also user-friendly and aligned with real-world clinical workflows. Universities must adapt their curricula to prepare the next generation of surgeons for this new state-of-the-art environment.

Yet, the path is clear. Digitalization in vascular surgery is not a trend—it is a transformation toward a predictive, personalised, and more effective healthcare system. As the cost of computing power decreases and clinical validation accelerates, broader access and adoption are inevitable.

Conclusion

Vascular surgery stands at the threshold of a new era. We can no longer rely solely on human cognition, no matter how skilled. The demand for precision and the complexity of patient care require more.

With AI-powered Digital Twins, we simulate and decide before we act. Predictive indicators like the ERI are entering standard practice. Companion algorithms enhance device use. Robotics is poised to extend surgical capabilities beyond human limits.

Digital intelligence is not replacing the surgeon; it is enhancing every decision they make. This is the future of vascular interventions—a convergence of human and machine, of simulation and judgment, delivering on the promise of truly personalised medicine.

As Professor Salter said, “Decisions are more important than incisions.” ■

AUTHOR BIO

Bruno Virieux is a French engineer, artificial intelligence specialist, and seasoned med-tech executive with over 20 years of experience in the medical technology sector. Since December 2022, he has served as CEO of PrediSurge, a Saint-Étienne-based company specializing in decision-support software for physicians and medical device manufacturers. He is also actively engaged in the scientific community, serving as a member of the Lyonbiopôle cluster and as a guest lecturer in artificial intelligence at the University of Dijon.

From Vision to Practice

Towards the Medical Professional 2.0

The focus would be on how real patient data can elevate Prof Valmed as a Clinical Decision Support System (CDSS) to a new level, especially when deeply integrated into a Clinical Information System (CIS).

Dr. Vera Roedel
CEO and Co-Founder, Prof. Valmed®

The deployment of artificial intelligence in healthcare is progressing rapidly, but its safe and effective implementation requires careful design, certification, and integration. Earlier work highlighted the path to CE certification and the design principles of trustworthy AI assistants. The next stage is to understand how such systems perform in real-world clinical environments and how they interact with education to shape the profile of the 'Medical Professional 2.0'.

Real-World Deployment

At the University Medical Center Freiburg, a CE-certified AI assistant has been deployed across more than twenty departments. This reflects its modular design, enabling support ▶

across neurology, cardiology, oncology, internal medicine, and other fields. Each response is grounded in validated, peer-reviewed evidence, ensuring reliability across multiple specialties.

Case Vignettes

Vignette 1 — Neurology: Acute Stroke Thrombolysis

A junior neurologist uses the assistant within the clinical information system. Eligibility and contraindication criteria for thrombolysis are presented alongside imaging and laboratory values. The structured, evidence-based output reassures the clinician and aligns team decision-making.

Vignette 2 — Oncology: Multimodal Planning

During a tumor board meeting, the system contextualizes treatment pathways with patient comorbidities and prior therapies drawn directly from the electronic health record. By appearing within the workflow rather than as a separate application, the system functions as a co-pilot rather than an accessory.

Prompt of the Week

To demonstrate real-world use, structured prompts are shared weekly. An example prompt is: 'What are candidates for thrombolysis, and what are contraindications?' Such examples illustrate how AI support can reduce cognitive burden and align decisions with current evidence under time pressure.

Integration into CIS and Workflow

Experience shows that integration into clinical information systems (CIS) significantly increases adoption. When embedded, decision support is delivered directly at the point of care, contextualized with patient data. Internal surveys indicate that integration can double the frequency of use compared to stand-alone deployment.

Risks of Uncertified LLMs

Recent studies raise concerns about the use of large language models without medical certification. A 2025 Nature study tested six LLMs with 300 clinical scenarios containing fabricated details. Hallucination rates ranged from 50% to 82%, with the best-performing model still producing errors in 53% of cases. Even mitigation strategies only reduced errors to 44% [1]. Other reviews confirm that general-purpose LLMs often oversimplify scientific findings, misinterpret nuances, and generate factually incorrect outputs [2,3]. Without certification, such systems may create liability 'grey zones' in healthcare.

Reality vs Vision in Healthcare 2025

In many hospitals, digital transformation still resembles a 'Ferrari fax'—faster but functionally unchanged. True innovation requires validated, workflow-integrated AI that supports clinical teams from admission to discharge. This approach enables evidence-based, efficient, and safe care rather than superficial digital upgrades.

Combination of AI and Education

Safe adoption of AI depends not only on the tool itself but also on education. Structured programs that build competence in digital literacy, ethical AI use, and regulatory compliance are essential. Combining validated decision intelligence with continuous medical education creates the foundation for the 'Medical Professional 2.0'. This model empowers clinicians to remain responsible decision-makers while benefiting from reduced cognitive load and enhanced efficiency.

Modular Decision Intelligence Layer

Decision intelligence systems should not be stand-alone applications but modular components that can be embedded across the healthcare continuum. Their architecture should enable use in CIS/EHR systems, telemedicine platforms, and educational programs. Such modularity ensures scalability and adaptability across hospitals, private practices, and academic contexts.

Ethics and Safeguards

To prevent overreliance, outputs must include references, confidence levels, and reminders of physician responsibility. Where uncertainty exists, the system should direct clinicians to guidelines rather than speculate. Such safeguards preserve trust and ensure alignment with evidence-based medicine.

Outlook

The combination of certified decision intelligence and structured education offers a pathway towards sustainable adoption of medical AI. Future work will focus on deeper integration into health records, broader institutional scaling, and transparent reporting of outcomes. This model positions clinicians as empowered professionals—Medical Professionals 2.0—supported by validated intelligence rather than replaced by it. ■

References are available at www.europeanhhm.com

AUTHOR BIO

Dr. Vera Roedel is the CEO and Co-Founder of Prof. Valmed®, where she leads the development of trustworthy, CE-certified medical products driven by a passion for advancing medical technology. With core competencies in medical device regulation and strategic communication, Dr. Roedel plays a critical role in guiding the company's innovation and compliance efforts. Her leadership is grounded in the values of integrity, excellence, and a commitment to making a meaningful impact through inclusive and diverse perspectives.

Digital Strategy for Healthcare Organisations

Building a Resilient and Patient-Centered Future

In an era defined by rapid technological advancement and shifting patient expectations, the healthcare sector faces a defining question: How do we use digital tools to improve care without losing the human touch?

For decades, medical care relied heavily on physical interactions, paper-based systems, and face-to-face consultations. While these still hold value, the pandemic accelerated the adoption of telemedicine, AI-powered diagnostics, wearable devices, and cloud-based medical records. This shift has shown us that technology can bridge gaps in access, improve efficiency, and empower patients, if implemented thoughtfully.

Marina El Khawand
Founder, Medonations

Having worked across health innovation projects with Medonations and launched CuraLoop Global, I have witnessed the challenges healthcare organisations face when going digital. It is not simply about purchasing new software or building a mobile app; it is about crafting a long-term, patient-centered digital strategy that supports both the mission and the people it serves.

Below, I explore the essential pillars of a successful digital strategy, illustrated with real-world examples and lessons learned.

Begin with a Clear and Shared Vision

Every successful transformation starts with clarity. Before adopting new technologies, leaders must define:

- What problems they want to solve.
- How success will be measured.
- Who will be impacted, from doctors and nurses to patients and families.

A clear vision prevents organisations from chasing trends that sound exciting but lack real impact. For example, a hospital in Singapore launched a digital health initiative not by buying the latest AI software, but by first consulting frontline staff. They discovered the most urgent issue was not diagnostics, but reducing the time nurses spent on paperwork. This insight led to implementing digital patient charts, freeing up an average of 2.5 extra hours per nurse per shift for patient care.

The takeaway? Digital strategy begins with listening, not purchasing.

Data: The New Lifeblood of Healthcare

In the digital age, data drives smarter decisions. From patient histories to public health trends, healthcare organizations have access to an unprecedented amount of information. But more data does not automatically mean better care.

The key lies in **data quality, security, and usability.**

- Quality ensures that information is accurate, up-to-date, and relevant.
- Security protects patient trust and complies with regulations like HIPAA or GDPR.
- Usability means that data can be easily accessed and acted upon by the right people at the right time.

A practical example comes from Rwanda's national health system, which collaborated with an AI company to predict potential disease outbreaks using anonymised patient records. The data analysis helped detect a cholera outbreak two weeks earlier than traditional methods, enabling faster containment and saving lives.

Yet, with great data, power comes great responsibility. Cybersecurity must be integral to any digital plan. A single breach can erase years of trust, and trust is the currency of healthcare.

Humanising the Patient Experience

Digital tools should enhance - not replace -the human connection in healthcare. Telehealth consultations, for instance, allow rural patients to access specialists without travelling hours to urban centers. However, if the system is complicated, poorly explained, or inaccessible to people without high-speed internet, it will exclude those who need it most.

Personalisation is key. Imagine a patient portal that not only shows lab results but also provides simple explanations, sends culturally relevant health tips, and allows easy follow-ups with a care team. This turns a static digital platform into a living extension of patient care.

In Lebanon, some clinics integrated WhatsApp-based appointment reminders for elderly patients who found apps confusing. The result was a 30% drop in missed appointments

> When technology is used as a bridge, connecting patients, providers, and communities, it can truly transform healthcare for the better...

and an increase in medication adherence. The technology was simple, but the human thinking behind it made the real difference.

Interoperability: Breaking Down the Silos

One of the most frustrating realities in healthcare is fragmented information systems. A patient's medical history might be scattered across different hospitals, labs, and insurance providers, none of which can communicate with each other.

Interoperability is the ability of systems to work together, sharing data securely across platforms. Without it, digital transformation remains incomplete.

Estonia offers a leading example. Its national e-health system integrates all healthcare providers, pharmacies, and insurers into one network, accessible via secure digital IDs. Citizens can view their prescriptions, test results, and treatment history from anywhere, while doctors can make faster, more informed decisions.

For organisations starting small, interoperability may begin with connecting a clinic's internal departments, ensuring lab results flow directly into the doctor's interface, rather than being emailed or faxed.

Building Digital Literacy for All

Technology is only as effective as the people who use it. A brilliant new telehealth platform will fail if staff do not understand it or patients feel intimidated by it.

Digital literacy training should be embedded in both staff onboarding and patient education. This is not a one-time workshop, but an ongoing process. Training should also be empathetic, acknowledging that for some people, learning to use a tablet for a video consultation may be as stressful as the medical issue itself.

In my own work with community health outreach, I have seen that small, hands-on demonstrations, sometimes even at patients' homes, can completely change adoption rates. The more confident people feel using a tool, the more they will benefit from it.

Innovation with Integrity

AI-powered diagnostics, blockchain for medical records, and wearable biosensors are transforming healthcare's possibilities. However, new technology must be implemented with **ethical safeguards.**

For example, AI can process medical images faster than humans can, but it must be trained on diverse datasets to avoid biases that could harm underrepresented populations. Blockchain

can secure patient data, but its energy use and cost must be considered.

Responsible innovation means asking:

- Does this solve a real healthcare problem?
- Is it accessible to everyone, not just the privileged?
- What are the long-term implications for privacy, equality, and trust?

Sustainability and the Digital Future

Sustainability should be at the core of healthcare's digital journey. E-waste, energy consumption, and even server cooling systems have environmental impacts.

With **CuraLoop Global,** my focus is on turning healthcare waste, like expired medications, into resources rather than landfill. Similarly, a sustainable digital strategy can include:

- Using energy-efficient servers.
- Recycling outdated devices.
- Choosing vendors committed to green practices.

The healthcare sector's responsibility extends beyond patients to the planet that sustains them.

Conclusion: Technology as a Bridge, Not a Barrier

Digital transformation in healthcare is not a race to adopt the latest gadget; it is a long-term commitment to better care, equity, and resilience. The best strategies:

- Begin with listening to real needs.
- Build systems that connect rather than fragment.
- Empower people to engage confidently with their care.

In my journey as a healthcare advocate and entrepreneur, I have seen that the most successful digital strategies are those that balance innovation with compassion. When technology is used as a bridge, connecting patients, providers, and communities, it can truly transform healthcare for the better. ■

AUTHOR BIO

Marina El Khawand is a Forbes under 30 honoree, Diana Award recipient, and HIMSS24 Changemaker in health. She is the founder of Medonations and CuraLoop Global. Marina is a trainee lawyer, pharmacy student, and global health advocate dedicated to bridging healthcare gaps through innovation, sustainability, and community-driven solutions across more than 65 countries.

Beyond Monitoring

How RPM is Redefining Proactive Care

Remote Patient Monitoring devices are transforming healthcare delivery by enabling continuous patient data collection outside the clinical setting. It is an opportunity to improve outcomes, reduce hospital readmissions, and optimise resource utilisation, especially in remote areas with less care coverage. This Interview will look at key technologies, integration with existing care models, and strategic considerations for adoption, highlighting how Remote Patient Monitoring can drive value-based care, support healthcare professionals and enhance patient engagement.

Aline Noizet
founder of Digital Health Connector

1. Remote Patient Monitoring (RPM) is often framed as a cornerstone of value-based care. From your perspective, how is RPM reshaping care delivery models in Europe compared to traditional episodic care?

Remote Patient Monitoring (RPM) is transforming European care models from episodic, in-clinic visits to continuous, team-based management. It provides care teams with valuable data on a patient's health between appointments, not just during the window of the visit, enabling a more accurate diagnosis and personalised treatment plans. By continuously tracking biomarkers, RPM allows for early intervention, which helps to prevent hospitalisations and reduce healthcare costs.

The rise of digital hospitals in Europe is shifting care to the home whenever possible. This leads to shorter inpatient stays, fewer urgent visits, and better-coordinated care between hospitals, general practitioners, and community nurses.

RPM also delivers significant value in follow-up care, particularly for rehabilitation, by adjusting the treatment plan, or for cancer patients, by helping to detect relapse early.

2. What are the most promising technologies driving the next generation of RPM devices, and how are they improving the accuracy, usability, and scalability of remote care?

RPM devices are rapidly evolving, becoming less invasive and more integrated into daily life. This is driven by next-generation wearables, including:

- Smart rings and earrings that track an increasing number of biomarkers
- Oral sensors to monitor saliva and medication efficiency
- Innovative patches to track metabolic biomarkers through sweat or monitor bladder fullness without the need to do a blood test or an ultrasound

These technologies are enabling the continuous monitoring of complex metrics, from hydration and stress to respiration and blood oxygen saturation.

It is made possible by key advancements that include:

- Medical-grade sensors that are moving from consumer-grade accuracy to clinical-grade precision.
- Non-contact and ambient sensing, which eliminates the need for patients to wear a device at all.
- Low-power chips to extend battery life.
- The expansion of 5G networks to enable seam

3. Integration with existing hospital information systems and EHR platforms remains a challenge. How should healthcare organisations strategically approach interoperability to maximise RPM's benefits?

To maximise RPM's benefits, interoperability with healthcare systems is key. Healthcare organisations should look at integration as a strategic priority, fostering close collaboration between clinical and IT teams to align medical needs with technical readiness.

Healthcare systems should establish and share technical requirements like standards for data formats, security, and workflow integration, with RPM vendors from the beginning. This proactive approach ensures faster integration, smoother adoption and allows data to flow seamlessly into EHRs. It results in more actionable insights for care teams, better and faster continuity for patients, and stronger outcomes across the care pathway.

4. In rural or underserved regions, where healthcare access is limited, how can RPM devices realistically bridge the care gap without overburdening existing resources

In rural or underserved regions, particularly, RPM helps extend care by monitoring chronic patients from their home, reducing hospital visits and anticipating health issues before they escalate. In Galicia (Spain), a regional nurse-led program monitoring chronic and acute patients in rural areas has shown improved biometrics and great satisfaction: 86% of the 700 participants reported improved quality of life. ▶

> RPM devices are evolving from standalone tools into integrated ecosystems embedded into patients' daily lives and fully part of the care routine.

In underserved areas, eye checks or gynecological screenings can be performed by community health workers or nurses visiting patients where they are, with results analysed remotely by specialists. Patients who need further medical attention are referred to the closest medical centre. Those programs ensure early detection, prevent late-stage disease, and expand access without overwhelming resources, relying on collaborative and local care teams.

Reliability and simplicity are key for RPM to work in those areas —devices with embedded cellular connectivity and long battery life avoid infrastructure barriers.

5. Data security and patient privacy are critical concerns. What frameworks or innovations are emerging to ensure compliance with European data protection regulations like GDPR while enabling seamless RPM adoption?

To ensure patient privacy and data security, several key frameworks are emerging to ensure compliance with GDPR:

- Privacy by Design: Systems are built to minimise data collection and use default encryption from the beginning.
- End-to-End Encryption: All data transmitted is secured, ensuring it remains unreadable to unauthorised parties.
- Secure Cloud Infrastructure: Platforms use certified cloud services adhering to European data sovereignty rules.
- Federated Learning: AI algorithms are trained on data that does not leave the patient's device or the hospital's secure server, preserving privacy and enabling access to more data.
- Granular Consent Management: Patients are given easy-to-use tools to control which data they share and with whom.

6. What role do AI and predictive analytics play in interpreting continuous patient data streams, and how are they helping clinicians move from reactive to proactive care models?

AI and predictive analytics enhance RPM solutions by helping clinicians triage and prioritise patients, focusing on what matters most. They unify and interpret large volumes of data from multiple devices, and when combined with genetic profiles and lab results, AI can create a digital twin of the patient to identify risks, enable early detection and create personalised prevention programs.

To reduce alert fatigue, AI alerts clinicians only when immediate attention is needed. By providing a strong, integrated data foundation, AI enables informed decisions, timely responses, and more efficient patient management, while taking workload off from healthcare teams and improving the effectiveness of continuous care.

7. How do reimbursement models and payer policies in Europe influence the pace and scale of RPM device adoption? Are current frameworks sufficient to support widespread use?

Reimbursement frameworks are pivotal to RPM adoption in Europe. Countries like Germany and France have been leading the way with structured programs, such as Germany's Diga or France's List of Medical Telemonitoring Activities (LATM), which provides monthly payments to both RPM manufacturers and healthcare providers. Clear reimbursement and incentives accelerate adoption, while in countries without them, pilots don't scale easily.

However, having reimbursement in place doesn't equal adoption. Training and educating healthcare professionals is key for them to understand when and how to prescribe RPM effectively.

Private insurers are also driving uptake, increasingly bundling RPM into their packages to attract and retain customers, especially the younger, digital-savvy patients.

8. Could you share insights into how RPM devices are impacting patient engagement and adherence, particularly for chronic disease management?

RPM solutions are transforming chronic disease management by empowering patients to actively engage in their care. Through feedback loops and gentle nudges, patients receive concrete, actionable insights that help them track progress, reach goals, and improve their conditions.

By sharing bite-sized educational content, RPM also supports patients' understanding of their disease, which enhances both engagement and adherence. This combination of real-time feedback and ongoing education fosters better self-management, encourages earlier symptom reporting, and supports proactive care.

RPM not only strengthens the patient's role in their health journey but also delivers measurable improvements in disease control and overall quality of life.

9. From a clinical workflow standpoint, what are the most significant barriers healthcare professionals face in adopting RPM, and how can these be addressed through design or training?

Healthcare professionals face several workflow barriers when adopting RPM:

- Data overload: large volumes of data coming from multiple devices.
- Digital literacy gaps: uneven ability of the care team members to use digital tools and interpret data.
- Fragmented workflows: switching between RPM platforms and EHRs to enter and review data.
- Extra workload: Additional time reviewing and interpreting data, creating a new, time-consuming responsibility.

RPM providers should develop solutions that include:

- Involving and co-creating solutions with clinicians to address real unmet needs.
- Comprehensive training on usage and interpretation.
- Seamless EHR integration for automatic data flow.
- Intelligent alert systems with prioritisation of patients.
- Automating patient reminders, routine messages and nudges.

10. How can RPM solutions be tailored to the unique needs of multi- ▶

> RPM provides care teams with valuable data on a patient's health between appointments, not just during the window of the visit

morbidity patients, where simultaneous monitoring of multiple conditions is required?

RPM can be very valuable for patients with co-morbidities who are often using several devices to manage their different conditions. By aggregating and synthesising data from diverse devices, apps, and surveys, RPM solutions can offer a holistic view of the patient's health, reducing fragmentation and duplication while simplifying the experience for the patients and increasing their adherence.

For major effectiveness, clinical workflows should be redesigned to support multidisciplinary teams with harmonised and cross-functional escalation protocols. RPM dashboards should be personalised so specialists only have access to the information that matters to them without being overwhelmed. The main coordinator (e.g., nurse or coach) has access to all the data and can escalate issues when needed.

11. Partnerships between device manufacturers, healthcare providers, and technology companies are increasingly common. What collaboration models have proven most effective in scaling RPM deployment?

Partnerships between device manufacturers, healthcare providers, and technology companies are increasingly common. The most effective RPM collaboration models are those that align incentives, integrate seamlessly, and support the patient journey.

Partnerships thrive when solutions answer a real clinical unmet need and integrate smoothly without disrupting clinical workflows. Success also depends on designing technology that patients can easily embed into their daily lives, preventing drop-off and enabling scale.

A clear business model is essential, one that reflects the priorities of all partners involved. Past collaborations have struggled when innovations, despite offering clinical value, drove up treatment costs, which hindered adoption. To prevent this, risk-sharing models can provide a balanced approach, ensuring that incentives are aligned and benefits are distributed fairly across stakeholders.

12. Considering cost-effectiveness, how do you measure ROI for healthcare systems implementing RPM, beyond just reduced readmissions?

In terms of cost-effectiveness, RPM enables healthcare systems to assess ROI through multiple dimensions:

- Healthcare professional efficiency: Time saved on manual data entry, patient check-ins, and follow-ups.
- Resource optimisation: Treating more patients with the same or fewer staff.
- Care coordination: Streamlined communication between clinicians improves workflow and patient management.

- Post-care management: Earlier discharge and better post-procedure monitoring from home reduce downstream complications and hospital readmissions.
- Patient outcomes: Improved adherence and health results, leading to long-term cost savings.
- Patient satisfaction & retention: Enhanced experience can attract and retain patients, particularly in private systems.

13. With Europe's aging population and rising prevalence of chronic diseases, where do you see the greatest untapped potential for RPM adoption in the next 5 - 10 years?

With Europe's aging population and a growing shortage of healthcare professionals, especially in nursing and geriatric care, RPM will enable monitoring more patients with fewer resources, letting clinicians focus on those who need care most. Early symptom detection and proactive management can prevent deterioration and improve long-term health.

In geriatric institutions, RPM could support better oversight, reducing falls, complications, and hospitalisations through non-invasive solutions like radar or ballistocardiography technologies already used in Korean institutions.

Smart homes are growing and offer another opportunity. Connected devices like smart mirrors, smart mats, under-bed sensors, and even smart fridges could integrate RPM into daily environments, collecting a large amount of data to track early signs of deterioration.

14. Looking ahead, how do you envision RPM devices evolving - from standalone tools to integrated ecosystems that enable personalised, predictive, and preventive healthcare?

RPM devices are evolving from standalone tools into integrated ecosystems embedded into patients' daily lives and fully part of the care routine. Future devices will be more powerful, accurate, and unobtrusive. Integrated with genomics and other health data, RPM will enable personalised prevention and treatment plans based on individual risk profiles.

Programs like Roussy's cancer prevention model or Sanitas's genomic program illustrate how RPM can become part of a holistic, predictive, and preventive healthcare approach, improving outcomes and optimising clinical workflows.

AI will play an increasing role: AI algorithms and agents will detect subtle health changes, trigger early alerts, and support healthcare professionals with actionable insights.

Humans will remain in the loop to guide patients, ensuring adherence and proactive care.

References are available at www.europeanhhm.com

AUTHOR BIO

Aline Noizet is the founder of Digital Health Connector, with over 14 years of experience fostering collaboration within the digital health ecosystem. Drawing on her extensive international network, strong business acumen, and deep industry expertise, she collaborates with innovative companies to strategically advance their solutions and ensure they effectively reach the patients and providers who need them most.

The Future of Patient Care with Human Digital Twins

True Human Digital Twins are a unique technology that uses clinical, biological, mental, environmental, and social data to create a unique, real-time digital representation of an individual's entire health profile. Using AI and machine learning, they act as an early warning system for life-threatening illnesses, detecting emerging risks 72 hours earlier than traditional diagnostics.

Benedikt
von Thüngen, Founder & CEO, Sanome

1. How do you define a "true human digital twin" in contrast to traditional digital health models or digital patient records, and what makes it fundamentally transformative for healthcare delivery?

A true human digital twin (HDT) comprises three crucial components: access to an individual's personal health data, a certified AI model that uses this data to predict specific outcomes, and a mechanism to deliver these results to clinical teams for enhanced patient care. This approach builds on traditional healthcare delivery by providing powerful, actionable insights to empower overstretched clinical teams, giving them the relevant patient information, emerging risk predictions, and recommendations for the best actions to take.

The ever-increasing challenges facing healthcare systems today, significant healthcare professional shortages, coupled with an ageing population with more complex ailments, mean that relying on established care models can no longer ensure the high standard of care patients expect and deserve. The transformative aspect of an HDT lies in its ability to support clinical teams to deliver higher quality, person-centered care without drastically altering their existing workflow, serving as Clinical Decision Support.

The HDT approach is distinct from other digital models, as it provides a full 360 overview of the patient and models out the appropriate actions based on the totality of evidence available etc.

2.The concept involves integrating clinical, biological, mental, environmental, and social data into a single digital construct. What are the biggest challenges in harmonising such diverse and complex datasets into a reliable and real-time health representation?

The main challenges we have found are:

- Accessing, linking and standardising patient data: in addition to various levels of data-sharing across healthcare practices, vast amounts of our personal health data reside in siloed databases and are saved in various formats, creating a complex and labour-intensive process to create unified datasets.
- Building AI models that are fit-for-purpose and that can interpret the temporal value of data. For example, models that can assess the comparable relevance of blood test results from two years ago to current measures available, can provide clinically meaningful recommendations..
- Cybersecurity: of course, throughout this process, robust data protection and cybersecurity measures are crucial, with governance structures in place to ensure the safeguarding of patient privacy.

3. From a technical perspective, what role do AI and machine learning play in ensuring that a human digital twin is both predictive and adaptive to an individual's changing health profile?

Our approach leverages a variety of futuristic techniques, including continuous and adaptive learning, integrated within our platform, to ensure the HDT operates consistently within regulated boundaries. In addition, we have pre-established robust mechanisms to retrain models automatically, maintaining accuracy and compliance.

4. One of the most striking claims is the ability to detect life-threatening illnesses up to 72 hours earlier than conventional diagnostics. Could you explain how this predictive window is established and validated in real-world clinical settings?

Similar to how we know that symptoms like an itchy throat, fatigue, or loss of appetite can appear a couple of days before developing the flu, HDT can identify early trends that indicate a patient's changing condition by analysing several clinical data points live and in situ, eliminating the risk that these subtle signals will go unnoticed.

In collaboration with clinical teams, we have defined the ideal "window of opportunity" - the optimal time to alert HCPs to potential risks with clinically relevant sensitivity and specificity, thus prompting timely and effective action. Our models are capable of predicting risks up to seven days in advance. Through clinical co-design, we found the optimal alert window to be 12-36 hours, providing sufficient time to administer the right treatment

or prevent ward closures by isolating patients promptly and balancing the risk of false positives, avoiding alert fatigue among clinicians.

Our latest feature, soon to be released, allows clinical teams to customise their preferred alert window and sensitivity. This flexibility enables teams to customise the alert frequency based on the individual patient needs; for example, it may be preferable to have earlier, more sensitive alerts for high-risk patients on respiratory wards, while general ward teams may prioritise higher accuracy.

5. Real-time monitoring at such a holistic scale raises questions about interoperability with existing healthcare infrastructure. How do you envision seamless integration of digital twins into current hospital systems, electronic health records, and diagnostic workflows?

We are able to integrate the HDT directly into clinical workflows by partnering with several leading Electronic Patient Record (EPR) providers to securely embed MEMORI and create a seamless experience for clinical teams who can continue using their familiar tools without disruption.

6. What ethical considerations come into play when creating a digital representation of an individual's entire health profile, particularly regarding data ownership, consent, and patient autonomy?

Gaining consent to share patient data is a highly complex and often difficult process, but at Sanome, we're acutely aware of the sensitivity surrounding accessing and handling such personal data, and don't take this responsibility lightly.

Over 82% of patients support the use of their data for clinical research and the development of better tools to improve care, provided that appropriate governance structures are in place.

To ensure data is shared safely and ethically, we have worked closely with several Ethics Committees, Confidentiality Advisory Groups, and patient advocacy groups to establish robust governance and oversight frameworks to ensure that data is shared safely and ethically:

- Data ownership always remains with the individual, while the healthcare provider (in this case, the NHS) acts as the Data Controller.
- We have implemented strict data de-identification protocols to protect individuals.
- We acknowledge and uphold patients' rights to opt out at any time.

7. Environmental and social determinants of health are often overlooked in medical diagnostics. How does incorporating these dimensions into a human digital twin improve early detection and overall patient outcomes?

Absolutely, these factors play a significant role in patient health. For example, high pollen levels can worsen conditions like asthma or chronic obstructive pulmonary disease (COPD), increasing the likelihood of hospital admissions or the need for additional oxygen treatment. Similarly, elevated temperatures can contribute to blood pressure complications, raising the risk of cardiovascular issues.

Additionally, unfortunately, lower socioeconomic status is often linked to poorer health due to a range of factors such as inadequate housing, underlying health problems, and poor nutrition.

Our HDT model takes these additional factors into consideration, along with the patients' personal and clinical data (health profile, medi-

cal records and any wearable data) to provide healthcare professionals with a full picture of the patients' overall health, as well as accurate insights and actionable recommendations.

8. Predictive models in healthcare are often criticised for a lack of explainability. How does your system ensure transparency so that clinicians can understand, trust, and act upon the insights generated by a human digital twin?

From day one, we have prioritised transparency and clear communication. MEMORI clearly highlights the key data points that explain why the model predicts a certain outcome – we call this the AI explainability. These have been co-designed with clinical teams to ensure alignment with real-world applicability and to enhance readability and interpretability.

Furthermore, all of our AI models undergo rigorous evaluation, auditing, and certification by our Notified Body, and our results are submitted for peer review to ensure suitable external scrutiny and best practice.

9. Beyond early detection, how do you see human digital twins evolving in terms of preventive care, personalised medicine, and long-term disease management?

The future we envision is one where everyone has access to their own HDT that serves as both an entry point and triage tool in healthcare, easing the strains on healthcare services and suggesting personalised recommendations for the best course of action for the individual based on the information gathered, all under the oversight of clinical teams across community care, pharmacies, general practice, and secondary care. This could include personalised recommendations for preventative care and long-term disease management, such as prescription reminders based on real-time and real-world insights into current health conditions and environmental factors.

10. In terms of scalability, what infrastructure and policy frameworks are required to bring human digital twins from proof-of-concept to widespread adoption across diverse healthcare systems worldwide?

There are several key factors to consider. First and foremost, MEMORI is classified as a Software-as-a-Medical Device and is therefore highly regulated by health authorities such as the Medicines and Healthcare products Regulatory Agency (MHRA) in the UK, the Food and Drug Administration (FDA) in the US, and the EU Medical Device Regulation (EU: MDR) in Europe. As of April 2025, MEMORI is a CE-marked Class IIb medical device; the first real-time infection-prediction tool cleared at this level in Europe, while maintaining compliance with section 251 regulations on the use of patient data. These AI advancements are more than futuristic ideas, and we take our responsibility to patients seriously.

As our technology is embedded within existing EPR providers and leveraging their established infrastructure, we can ensure seamless integration and scalability for clinicians and the health system.

In order to bring this advancement to clinicians and patients in the real world, it needs to be sustainable. Our reimbursement model is focused on ensuring our platform provides actual value to clinicians and patients, and we operate on a shared benefit agreement approach.

11. Could you share examples or case studies where human digital twins have already demonstrated significant impact in clinical decision-making, patient outcomes, or healthcare efficiency?

So far, there are no large-scale case studies of complete HDTs in daily clinical practice. However, adjacent systems like multimodal risk stratification platforms, early warning systems, and precision prescribing platforms are some examples where AI is having a significant impact on earlier disease detection, reduced clinical workload, and better decision-making.

12. With constant advancements in genomic medicine, wearable technology, and real-world evidence, how do you see these fields converging with human digital twins to create a more precise and individualised healthcare ecosystem?

These are fantastic developments, and we are extremely excited about the opportunities they present. The key to success will be integrating these advancements into our HDT, enabling seamless support for clinicians' decision-making at the point of care, directly within the EPR. Ultimately, this will empower better, earlier, and more personalised clinical decisions.

13. Looking ahead, what do you consider the greatest opportunity - and the greatest barrier - in ensuring that true human digital twins become a standard of care rather than a futuristic concept?

We are already delivering on this vision, delivering the future of healthcare today, with several partnerships with the NHS and private hospitals,

The greatest challenges and opportunities go hand-in-hand; initiatives that promote better and easier data sharing, enhance interoperability between EPR vendors, and address the significant cost pressures facing healthcare to deliver improved care more efficiently will provide a more seamless overall experience.

MEMORI has the potential to support 55,000 clinical decisions across millions of unique patients. Our goal is to continue building on the work we have initiated with our pilot programmes; delivering bespoke clinical decision support and providing personalised recommendations to clinicians, easing the burden on healthcare services and empowering the system to shift from a reactive to a proactive model of care.

AUTHOR BIO

Benedikt is the Founder and CEO of Sanome, driven by a lifelong vision to create a true Human Digital Twin that empowers clinical teams to detect health changes earlier and more accurately. With a strong background in biosciences and venture technology, he has extensive experience scaling ventures across AI, enterprise software, and healthcare. Benedikt combines visionary thinking with high energy and practical execution to drive innovation and growth.

Big Data in Health care Decision Making

The utilisation of big data in healthcare decision-making harnesses extensive volumes of patient, clinical, and operational information to improve clinical results and operational effectiveness. Through the analysis of both structured and unstructured data, healthcare professionals can make well-informed decisions, forecast patient outcomes, refine treatment strategies, and enhance resource distribution. This data-centric methodology promotes personalised care, lowers expenses, and bolsters evidence-based practices.

Jiten Jain
Vice President & General Manager, Doceree

1. How do you define the role of big data in transforming clinical decision-making within modern healthcare systems?

To me, big data is the bridge between clinical intuition and scientific precision. Having worked across diverse healthcare ecosystems, I have seen firsthand how unlocking insights from vast datasets, clinical records, prescribing behavior, and real-time patient interactions enables more proactive and personalised care. It empowers clinicians to move beyond reactive decisions toward predictive, evidence-based actions. Ultimately, it's not just about technology; it's about delivering better outcomes, faster, and at scale, which I believe is foundational to modern healthcare transformation.

2. What are the primary data sources leveraged in big data analytics for healthcare, and how is data integrity maintained across these diverse sources?

We pull from a range of sources, including EHRs, prescribing data, insurance claims, lab results, real-time patient monitoring, and even digital engagement touchpoints. The challenge is not just access, it's consistency. Data integrity comes down to context: understanding how and why the data was captured, standardising formats across markets, and applying rigorous validation before analysis. In my experience, it's this discipline, more than the data itself, that ensures insights are actually useful and actionable.

3. In what ways can predictive analytics derived from big data improve patient outcome forecasting and risk stratification?

Predictive analytics helps us move from reacting to anticipating. By analysing trends in clinical history, treatment responses, and behavioral data, we can flag at-risk patients earlier and tailor interventions before issues escalate. I've seen this make a real difference, whether it's identifying non-adherence patterns in chronic care or predicting the likelihood of readmission. It's not about replacing clinical judgment but sharpening it with evidence that's otherwise invisible in day-to-day workflows.

4. How do you ensure the interoperability of disparate healthcare data systems to facilitate comprehensive big data analysis?

Interoperability isn't just a technical problem; it's a strategic one. You need alignment across systems, standards, and stakeholders. In my work, we focus on mapping data to shared frameworks, but just as importantly, we invest in understanding local market nuances. A dataset from the US won't look the same as one from the UK. The key is building connectors that respect both the source and the broader ecosystem. Without that layer of intelligence, integration becomes noise instead of insight.

5. What are the ethical challenges associated with using big data in healthcare decision-making, particularly concerning patient privacy and data consent?

One of the biggest challenges is using data responsibly without losing sight of the person behind it. Consent isn't a checkbox; it's a matter of trust. In Europe, with strict regulations like GDPR, we're rightly held to high standards. But ethics go beyond compliance. It's about being transparent with how data is used, limiting use to what's necessary, and building systems that protect privacy by design. I believe if we can't explain to a patient why and how their data helps improve care, we shouldn't be using it.

6. How can unstructured data from electronic health records (EHRs), clinical notes, and imaging be effectively integrated and analysed for decision support?

Unstructured data is where a lot of the real insights live—but it's also messy. Clinical notes, free text in EHRs, imaging reports—they carry context that structured fields often miss. We use natural language processing (NLP), computer vision, and AI models to extract meaning from that noise. But tools alone aren't enough. You need clinical understanding to interpret what the data is actually saying. In my experience, the most effective systems combine smart technology with human context to turn unstructured input into usable, trustworthy insight.

7. To what extent has big data analytics influenced the development of personalised treatment plans in your experience?

In my experience, big data has moved personalised treatment from concept to practice. By connecting clinical history, prescribing behavior, response patterns, and even socioeconomic factors, we can build a far more accurate picture of what's likely to work for a specific patient, not just the average one. I've seen this approach improve adherence, reduce trial-and-error prescribing, and support more meaningful conversations between HCPs and patients. It's not perfect yet, but the direction is clear: care is becoming more tailored, and data is a big reason why.

8. What machine learning or AI techniques do you find most effective in analyzing healthcare big data, and why?

The most effective techniques are the ones that fit the complexity of the question, not just the data. In healthcare, that often means starting with supervised learning, especially for use cases like risk prediction, readmission likelihood, or treatment outcome forecasting. When we have solid historical data, these models can give strong signals that clinicians can act on.

Natural language processing has been a game-changer for us in Europe, especially when dealing with physician notes, discharge summaries, or even social determinants documented in free text. It helps surface insights that structured fields miss entirely. I've also seen growing value in graph-based models; they're especially useful in mapping patient journeys and identifying care gaps across fragmented systems.

That said, the best models are useless without context. We spend just as much time on validation and clinical input as we do on the algorithms themselves. In healthcare, it's not just about accuracy; it's about whether the insight leads to a better decision. That's the only benchmark that matters.

> Natural language processing has been a game-changer for us in Europe, especially when dealing with physician notes, discharge summaries, or even social determinants documented in free text. It helps surface insights that structured fields miss entirely.

9. How do you evaluate the clinical relevance and actionability of insights generated from big data tools?

Evaluating clinical relevance starts with one simple question: Does this insight help someone make a better decision at the point of care? If it doesn't, it's noise. We test insights against real-world workflows, involve clinicians early, and ask them what's useful, not just what's statistically significant.

I've learned that insight only becomes actionable when it's timely, easy to interpret, and tied to a clear next step. Fancy dashboards or high-accuracy models mean nothing if they don't fit into how care is actually delivered. It's not about more data; it's about better judgment, enabled by the right data.

10. What role does big data play in optimising hospital operations, resource

> Big data has moved personalised treatment from concept to practice. By connecting clinical history, prescribing behavior, response patterns, and even socioeconomic factors, we can build a far more accurate picture of what's likely to work for a specific patient, not just the average one.

allocation, and reducing healthcare delivery costs?

Big data gives hospitals the ability to see patterns they could not before. Instead of relying on averages or gut feel, administrators can use real-time insights to forecast patient volumes, plan staffing, and optimise bed turnover. I've seen this lead to better preparedness during seasonal surges and more effective use of clinical teams across departments.

It also helps flag inefficiencies, whether it's delays in diagnostics, underused equipment, or recurring bottlenecks in patient flow. In some cases, predictive models have helped hospitals identify which patients are likely to need ICU support or longer stays, allowing for smarter triage and resource allocation.

Especially in Europe, where healthcare budgets are tight and expectations are high, this kind of operational intelligence helps systems do more with less, delivering quality care while controlling costs. It's not about squeezing margins; it's about allocating effort where it matters most.

11. How do regulatory frameworks such as HIPAA or GDPR impact the deployment of big data technologies in healthcare?

Regulations like GDPR and HIPAA, to some extent, in global work, set clear guardrails, which I see as a good thing. They force us to build systems that respect privacy from the start, not as an afterthought. In Europe, especially, GDPR shapes everything from how we collect consent to how long we store data and who can access it.

Yes, it adds complexity, but it also builds trust. Patients and providers are more willing to engage with data-driven solutions when they know their rights are protected. In my experience, working within these frameworks doesn't limit innovation; it challenges us to be more thoughtful, transparent, and accountable in how we use data.

12. What are the common technical or infrastructural barriers healthcare organisations face when implementing big data solutions?

One of the biggest barriers is fragmentation; data lives in silos across EHR systems, labs, payers, and sometimes even paper records. Getting those systems to talk to each other is a major technical lift. Then there's the issue of data quality: inconsistent formats, missing fields, and outdated entries all compromise what you can actually do with the data.

Infrastructure is another challenge. Many healthcare organisations, especially in public systems, don't have the computing power, storage, or internal expertise to deploy advanced analytics at scale. I've seen projects stall not

because the tech didn't work, but because the foundation wasn't ready.

Solving this isn't just about buying new tools; it's about investing in integration, governance, and talent that understands both healthcare and data. Without that, even the best big data platforms won't deliver meaningful results.

13. How can healthcare institutions ensure continuous improvement and learning from data-driven decision-making processes?

Continuous improvement starts with treating data as a feedback loop, not just a one-time report. It's not enough to generate insights; you have to track what happens after you act on them. Did the intervention improve its outcomes? Did it reduce costs? Did it change behavior? If not, why?

In my experience, the most effective institutions bake this into their culture. They create multidisciplinary teams, including clinicians, analysts, and operations, who regularly review what the data is telling them and adjust courses when needed. It's less about chasing perfect predictions and more about staying curious, asking the right questions, and being willing to adapt based on what you learn. That's where real progress happens.

14. Looking ahead, what future innovations or trends in big data do you anticipate will have the most significant impact on healthcare decision-making?

What excites me most is the shift from retrospective analytics to real-time, point-of-care intelligence. We are moving toward systems that do not just tell us what happened, but help guide what should happen next, right when decisions are being made. That is a fundamental change in how care is delivered.

I also see a growing role for non-clinical data, things like lifestyle behavior, social context, and digital touchpoints. These are not just peripheral signals; they are central to understanding the full picture of a patient. Integrating them meaningfully into care decisions will make treatment more personal, more predictive, and ultimately

And as AI becomes more embedded in healthcare, explainability will matter more than complexity. A model that cannot justify its output in a way a clinician understands is a black box, and black boxes do not build trust. The future of big data in healthcare is not just about better algorithms. It's about smarter, more transparent collaboration between humans and machines. That is where the real transformation will come from. ■

AUTHOR BIO

Jiten Jain is a seasoned healthcare professional with over 15 years of experience across Pharma, Medical Devices, OTC, and Health Insurance. Leading Doceree's European operations from London, he combines a biotech engineering background with strong business acumen. Starting as a vaccine researcher, Jiten transitioned to medico-marketing, advertising, and digital health. His extensive experience in APAC and EMEA equips him with global insights and strategic expertise. Jiten is recognized for his innovative approach and leadership in healthcare marketing and strategy.

ESC Congress 2025 - Experience

Prof. Mathias Goyen reflects on ESC Congress 2025, highlighting innovations in imaging, AI, and workflow efficiency. He emphasizes equity, collaboration, and the integration of advanced visualization in cardiology. The event showcased transformative technologies and global health strategies, setting a clear trajectory for personalized, digitally enabled cardiovascular care.

Prof. Dr. med. Mathias Goyen

Chief Medical Officer, Imaging & Advanced Visualization Solutions, GE HealthCare

1. How was your overall experience participating in the ESC Congress 2025?

My experience at ESC 2025 in Madrid was deeply energizing and thought-provoking. From the opening sessions through the late-breaking science panels and guideline updates, the congress felt precisely like the pulse of modern cardiology. The breadth of participation from clinicians, researchers, industry leaders, and health systems created a vibrant environment for exchanging ideas. For me, it was refreshing to see both scientific rigor and human stories intersect: technologies not only for innovation's sake, but to address real clinical problems and global health disparities.

2. What motivated you to contribute to this year's congress, and how did your role align with the event's central themes?

At GE HealthCare, we have a comprehensive cardiology portfolio from diagnostics to advanced visualization, imaging, AI, and workflow solutions. My motivation was to engage in conversations that push boundaries: how can imaging and visualization help close practice gaps, improve diagnostic speed and accuracy, and ultimately support better patient outcomes? ESC 2025 had several themes I deeply care about: digital transformation, global health, performance & efficiency, and clinically meaningful innovation. My role as Chief Medical Officer for Imaging & Advanced Visualization Solutions is to guide our development so it aligns with those themes, and ESC provided the stage to compare, contrast, learn, and share.

3. What were the most significant discussion points you observed during the congress?

Several key discussion threads stood out:

- Health equity and global burden of cardiovascular disease: how care access, diagnostic capacity, and follow-up care vary dramatically among regions, and what scalable, cost-effective technologies might help close those gaps.
- Ethical, regulatory, and practical aspects of AI in cardiology: biases, transparency, explainability, data privacy; ensuring that AI tools are validated, integrated properly, and benefit rather than undermine patient care.
- Guideline updates and implementation: new recommendations for valvular heart disease, myocarditis, pericardial disease, lipid and blood pressure management; plus "Guidelines in Practice" sessions addressing how to make these real in daily care.
- Imaging efficiency and workflow innovations: reducing manual burden, improving image acquisition, cutting scan time, optimizing radiation dose. These practical improvements can make a real difference in both high-volume centers and lower-resource settings.

4. Which sessions or panels stood out to you as particularly relevant or impactful for cardiology professionals?

- The Late-Breaking Science sessions were remarkable: they showcased studies with immediate relevance to clinical care, especially trials in hypertensive therapy and coronary artery disease risk stratification.
- The Guidelines in Practice panels, which dove into case studies to show how new recommendations can be applied in real institutions, were especially valuable. They bridge the often-large gap between what is "recommended" and what is feasible in varied care settings.
- Sessions on AI and imaging innovation, particularly those showing how advanced visualization and automation can shift workflow burdens and improve diagnostic precision, were highly relevant.
- The Global Health sessions highlighting disparities, low- and middle-income settings, and scalable innovations truly underscored the global responsibility cardiology carries now and soon.

5. What were your key takeaways from the event, both as a participant and as a medical leader?

- Innovation must always be coupled with validation, equity, and integration. It is not enough to produce cutting-edge devices or AI tools; these must be accessible, validated in diverse populations, and embedded into existing clinical workflows.
- Workflow efficiency matters as much as diagnostic capability. Technologies that reduce time, reduce operator burden, and improve consistency can have as big an impact as new pharmaceuticals or interventional techniques.
- Imaging and visualization are central in modern cardiology. They are foundational to diagnosis, treatment planning, risk stratification, follow-up. Advances in imaging resolution, AI-assist, and interactive visualization will continue to unlock better patient care.

- Collaboration is essential. Clinicians, industry, payers, health systems, regulators when aligned, they can accelerate adoption without compromising safety or ethics.
- Global health is no longer a niche. It must be part of every institution's strategy: ensuring that cardiology innovation benefits people in diverse settings, not only those in resource-rich systems.

6. How do you see the discussions at ESC Congress 2025 shaping the future of cardiology and patient care?

ESC 2025 has set a clear trajectory: patient care will become more personalized, anticipatory, and digitally enabled. We are moving toward a future where diagnostics are earlier and less invasive, AI supports decision-making in real time, and care pathways are optimized end to end. The conversations around guidelines + implementation will drive standardizing excellence across geographies. Also, the demands for equity and global health will push for technologies designed not only for high-resource hospitals, but for use in varied contexts. Regulatory, reimbursement, and ethical frameworks will adapt, hopefully bringing structure to fast moving innovation. Patient care will increasingly depend on integrated imaging, advanced visualization, and tools that help clinicians manage complexity with clarity.

7. What were the most exciting innovations or technological advancements showcased at the congress?

- Imaging systems with AI-powered automation: improved measurement tools (ejection fraction, strain imaging) that reduce operator variability and speed up reporting.
- One-beat CT angiography technologies: faster acquisition, motion correction, reduced radiation exposure: progress that directly benefits patients.
- Advanced visualization tools: better post-processing, 3D/4D imaging, clearer rendering of anatomy, integration with treatment planning and navigation.
- Workflow/automation platforms for echo and overall imaging reporting: tools that reduce manual steps and free up clinician time.
- Digital health tools and predictive analytics: risk stratification platforms, remote monitoring integrated with imaging data, and AI models that help anticipate disease progression or complications.

8. How do you see imaging and advanced visualization playing a role in advancing cardiology in the near future?

Imaging and advanced visualization will increasingly be the backbone of cardiology in several ways:

- Early detection and risk stratification: better imaging lets us pick up disease earlier, e.g. subtle structural changes, fibrosis, plaque characteristics, calcium scoring. Advanced visualization and AI will help interpret these images with greater sensitivity and consistency.
- Guided therapy planning: 3D/4D visualization aids decision making in structural heart disease (valves, pericardial interventions), planning surgeries or catheter-based interventions.
- Reducing variability and human error: automation in standard measurements, reproducible protocols, AI-based decision support will reduce inter-observer differences and speed diagnosis.
- Improved patient workflow and throughput: faster imaging, more precise acquisition, reduced scan times and dose means better patient experience, higher capacity, and more cost-effective services. ▶

- Integrative data visualization: combining imaging with genomic, clinical, and remote monitoring data to give clinicians holistic views of patient risk and disease state.

9. How did ESC 2025 facilitate meaningful professional connections or opportunities for collaboration?

ESC 2025 was fertile ground for forging new connections and strengthening existing ones. As a representative of GE HealthCare, I had the opportunity to engage directly with:

- Clinicians and researchers working on AI and imaging to understand their unmet needs, gain insight into local practice challenges, and collaborate on solutions.
- Health systems and hospital leaders from different countries exploring how to scale and deploy advanced imaging in varied environments, from high-volume centers to more constrained settings.
- Policy makers and guideline authors, especially in sessions on global health and guidelines implementation, which opens dialogue on how innovations can conform to standards and be supported by regulatory frameworks.
- Partnering with academics and innovators in visualization, data science, AI to explore integrative research, validation studies, and multicenter trials.

These interactions are essential. They provide feedback loops on what works, what's acceptable, what evidence is needed and help shape the product roadmap and deployment strategies for real-world impact.

10. What message would you like to share with fellow professionals who could not attend the event?

Even if you couldn't make it to Madrid, the messages from ESC 2025 are clear and broadly relevant:

- Stay abreast of guideline updates especially those that address structural heart disease, myocarditis/pericarditis, lipids, and hypertension. They will increasingly inform what is "standard of care."
- Look for imaging and AI tools but scrutinize them: ask about validation in diverse populations, workflow fit, interpretability, and evidence of outcome improvements.
- Consider not just what technology can do, but what it should do: in terms of patient safety, clinician support, equity, cost.
- Seek collaboration: reach out to peers, industry, academic centers. The best advancements often come from partnership.
- Advocate for your patients: innovation must be guided by clinical value. New imaging or AI tools should ultimately reduce morbidity, mortality, or improve quality of life, not simply create new capabilities in isolation.

Thank you for the opportunity to share these reflections. ESC Congress 2025 has reminded me that the future of cardiology is not just being built. it is being shared.

AUTHOR BIO

Prof. Dr. Mathias Goyen, Global Chief Medical Officer for Imaging and AVS at GE HealthCare, leads global medical and clinical strategies. A radiologist and professor, he previously directed UKE Consult, advancing cancer care integration. He earned his MD from Bochum and served as Secretary General of the German Chinese Society of Medicine.

THROUGH THE HOURGLASS

The Rise of Remote Monitoring Is Reshaping Healthcare

This article explores how these innovations are revolutionising patient care, from early telemedicine to AI-driven wearable's and IoT integration. With the ability to reduce hospital visits, improve outcomes, promote self-care and data-driven insights, remote monitoring is not just evolving—it is redefining the future of healthcare delivery

Richard McGregor
Head of Digital and Performance, Cumbria Health

With a career spanning almost 20 years working in healthcare in the UK across a variety of departments within the tech space, I have been fortunate enough to witness and participate in the evolution of how we use technology in healthcare.

I was present for the initial modernisation of patient administration systems and the implementation of the NHS spine, which connected all health providers across the country, and I am here now, whilst instead of connecting health providers, we are now connecting patients to the same systems via the NHS App – our Digital front door.

Whilst some would argue (unfairly in my opinion) that 20 years to get to this stage is no great feat considering the pace at which the Banking industry achieved this, the complexity of what has been achieved should not be understated.

When we think of what we use online banking for and the available information is comparatively basic – money in, money out, balance and transaction history are the standard expectations and whilst some make other features accessible – mortgage and loan applications, overdraft management facilities, chat to an adviser features etc. a standard NHS health record will contain demographic information, allergies, medications, appointment records, health record notes, health status, blood tests, imaging and diagnosis whilst online consultations are now available across most GP practices via the NH. ▶

Further to this complexity, making up the complex structure of NHS providers are 6,277 GP practices and 215 hospital trusts feeding into the NHS App directly via either their primary care EPR (electronic patient record), NHS-developed systems or a range of third-party providers. The journey to get to this stage has been challenging, but there is so much more to come, and it is exciting, particularly given the challenges to come.

I use the word exciting because as well as being a health-tech enthusiast and employee, I am also about to need the NHS more frequently – I have recently had my 40th birthday and will soon be invited for my NHS Health Check (Health MOT – more on that later in the article) and statistically, I know that over the next 2 decades, I will use the NHS more than I have done in the first 4 decades of my life. I have become increasingly health-conscious, and advances in technology mean that I can now monitor my blood pressure, blood oxygen levels, stress levels, sleep performance, heart rate variability and activity levels using consumer wellness products such as smart-watches and health bands. I can do this continuously or as a spot measurement, and whilst the products I use are not registered medical devices, they allow me to self-monitor my own health, wellbeing and fitness.

Remote patient monitoring is not a new concept and has been around since before the first NHS PAS system in the late 60's (IRC PAS). Alan Shepherd (the second man in space) was monitored on a space flight in 1961. Following this, we had the ECG Holter in 1962; however, remote patient monitoring as we know it today did not become a standard offer until far later. A large majority of clinicians would probably refer to the COVID-19 pandemic as the first time they truly benefited from what the technology can offer.

I am often asked why it took from 1961 until 2020 for clinicians to be able to receive readings from patients when the technology has been there all this time, and unlike climbing Mount Everest, the conditions haven't needed to be perfect, which brings me to Everett Rogers Diffusion of Innovations (Everett Rogers, 1962 - Diffusion of Innovations). Everett theorised that widespread adoption typically moves through five groups: innovators, early adopters, early majority, late majority, and laggards.

When I describe the remote patient monitoring journey, I use these stages. The first group of innovators was the Whole System Demonstrator programme, which involved 6,191 patients who were registered with 238 GP Practices across Newham, Kent and Cornwall. Whole system demonstrator programme: Headline findings – December 2011 - GOV. UK and concluded with demonstrable benefits which reduced mortality, hospital admissions, reductions in length of stay for those who did need to be admitted and reduced time in ED.

My early adopter example is in 2016 when a solution named Florence reported 22,000 patients across 70 health providers utilising their SMS solution to send reminders for medication, monitor self-reported readings (blood pressure,

symptoms), with clinicians receiving alerts if a patient's condition was to deteriorate. Evaluations showed high patient satisfaction, feasibility across a range of conditions, and usability, including those typically referred to as non-tech-savvy.

Our early majority came in 2020 through the introduction of Oximetry@Home services and Covid virtual wards, NHS England » COVID virtual wards, the catalyst of which was the Covid pandemic. This is the first example in the NHS of a remote monitoring service being scaled nationally, and over 26,000 patients benefited from the service in less than a year. PowerPoint Presentation with 120 from the 125 Acute Trusts reporting having a COVID-19 virtual ward.

Our late majority will come soon afterwards, with the NHS investing £200 million in the implementation of virtual wards and a further £250 million (match-funded in 23/24). In 24/25, 111,000 patients were admitted to a virtual ward.

Which now brings us to the laggards, which remain.

Across England, 19 trusts do not have a modern EPR, eight of which are Acute Hospital providers.

Therefore, it limits their ability to embrace the benefits of remote patient monitoring. Despite the benefits shown by remote patient monitoring across thousands of published and peer-reviewed clinical papers, there are still clinicians who prefer the traditional face-to-face models, are not convinced by the accuracy of medical devices despite robust medical certification processes, and many have a mistrust of the intentions of implementing digital technologies at the fear of being replaced.

Technology trust and the fear of a new revolution are not new concepts, and the AI revolution is often likened to the Industrial Revolution of the 1800s.

Public perception of the Industrial Revolution was one of excitement, a feeling of incredible progress for humankind, with hope of new opportunities, faster travel, more cost-efficient household budgets, and a greater quality of living. Those working in industry, however, saw this as a threat to their jobs, livelihoods and complained of their working conditions (long hours, low pay and unsafe working environments) whilst their communities had concerns about the breakdown of their traditional way of life and protecting rural economies.

Whilst the parallels are striking, the circumstances and challenges of today differ significantly, so the comparison can only be taken so far.

Arguably, today our challenges are greater. From a public service perspective, our population has increased 325% (the 1810 population was approximately 16m) whilst life expectancy has doubled.

The NHS is a UK national treasure; however, it is not sustainable in its current form. The Health Foundation estimates a need for a further £38 billion per year by 2030 to meet impending demand, largely due to our growing

population and ageing demographic - to put this into context, Iceland's GDP is £30 billion.

As well as the hefty cost of the NHS, A&E attendances have risen 15% in the last 10 years, whilst 12-hour trolley waits in A&E have increased from 47 to 74,000 over the same time. From a population growth perspective, by 2040, the number of 85+ will double, and the number of people diagnosed with ill health is likely to increase by 39% over the same time.

So what more can be done to help our health services, whilst the remote monitoring examples show how we can cycle through the innovation cycles from an early adopter to coverage on almost all the Hospital Trusts in a population of 67 million, these examples were for specific conditions and severities. What can we expect next from innovation?

Innovation, of course, is an interesting paradigm. One of the greatest feats of mankind was the moon landing in 1969. The ability to crash land a spacecraft on the moon safely and then return it to earth safely is extraordinary and when you consider some of the greatest minds on earth designed and planned this feat, I find it surprising that Neil Armstrong when gazing at the marvel he was about to accomplish, picked up his suitcase and carried it on to aircraft because at that time no one had thought to attach wheels to the suitcase.

The suitcase of course is another example of delayed adoption following innovation, the idea was patented in 1972 but never fully embraced by the public until the early 1990's largely due to 3 x core reasons, the floor surfaces were bumpy and not the smooth surface we have become used to (infrastructure), there were already a sufficient number of staff to carry (resource available and identified) and the masculine stereotype (culture) associated with carrying a suitcase.

I have been involved in a project recently utilising the PocDoc Healthy Heart Check, which essentially allows a patient to conduct a cardiovascular screening check without any clinician involvement and includes a self-blood test, which will deliver a full lipid panel in less than 10 minutes. The project I was involved in conducted over 5,000 of these checks in less than 6 months (including the three x winter months, the busy period in health, particularly the NHS). From the 5,000 tests conducted, only 550 required any clinical follow-up and therefore, a significant reduction in workforce was required to deliver. For the 4,450 patients who didn't need anything done, we now have some baseline data for them to measure going forward as the reports integrate into the Practice record via the NHS App. Each of these patients, of course, also now has their cholesterol, BMI, stroke risk and heart age stored within their own personal phones and has more of an understanding as to what this means.

This project was a massive success and a perfect response to the perfect storm we are in when you consider the quality-of-life years that prevention of cardiovascular disease can bring

our loved ones and us, and for us working in health allows us to focus our capacity elsewhere.

NHS Health check compliance for the country is 1 in 4 being screened (focusing solely on the 40 – 74 age group), and in some parts of the country, this is 1 in 10. The core reasons, based on feedback from clinicians and the public, are concerns about the capacity to deliver care and difficulties taking time off work to attend appointments when they are not unwell.

Over the past 3 years, we have seen a significant increase in consumer wellness products and services and a significant uptake in the utilisation of these across all age groups.

Culture is changing across large parts of the country with our 30 plus age groups becoming more health conscious, we have an Instagram obsessed younger generation are choosing health clubs over pubs, high speed internet is available across the nation, 99% of our population have a smart-phone and over 50% of the population have some form of fitness tracker whilst in the NHS we have transitioned from connecting our health systems together to connecting our patients to our health systems via the NHS App. In addition to this, we have a nationally scaled remote monitoring programme in most of our Acute Hospitals whilst we have made significant strides in the development of artificial intelligence and intelligent automation solutions.

I leave you today with the following questions, and would love to hear your thoughts.

What if the wheel on the suitcase is to utilise what our patients already have, what our patients are already doing or are prepared to do for their own health and connect them to our health systems via the NHS App and fully embrace the potential of remote monitoring?

What if my Diffusion of innovation example is wrong, and we haven't moved past the early adopter stage, and the 50% who already have health trackers are our early majority, and it is up to us to knit them into the fabric of the NHS health systems.

The views and opinions expressed in this article are solely my own and do not necessarily reflect those of my employer or any organisation with which I am affiliated.

AUTHOR BIO

Richie McGregor is a visionary leader with over 17 years of experience driving digital innovation in healthcare. They have consistently delivered transformative solutions by leveraging cutting-edge technologies, including artificial intelligence, to improve patient outcomes and enhance operational efficiency. As a sought-after speaker at industry conferences, Richie has also published numerous articles on the role of technology-enabled care and AI in creating more inclusive, sustainable healthcare systems.

THROUGH THE HOURGLASS

Interventional Pain Medicine

A Practice at the Crossroads of Technique and Listening

Interventional pain medicine creates an essential space where chronic pain defies conventional medicine. Through various clinical experiences, this article offers a personal perspective on the therapeutic potential of targeted procedures—ranging from regional anesthesia to neuromodulation—and the profound impact they can have on patients' quality of life.

Dr. Lamia Youssar

Anesthesia and Intensive care physician, CHIREC Hospital Group

Some types of pain elude any biomechanical logic. Others stubbornly resist conventional pharmaceutical treatments. As an anesthesiologist specialized in interventional pain management, I have often found myself face-to-face with these gray areas: patients labeled as being in "therapeutic failure," for whom a targeted, reimagined procedure could sometimes change everything.

My practice has led me to work in various settings—from Belgium to Spain, and even Morocco—each with its own protocols, constraints, and resources. Everywhere, a common reality emerges: chronic pain extends far beyond the physical realm. It invades daily life, undermines identity, and gradually isolates patients from their social and emotional world.

It is precisely in these spaces that interventional pain medicine has revealed itself as a valuable tool—not only technical, but deeply human. It has allowed me to offer some patients unexpected therapeutic paths, often absent from traditional care pathways.

Here, I share several cases that have shaped my vision of this demanding and fascinating specialty over the years.

Cervical Radiculopathy and Targeted Neuromodulation

I recall a 50-year-old, active patient suffering from chronic cervicobrachial radiculopathy due to a C6-C7 disc herniation. The pain radiating into his arm disrupted his sleep, affected his

mood, and progressively distanced him from his professional activities.

In this case, I combined two approaches: a targeted epidural block and ultrasound-guided neuromodulation of the cervical root. The first provided immediate relief; the second offered longer-lasting effects. Two weeks later, the patient reported complete pain relief, had returned to work, and, most importantly, rediscovered his ease of movement.

Although technically demanding, this type of procedure shows how a targeted approach can restore quality of life where conventional treatments fail.

Pancreatic Cancer and Refractory Visceral Pain

Among the most intense pain I have encountered, that associated with pancreatic cancer stands apart. A 65-year-old patient with non-resectable cancer remained in relatively

good general health but experienced daily abdominal pain radiating to the back, despite heavy opioid use.

A celiac plexus neurolysis was indicated. Performed under imaging guidance, this procedure selectively interrupts the nerve transmission responsible for visceral pain. Four months after the intervention, the patient was pain-free, had resumed personal activities, significantly reduced his medication, and described a true return to a dignified life.

This experience underscores that even in advanced oncological contexts, pain can—and must—be addressed differently.

Knee Osteoarthritis and Genicular Nerve Neurolysis

Musculoskeletal pain is another major component of chronic pain. I treated a 48-year-old patient with severe knee osteoarthritis. At the time, surgery was not an option, and the pain prevented him from walking, working, or sleeping.

He visited the emergency department almost every night for IV analgesics. We then

performed an ultrasound-guided neurolysis of the genicular nerves.

Three days later, he was walking again, had returned to work, and significantly reduced his medication. This minimally invasive intervention perfectly illustrates the functional role of interventional pain medicine: restoring autonomy without necessarily resorting to surgery.

Reflection – A Demanding and Forward-Looking Discipline

Interventional pain medicine remains, in many ways, a specialty of the future. It relies on solid technical foundations, a deep understanding of pain mechanisms, and constant adaptability to both clinical and human contexts. It is a discipline that requires true expertise, built over a long and gradual learning curve.

Each procedure demands precision, caution, and careful consideration of the patient's history. It is not a "simple" alternative to medication or surgery, but a complementary path—sometimes a decisive one—when standard treatments fall short.

Still emerging in some healthcare systems, it deserves greater integration, better training, and, above all, recognition as a full-fledged therapeutic lever—capable of transforming patients' daily lives, sometimes with a single intervention.

Conclusion

Far from being just a technical response to pain, interventional pain medicine represents a global, precise, and respectful approach to patients' lived experiences. In contexts as varied as cancer-related pain, advanced osteoarthritis, or complex neuropathic syndromes, it opens up concrete avenues for relief—where standard treatments reach their limits.

Demanding in its implementation, this discipline deserves a full and rightful place in modern therapeutic strategies. It invites us to rethink our approach to chronic pain—not as an unchangeable reality, but as a phenomenon that can be modulated, soothed, and at times, even overcome.

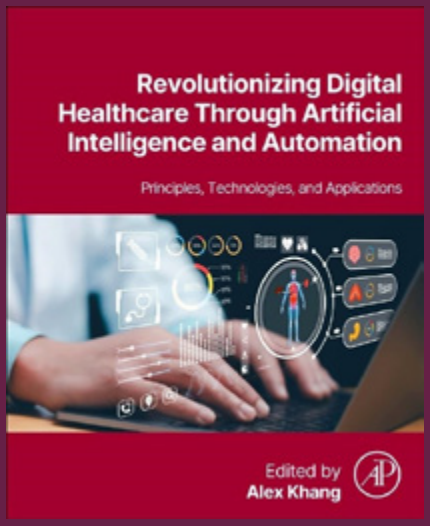
Interventional pain medicine does not replace—it complements. It enriches our therapeutic toolkit while keeping at its core the fundamental goal of all medicine: to restore the patient's freedom of movement, choice, and life. ■

AUTHOR BIO

Dr. Lamia Youssar is an anesthesiologist and intensive care physician with a subspecialty in interventional pain management. Practicing internationally, her diverse professional background enables her to integrate a range of methods tailored to the cultural and clinical contexts of patients suffering from chronic pain.

Revolutionizing Digital Healthcare through Artificial Intelligence and Automation

Principles, Technologies, and Applications



This book is your gateway to the transformative world of AI-powered healthcare. It explores how artificial intelligence, smart devices, and cutting-edge technologies are revolutionising medical diagnostics, treatment, and patient care. From AI-driven imaging to medical robotics, virtual reality, and the Internet of Things (IoT), it delves into groundbreaking innovations that enhance efficiency, accuracy, and security in digital healthcare. Whether you are a researcher, healthcare professional, or tech enthusiast, this book provides insights into the principles, applications, and real-world implementations of AI in modern medicine—bringing you one-step closer to the future of healthcare.

Alex Khang

Faculty, AI and Data Science, Global Research Institute of Technology and Engineering, Vietnam and the United States

1. Your book's title speaks of "revolutionizing" digital healthcare through AI and automation. In what specific ways do you believe current digital healthcare systems are undergoing this revolution?

Digital healthcare is being revolutionised by AI and automation through faster, more accurate diagnostics, predictive analytics, and personalised treatments. Automation streamlines administrative tasks, while virtual assistants and remote monitoring enhance patient engagement and access. AI-driven tools support clinical decisions, optimise drug development, and enable robotic surgeries. Together, these technologies are transforming care delivery from reactive to proactive, improving outcomes, efficiency, and accessibility across the healthcare system.

2. The subtitle mentions "Principles, Technologies, and Applications." Could you elaborate on the foundational ▶

principles that guided your exploration of AI in digital healthcare?

The foundational principles of AI in digital healthcare prioritise patient-centered care, ethical deployment, and interdisciplinary collaboration. AI technologies aim to enhance healthcare delivery with empathy, focusing on patient outcomes. Ethical considerations demand transparency, fairness, privacy, and accountability. Successful implementation hinges on collaboration between healthcare professionals, data scientists, and engineers. High-quality, representative data is crucial for reliable AI. Systems must also be scalable, interoperable, and compliant with healthcare standards. Clinical safety and validation are paramount, ensuring rigorous testing for trustworthy, effective, and sustainable AI integration into healthcare.

3. Among the many technologies you covered - AI-driven imaging, IoT, robotics, and VR - which do you believe is currently the most disruptive in healthcare, and why?

Among transformative technologies in digital healthcare, AI-driven imaging, IoT, robotics, and virtual reality, AI-driven imaging stands out as the most disruptive due to its clinical impact, scalability, and real-world integration. It enhances diagnostic accuracy for conditions like cancer and stroke, processes vast image data efficiently, and supports early intervention. Already deployed globally, it integrates seamlessly with radiology workflows and expands access in underserved areas. By reducing delays, unnecessary tests, and readmissions it improves resource efficiency. While other technologies show promise, AI imaging's maturity and immediate utility make it the most impactful innovation in healthcare today.

4. You discuss real-world implementations of AI in modern medicine. Can you share a case study or example from the book that best illustrates the tangible impact of AI in patient care?

In our book, Chapter 18 presents a compelling case study on an advanced AI system for brain tumor detection and classification using deep learning and MRI. This autonomous system, designed to support clinical decision-making, begins with a precise, computationally efficient ResNet50-based CNN for classifying MRI scans and detecting tumors. Subsequently, a ResUNet-based segmentation model localises tumour boundaries with high accuracy, using a focal Tversky loss function to address class imbalances. Achieving 96% training accuracy, this AI-driven approach significantly speeds up diagnosis and enhances precision, enabling more informed treatment decisions, improving patient outcomes, and augmenting clinical expertise in modern healthcare.

5. Security and data privacy are critical in healthcare. How does your book address the challenges and solutions around safeguarding digital health records in AI-powered ecosystems?

Our book highlights key risks in AI-powered, interconnected healthcare environments, including data breaches, outdated systems, and weak authentication. To mitigate these threats, it recommends secure key management, robust authentication protocols, regular system updates, and device hardening. It also promotes global best practices and urges developing countries to adopt secure smart lab systems. The central message is clear: protecting digital health records is vital for building trust and ensuring safe, reliable care in the age of AI and the Internet of Medical Laboratory Things.

> Achieving 96% training accuracy, this AI-driven approach significantly speeds up diagnosis and enhances precision, enabling more informed treatment decisions, improving patient outcomes, and augmenting clinical expertise in modern healthcare.

6. How do automation and artificial intelligence complement each other in the context of digital healthcare? Are there risks when automation outpaces human oversight?

AI analyses data, recognises patterns, and provides insights (e.g., predicting sepsis or billing issues). Automation then executes routine tasks based on these insights (e.g., alerting staff, initiating tests, rescheduling appointments). This synergy enhances efficiency, accuracy, and scalability, reducing manual workload and enabling faster, more personalised care.

Yes, significant risks arise when healthcare automation outpaces human oversight. These include loss of clinical judgment, amplified biases from flawed data, widespread harm from system errors or cyberattacks, and accountability issues. Mitigation requires human-in-the-loop oversight, transparent AI, regular audits, and strong ethical safeguards for all automated processes.

7. You write for researchers, healthcare professionals, and tech enthusiasts. How did you balance technical depth with accessibility in the structure and narrative of the book?

Our book strikes a thoughtful balance between technical depth and accessibility, making it valuable for researchers, healthcare professionals, and tech enthusiasts. It starts with foundational concepts and gradually introduces advanced topics, supported by real-world case studies that clarify practical applications. Simplified language, glossaries, and visual aids help non-technical readers, while detailed model architectures and in-depth discussions engage experts. The interdisciplinary narrative blending medical, technical, and ethical perspectives ensures relevance across professional boundaries. By fostering understanding and collaboration, the book serves as a comprehensive resource for both specialists and newcomers in the digital health space.

8. Medical robotics is a fast-emerging area. What are some of the futuristic or lesser-known applications of robotics in healthcare that your book brings into focus?

This book brings into focus the futuristic or cutting-edge applications of robotics in healthcare, focusing on emerging applications of medical robotics that extend far beyond traditional surgical systems. These include diagnostic AI robots like DAISY, which streamline emergency triage, and socially assistive robots such as Paro, offering emotional support in dementia and mental health care. Teleoperated surgical robots enable remote procedures, expanding access to expert care in underserved areas. Nanorobots, still experimental, promise targeted drug delivery for diseases like cancer. Advanced robotic prosthetics with brain-machine interfaces restore natural movement and sensation, while rehabilitation exoskeletons like Lokomat aid recovery from neurological injuries.

Together, these innovations are reshaping the future of personalised and accessible healthcare.

9. With the increasing adoption of AI in diagnostics, how do you envision the evolving role of human doctors and specialists? Does your book propose any hybrid models for decision-making?

Our book explores how AI transforms, not replaces, the role of human doctors. As diagnostic tools grow more advanced, physicians shift toward clinical judgment, ethical decisions, and compassionate care. It introduces hybrid models where AI offers data-driven insights, while doctors interpret results within broader patient contexts. Technologies like Clinical Decision Support Systems (CDSS) and AI-assisted diagnostics enhance efficiency without undermining medical authority. While AI automates complex analysis, only clinicians can integrate patient history, values, and subtle symptoms. This human–AI synergy is essential for delivering personalised, ethical, and trustworthy healthcare in the digital age, redefining medicine as a collaborative, tech-enhanced practice.

10. Virtual reality in healthcare is often underexplored. What unique contributions does your book make in highlighting VR's potential in treatment or medical training?

Our book highlights VR as a powerful yet underexplored tool in healthcare, especially when integrated with IoT and wearable devices. It emphasises VR's role in personalised treatment, such as stroke rehabilitation using platforms like Neuro Rehab VR, pain management, and mental health therapy by leveraging real-time biometric data to tailor sessions and monitor physiological responses during therapies like exposure treatment for PTSD or anxiety. In medical training, VR enables professionals to simulate real-life scenarios and safely operate IoT-connected devices like ventilators and infusion pumps. Framed as both a therapeutic and educational asset, VR emerges as essential to immersive, patient-centered care.

11. From wearable devices to smart monitoring systems, IoT is reshaping patient engagement. What role does edge computing or real-time analytics play in these smart healthcare systems, as discussed in your book?

Revolutionising Digital Healthcare emphasises edge computing and real-time analytics as crucial for responsive IoT-enabled systems. As sensors and wearable devices generate vast physiological data, edge computing processes it near the source, drastically reducing latency for immediate analysis vital in time-sensitive scenarios like cardiac monitoring. This empowers healthcare providers with predictive insights, supports continuous patient monitoring, and facilitates timely interventions, improving outcomes. Edge processing also enhances data security and privacy by minimising raw data transmission. Ultimately, these technologies form the backbone of a more efficient, proactive, and patient-centered healthcare model, ushering in intelligent, decentralised, and secure digital healthcare.

12. Given the rapid pace of AI development, how do you ensure the book remains future-proof or adaptable for readers looking to understand long-term implications?

Our book is designed to remain future-proof by emphasising core principles and adaptable frameworks over transient technologies. The book focuses on enduring themes such as ethi-

cal AI, human–AI collaboration, explainability, interoperability, and data governance, ensuring relevance even as tools and platforms evolve. It explores forward-looking innovations like edge computing, federated learning, and digital twins, offering insight into the future trajectory of smart healthcare. Real-world case studies and scalable models illustrate how AI can be responsibly integrated into clinical practice. By encouraging critical thinking about the regulatory, ethical, and societal dimensions of AI, the book prepares readers to engage with emerging developments and adapt effectively as the digital healthcare landscape continues to transform.

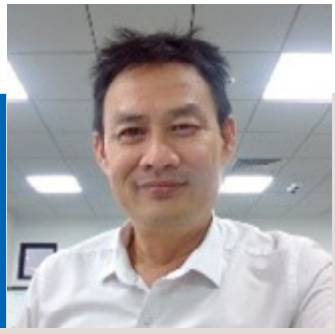
13. If a healthcare institution were to use your book as a roadmap, what would be the first three transformative actions you'd recommend they take?

If a healthcare institution were to use our book as a roadmap, the first three transformative actions to take would be:

- Establish a Scalable Data Infrastructure: Institutions must build robust, secure, interoperable data systems (EHRs, IoT data, imaging) for real-time analytics and future AI. Prioritise data standardisation and privacy compliance (HIPAA, GDPR).
- Implement AI-Driven Clinical Decision Support Systems (CDSS): Adopt AI tools assisting clinicians in diagnostics, treatment planning, and risk prediction. Begin with targeted use cases, scaling gradually. Emphasise human-in-the-loop design to complement clinical judgment.
- Invest in Workforce Training and Digital Culture Shift: AI adoption requires cultural transformation. Train staff to engage with AI, building trust through transparency, explainability, and ethical use. Foster multidisciplinary collaboration for successful implementation.

14. Lastly, what future volumes or areas are you currently exploring in relation to digital healthcare or AI? Can readers expect a sequel or companion book to this title?

While there's no confirmed sequel to Revolutionising Digital Healthcare through Artificial Intelligence and Automation, both Elsevier and editor Alex Khang remain active in publishing related works. Elsevier's "Future of Health" initiatives regularly explore AI in healthcare, digital transformation, and the evolving role of clinicians. Alex Khang has also authored or edited titles such as AI-Centric Modelling and Analytics, Data-Centric AI Solutions, and AI and IoT Technology for Smart Healthcare Systems, which expand on similar themes. These publications serve as valuable companion resources, offering continued insight into emerging technologies and long-term implications for digital healthcare and AI-driven innovation. Hopefully, readers can definitely look forward to future books expanding on our themes.



AUTHOR BIO

Alex Khang is a Professor of Information Technology, holding a Doctor of Philosophy (Ph.D.), a Doctor of Literature (D.Litt.), and an MBA. He is an AI and Data Scientist, currently serving as Chief of Technology at the Faculty of AI and Data Science, Global Research Institute of Technology and Engineering, with operations in both Vietnam and the United States. He has been recognized among the world's top 2% scientists in 2024 and top 1% scientists in 2025.

Driving Innovation

Latest Appointments You Need to Know

Robert Ballantine Appointed to the Board of Directors at Cumulus Neuroscience

Cumulus

Jonathan M. Vigdorchik Appointed as Chief Medical Advisors at Zimmer Biomet

ZIMMER BIOMET
Moving You Forward.

Dr. Ted James Appointed as Chief Medical Officer at Perimeter Medical Imaging AI

PERIMETER

Eric Benjamin Appointed as Chief Operating Officer at Insulet

Insulet

Keith Carlton Appointed as Executive Chairman at Newronika

Newronika

Sarah van Hellenberg Hubar-Fisher Appointed as CEO at Bioretec

bioretec
better healing – better life

Victor Ku Appointed as Chief Technology Officer at Butterfly Network

Butterfly™

Jay Jennings Appointed as Chief Financial Officer at QT Imaging

QT IMAGING

Chris Smith Appointed as Chief Executive Officer at Laborie

Laborie
FOR DIGNITY. FOR LIFE.

The Future of AI-Enabled Health

Leading the Way

AI in healthcare can be transformative, but if action is not taken on six pivotal transitions, the health sector is at risk of not reaching its full potential and falling behind.

Artificial intelligence (AI) is part of a broader digital revolution that has the potential to transform healthcare in many ways. At the front end, AI enabled tools can improve care, from enhancing clinicians' capabilities and freeing up time for them to focus on patient relationships to enabling patients to take greater control of their own health; at the back end, augmenting non-patient-facing elements improves the efficiency of all facets of healthcare delivery and life sciences by optimizing system-wide operations. However, the adoption of AI at scale remains slow, and there is a risk that its transformative potential in healthcare may not be fully realized.

The World Economic Forum Digital Healthcare Transformation (DHT) initiative has conducted research on AI adoption in healthcare through interviews with experts. Three major challenges were identified that hinder the scaling of AI in healthcare:

1. Complexity of AI in health deterring policymakers and business leaders: Despite the perception that AI in health receives significant attention and energy, it struggles to gain traction on political and strategic agendas.

2. Misalignment of technical choices with strategic visions: Health leaders often delegate technical decisions, missing opportunities to align technology with their strategic goals.

Additionally, misaligned incentives often hinder decisions from supporting shared goals and collective ideals.

3. Low confidence in AI within a fragmented regulatory and governance framework: Rising public distrust in AI and industry skepticism could hinder its adoption in health.

Six pivotal transitions are needed to enable AI-driven healthcare to reach systemic and global scale:

1. From dreaming of breakthroughs to delivering near-term benefits that accelerate a long-term vision: Focus on operational applications of AI in health and collaborate with private-sector leaders to demonstrate returns, leading to long-term investments.

2. From the private sector progressing technology independently to public–private ecosystems driving shared objectives and benefits: Align public and private leaders on priorities, recognize the potential value of AI in medical applications and agree on how to share this value.

3. From fighting on infrastructure to winning on services: Prioritize shared infrastructure such as digital public infrastructures (DPIs) at the forefront of technical choices. Where feasible, seek shared investments for public-good solutions that would align with private-sector service offerings.

4. From leaders with good intentions to leaders who make responsible technical decisions: Upskill and engage leaders at all levels to make strategic decisions with full awareness of the technical aspects.

5. From waiting for guidelines to proactively building trust: Actively engage in improving post-market surveillance to detect early AI-related risks with speed and transparency, as well as considering AI ethical committees and principles.

6. From dispersed data to deliberate integration: Advocate for local control of data within a globally connected and patient-centred system to both ensure patient privacy and safety and drive innovation.

These shifts will drive deployments of AI in healthcare that deliver truly transformative improvements in well-being, continuous access to personalized AI health assistants, enhanced operational excellence for healthcare systems and leapfrogging by low- or middle-income countries (LMICs). Realizing this vision necessitates overcoming risks and challenges related to privacy, cybersecurity, upskilling clinicians and patients, equitable access and regulation.

AI presents an opportunity for the private sector to build businesses that promote better health worldwide and for the public sector to reinvent approaches for managing population health. It also enables the public and private sectors to join forces to address the enduring healthcare challenges facing the world. The collaborative efforts required will vary by country, depending on digital maturity and specific issues. In LMICs, the focus will be on establishing foundational technology and expanding access to quality care in order to address ongoing challenges such as high disease burden and weak health information systems. In advanced economies, however, interoperability will be essential for improving efficiency and outcomes to meet the needs of increasingly strained healthcare systems. ■

Next Generation Patient Experience 2025

November 17 - 19, 2025 | Westin Rancho Mirage, Palm Springs, CA

https://patientexperience.wbresearch.com/

About Event: This conference will bring a community of passionate change makers committed to reimagining the patient experience. In a time of rapid transformation, rising expectations, and advancing technologies, NGPX offers a space to connect, share, and grow with peers who believe that putting patients first is not just a goal but a responsibility. Through actionable strategies, bold ideas, and authentic storytelling, NGPX empowers attendees to spark innovation, drive ROI, and elevate well-being across every touch point of the patient journey.

Listed Under: Healthcare Management

2nd International Conference on Dementia and Brain Disorders (ICDB 2025)

November 06-07, 2025 | London, UK

https://www.scitechseries.com/neurology-dementia

About Event: This conference focuses on the theme "Minds in Focus: Rethinking Dementia and Brain Disorders". ICDB 2025 Dementia and various brain disorders, including Alzheimer's, vascular dementia, and front temporal dementia, present complex challenges in healthcare, impacting millions globally. The intricate web of genetic, lifestyle, and environmental factors underscores the multifaceted nature of these conditions. Ongoing research strives to unravel the causative mechanisms, leading to innovative treatments.

Listed Under: Medical Sciences

3rd International Conference on Pediatrics & Neonatology

November 27-28, 2025 | Philadelphia, USA

https://www.scitechseries.com/pediatrics

About Event: This conference is focusing on the theme “Children's Health in a Changing World: Responding to New Challenges.” Pediatrics 2025 conference will spotlight the latest and ground-breaking innovations in Pediatrics and Neonatology research, providing a unique opportunity for global investigators to convene, connect, and explore new scientific advancements.

Listed Under: Medical Sciences

2nd International Conference on Biosensors & Bio-Sensing Technology

December 01-03, 2025 | Hilton Rome North Fiano Romano, Rome, Italy

https://cognitionconferences.com/biosensors/

About Event: The International Conference on Biosensors & Bio-Sensing Technology aims to serve as a hub for idea exchange, collaboration, and networking opportunities. Attendees can anticipate engaging in stimulating discussions, attending captivating keynote speeches delivered by industry leaders, and showcasing their research findings through oral presentations or poster sessions.

Listed Under: Technology, Equipment, and Devices

Global Healthcare Conference

December 8-10, 2025 |InterContinental DFC, Dubai, UAE

https://www.health2conf.com/

About Event: This conference brings together leaders and professionals in Dubai and Las Vegas to explore what's next in healthcare innovation. From digital health tools to patient care strategies and policy shifts, the agenda covers what really matters. Plus, with plenty of chances to connect and collaborate, it is a space where real conversations happen. If staying ahead of the curve is your goal, this is where you'll want to be.

Listed Under: Healthcare Management

16th World Digestive and Liver Diseases Conference

December 17-19, 2025| Dubai, UAE

https://digestive-liverdiseases.utilitarianconferences.com/

About Event: This conference focus on exploring groundbreaking research, innovative treatments, and the latest advancements in gastroenterology, hepatology, and related specialties. Renowned for its comprehensive scientific program, the event will feature expert-led lectures, hands-on workshops, and dynamic networking opportunities designed to meet the educational and professional development needs of clinicians, researchers, and healthcare practitioners.

Listed Under: Medical Sciences

17th International Healthcare and Nursing Conference

December 17-19, 2025|Dubai, UAE

https://healthcare.utilitarianconferences.com/

About Event: This conference is focusing on different aspects of healthcare, which typically bring together professionals from various fields within the healthcare industry, including nursing, medicine, administration, technology, policy, and more. They aim to discuss current challenges, innovations, and future directions in healthcare.

This forum focuses on quality improvement in healthcare. It brings together professionals who are committed to improving patient care and outcomes, with sessions on patient safety, healthcare quality, and innovation.

Listed Under: Healthcare Management

5th International Neurosurgery and Neurological Surgeons

January 14-16, 2026 in DUBAI, UAE

https://neurosurgery.utilitarianconferences.com/

About Event: This conference is specifically designed to provide a platform for neurosurgeons, neurologists, healthcare professionals, and researchers to come together and discuss the latest innovations, advancements, and challenges in neurosurgical practices. Attendees will have the chance to connect with global leaders in neurosurgery, build collaborations, and explore academic and industry partnerships.

Listed Under: Surgical Speciality

MEDICA 2025 – The World's Leading Medical Technology Trade Fair

17–20 November 2025 | Düsseldorf, Germany

This November, Düsseldorf will once again become the global meeting point for the medical industry as MEDICA 2025 opens its doors. Renowned as one of the world's largest B2B trade fairs in healthcare, MEDICA brings together over 5,000 exhibitors from 72 countries and attracts more than 80,000 visitors from across the globe.

The trade fair showcases groundbreaking innovations across diverse sectors including medical imaging, laboratory technology, diagnostics, health IT, mobile health, physiotherapy and orthopaedic technology, as well as medical consumables. Alongside the exhibition, attendees can engage with a rich programme of forums, conferences, product pitches, award ceremonies, and discussions with industry leaders and policymakers, making MEDICA a hub of knowledge exchange and networking.

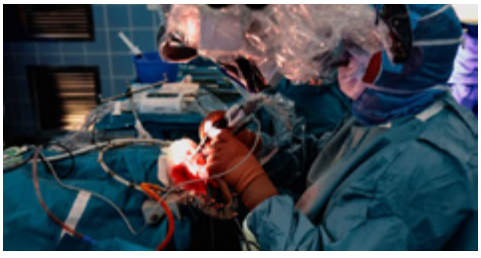
As the digital backbone of the event, MEDICA.de serves as the leading international information portal for medical technology. Updated daily, it provides insights into the latest industry trends, comprehensive exhibitor databases, product catalogues, online matchmaking, and even hotel search services - ensuring that participants can plan their visit effectively and maximize business opportunities.

With its unmatched scale, innovation focus, and networking potential, MEDICA 2025 remains the must-attend platform for producers, researchers, dealers, and healthcare professionals shaping the future of global medicine.

Marginum's HIVEN® Achieves Rapid CE Mark Clearance for Neurosurgery

Finnish medical technology company Marginum has reached a significant milestone as its flagship device, HIVEN®, receives CE mark clearance under the Medical Device Regulation (MDR).

Achieving regulatory approval in just over four and a half years, the company set a record pace for class IIb medical devices under the new framework.



HIVEN leverages the company's aspirate tissue monitoring (ATM) technology to address a critical clinical need in neurosurgery: the accurate intraoperative detection of tumorous tissue without disrupting surgical workflows.

By analyzing aspirated tissue samples in near real-time, the device provides surgeons with precise feedback on tumour margins, enabling safer and more complete tumour removal. This can reduce the likelihood of reoperations, enhance patient outcomes, and improve overall standards of care.

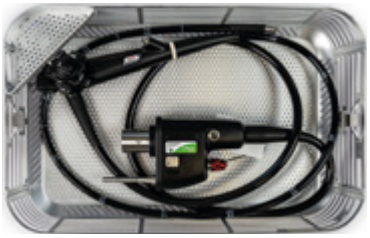
The technology is particularly valuable in surgeries involving high-grade gliomas, where preserving healthy tissue is crucial, and tumor cells may be difficult to detect. By transferring resected tissue directly for fluorescence analysis, HIVEN® overcomes challenges posed by limited visibility around critical structures such as blood vessels and tissue ridges.

HIVEN® seamlessly integrates into standard surgical procedures, offering objective tissue detection even in hard-to-reach areas. Surgeons gain enhanced insight into the surgical site, supporting more precise resections while simplifying clinical workflows.

With this CE mark approval, Marginum positions HIVEN® as a transformative tool in fluorescence-guided neurosurgery, promising improved surgical accuracy, reduced complications, and better

READ THE COMPLETE POST

PENTAX Medical and ASP Launch Sterilizable DEC™ Duodenoscope with 68-Minute Sterilization



PENTAX Medical, in collaboration with Advanced Sterilization Products (ASP), has introduced the Sterilizable DEC™ Duodenoscope in the U.S., offering a significant advancement in endoscopic safety and efficiency.

This next-generation reusable duodenoscope provides physicians with the handling and performance they expect, now enhanced with rapid, complete sterilization using ASP's STERRAD™ System in just 68 minutes.

The Sterilizable DEC™ Duodenoscope is engineered to prioritize sterility, stability, and control during procedures. By enabling full sterilization within a short timeframe, it significantly reduces the risk of cross-contamination, addressing a key concern in gastrointestinal endoscopy.

Hospitals and clinics can now deliver safer procedures without compromising on efficiency, providing both patients and medical staff with greater confidence in infection prevention.

In addition to improving patient safety, this duodenoscope supports operational efficiency and workflow continuity. Its built-in compatibility with established sterilization processes allows healthcare facilities to integrate rapid sterilization without major changes to existing practices.

Compared with single-use alternatives, it offers a more sustainable reprocessing solution, helping institutions meet both infection control and environmental objectives.

Available in the U.S. from 1 July 2025, the Sterilizable DEC™ Duodenoscope represents a notable innovation in endoscopic technology, combining reliable performance, rapid sterilization, and sustainability. By merging advanced engineering with practical clinical needs, PENTAX Medical and ASP are setting a new standard for safer, faster, and more efficient duodenoscopy procedures.

READ THE COMPLETE POST

Bunkerhill Health Secures FDA Clearance for AI-Powered Tool Detecting Reduced Heart Function from Routine ECGs

Bunkerhill Health has received U.S. FDA clearance for ECG-EF, an artificial intelligence (AI) algorithm designed to detect reduced left ventricular ejection fraction (LVEF), a critical measure of heart function, using standard 12-lead electrocardiograms (ECGs).

This approval expands Bunkerhill's footprint in ECG-based diagnostics, complementing its portfolio of FDA-cleared imaging tools.

Left ventricular ejection fraction indicates how efficiently the heart pumps blood. Low LVEF levels can signal heart failure or other serious cardiovascular conditions. Traditionally, diagnosing reduced heart function relies on echocardiography, which requires specialized equipment and may not be readily accessible, often delaying detection until disease progression.

ECG-EF offers a solution by identifying at-risk patients early through a routine, widely available ECG test.

Developed by Carelog, ECG-EF is integrated into Bunkerhill's Carebricks platform, enabling health systems to create AI-driven clinical workflows. The platform analyses patient data, alerts care teams, manages referrals, automates prior authorization, and triggers coordinated actions across other healthcare systems, enhancing operational efficiency.

By providing a noninvasive, rapid, and accurate method to detect impaired heart pumping, ECG-EF empowers clinicians to flag high-risk patients sooner, facilitating timely interventions. Early detection can improve patient outcomes, reduce complications, and lower the likelihood of hospitalization.

With FDA clearance, Bunkerhill Health positions ECG-EF as a transformative tool in cardiovascular care, combining AI technology with accessible diagnostics to enable earlier, data-driven clinical decision-making and enhanced patient care.

READ THE COMPLETE POST

Medtronic Expands London Operations to Establish Global Hub for Surgical AI and Robotics

Medtronic plc has significantly expanded its London presence, doubling its office space to 25,000 sq ft and increasing its workforce to over 200 staff.

This growth establishes the company's largest global centre dedicated to AI and robotics in surgery and forms part of a multi-million-pound UK investment over five years, supporting the research, design, and development of advanced robotic-assisted surgical technologies.

Located at London's Old Street "Silicon Roundabout," the Centre of Digital Excellence brings together leading UK medical software engineers to drive innovations in digital surgery for hospitals worldwide.

The centre has already developed specialized computing and software solutions for operating rooms across more than 30 countries and launched hundreds of AI algorithms to aid surgeons in procedure planning, intraoperative collaboration, and post-operative analysis.

The facility features a mock robotic operating theatre, enabling testing of new technologies and hands-on engagement for healthcare professionals with digitized procedure environments. Current initiatives include AI-powered decision support tools that provide real-time guidance during operations, enhancing precision and efficiency in surgical procedures.

Medtronic's UK operations extend to leading hospitals, including Imperial College, King's College, University College London Hospitals, and Guy's and St. Thomas', with technologies such as the GI Genius™ intelligent endoscopy module, PillCam™ capsule endoscopy system, and Hugo™ robotic-assisted surgery system improving diagnostic accuracy, patient outcomes, and access to minimally invasive procedures.

This expansion aligns with the NHS 10-Year Health Plan and underscores Medtronic's long-term commitment to UK healthcare, advancing innovation in surgical AI, robotics, and digital health technologies to support safer, smarter, and more efficient patient care.

READ THE COMPLETE POST

Techsomed Secures FDA Clearance to Expand BioTraceIO360 Platform for Kidney Ablation

Techsomed has received U.S. FDA 510(k) clearance to expand the use of its BioTraceIO360 software platform for percutaneous ablation of soft tissue in the kidney.

Previously cleared for liver procedures, this approval marks a significant milestone in Techsomed's efforts to develop a multi-organ, hardware-independent image-guided therapy system aimed at standardising minimally invasive treatments from procedure planning through verification.

Kidney cancer affects approximately 82,000 individuals annually in the United States. For select patients, minimally invasive, image-guided ablation offers a kidney-preserving alternative to traditional surgery and is increasingly adopted in clinical practice. By extending BioTraceIO360 to kidney procedures, Techsomed aims to enhance precision, safety, and efficiency in interventional oncology.

The platform supports clinicians throughout the procedure by enabling comprehensive planning, simulation, and verification of ablation zones. During treatment, BioTraceIO360 provides real-time guidance and quantitative feedback, helping clinicians adapt procedures as needed. Post-procedure, it allows verification and documentation of treatment coverage, promoting consistent and reproducible outcomes.

This expansion strengthens Techsomed's strategy of creating a unified image-guided therapy ecosystem that can be applied across multiple organs. By combining advanced software, procedural guidance, and treatment verification, BioTraceIO360 empowers clinicians with confidence and precision, improving patient outcomes while minimising invasiveness.

With the kidney clearance, Techsomed takes a step closer to realising a comprehensive, multi-organ image-guided therapy platform that supports standardised, high-quality care across diverse interventional oncology procedures.

READ THE COMPLETE POST

Thermo Fisher Scientific Launches Hypulse™ Surface Analysis System to Advance Materials Researc

Thermo Fisher Scientific has unveiled the Thermo Scientific™ Hypulse™ Surface Analysis System, a state-of-the-art instrument designed to deliver enhanced X-ray photoelectron spectroscopy (XPS) depth-profiling for advanced materials research.

This new system is poised to support innovation across diverse industries, including energy storage, medical implants, fire protection, and beyond.

By providing deeper insights into surface properties, the Hypulse system enables researchers to develop improved materials with enhanced performance and durability. In healthcare, for example, it can facilitate the study of coatings for medical implants, helping to improve biocompatibility, extend implant lifespan, and reduce infection risks.

A standout feature of the Hypulse system is its use of femtosecond laser technology for precise material removal. This approach preserves sample integrity, accelerates data collection, and allows the characterization of materials at greater depths.

By combining this laser technology with Thermo Fisher's established MAGCIS™ ion source, the system offers flexibility in applications where traditional ion beam techniques may be unsuitable, giving researchers more options for complex samples.

The launch of the Hypulse Surface Analysis System reinforces Thermo Fisher Scientific's leadership in advanced surface technologies, providing scientists with increased precision, speed, and versatility in surface characterization. By enabling high-resolution, reliable analysis, the system supports accelerated development of next-generation materials and coatings, driving progress in research and industrial applications globally.

With its combination of innovative laser technology, reliable ion sources, and advanced XPS capabilities, the Hypulse system is set to become a valuable tool for researchers seeking to push the boundaries of material science.

READ THE COMPLETE POST

EUROPEAN HOSPITAL & Healthcare MANAGEMENT

UPGRADE YOUR MARKETING STRATEGY

Let the true **"Digital Transformation"** be the base of all your marketing campaigns

AFTER COVID-19 PANDEMIC

"DIGITAL TRANSFORMATION IS THE WAY FORWARD"

Highly accountable marketing campaigns. Every dollar counts. Digitally powered marketing campaigns may be cheaper than you thought...

Email: advertise@europeanhhm.com

Web:-www.europeanhhm.com

- **Use the webinar as a platform to launch new products and services**
- **Grow your audience with increased reach, Impact and user-friendliness**
- **Rise above geographical boundaries**
- **Generate new business**
- **Gain the strong web presence differentiating yourself from competitors**
- **Connect and engage with your target audience**
- **Give more exposure to industry specific people**
- **Increase your brand profile and share your capabilities with leading industry professionals**

Our recent **successful partnerships:**

suez · ThermoFisher SCIENTIFIC · ORACLE Health Sciences · Catalent