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EDITORIAL

# The Benefits and Challenges of Digitally-Enabled Cardiology

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## Abstract

Digital health technologies, including artificial intelligence, offer immense potential to revolutionise cardiology by improving patient care, enhancing efficiency, and increasing access to specialised services. Benefits may include precision medicine, remote monitoring, streamlined workflows, and accelerated research. However, challenges such as cost, digital literacy, data privacy, interoperability between various digital health solutions and the digital divide must be addressed to ensure equitable implementation. By embracing a patient-centric approach and fostering collaboration among stakeholders, we can leverage the potential of digital tools. This collaborative effort can pave the way for a future where cardiovascular care is characterised by enhanced accessibility, improved efficiency, and a higher degree of personalization.

**Key words: digital health; cardiology; artificial intelligence; patient care; access to healthcare**

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Cardiovascular diseases remain a major global health burden. The staggering statistics—17.9 million annual cardiovascular deaths (World Health Organization, 2019) with over 64 million individuals affected by heart failure (Shahim et al, 2023)—underscore a call to action, urging healthcare systems across the world to undergo a profound transformation. The rapid advancement of digital technologies offers a potential solution. Traditional healthcare systems are no longer able to meet demand (World Health Organization, 2019), and the scientific community largely agrees that digital transformation is not only inevitable but also beneficial. However, this digital revolution also brings challenges that need to be carefully addressed to ensure its successful and equitable implementation.

But what exactly is "digital health"? The World Health Organization (WHO) defines it as "the integration of digital technologies into healthcare systems to enhance the efficiency of healthcare delivery, improve patient outcomes, and empower individuals to manage their health more effectively using digital tools and platforms" (Russell and Norvig, 2020). The WHO's definition inherently promotes the use of such technologies in medical practice.

While digital health (DH) and artificial intelligence (AI) may seem similar, they are not interchangeable. DH encompasses AI, but not vice versa. AI is, in fact, a branch of informatics which creates systems capable of learning, reasoning, making decisions, and acting independently (Elias et al, 2024).

Digital transformation has vast potential across the entire patient journey, from early diagnosis and remote patient monitoring to AI-guided telemedicine and screening (Yeung et al, 2023). The integration of digital solutions into cardiology presents

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an exciting array of opportunities to improve patient care, enhance efficiency, and potentially revolutionise how we approach cardiovascular health.

Let's consider the benefits of a digitally-enabled cardiology from three key perspectives: the patient, the clinician, and global health.

Arguably, the most significant benefit of digital technologies in cardiology lies in their potential to improve patient care and access. Digitally enabled cardiology differs from traditional healthcare in several key aspects: the direct patient-physician relationship evolves into a patient-machine-physician interaction, where digital technology acts as a bridge. While direct patient-doctor interaction inherently offers an individualised approach, traditional healthcare models rely on standardised protocols and guidelines. Digital health has the potential to shift from the standardised care model towards a more personalised approach and precision medicine with innovative workflows. However, this necessitates careful design and implementation to avoid over-reliance on algorithms and ensure that technology complements, rather than replaces, the clinician's expertise and the patient-clinician relationship (Hammersley et al, 2024).

A crucial differentiating feature is data accessibility and control. While traditional medicine often limits patients' practical access to and sharing of their own data, the digital horizon enables more fluid data sharing among multiple stakeholders, with the patient at its center. This shift has the potential to decentralise care leadership, fostering a more collaborative model between patients and cardiologists. However, this increased access necessitates robust data security measures to ensure patient privacy (Hammersley et al, 2024).

Consequently, clinical responsibility is shared between clinician and patient, fostering digitally-supported self-care and improved access to educational resources. This empowers patients and enhances their awareness. A key advantage is the shift from post-care awareness to proactive lifestyle modification. Wearable devices and mobile apps enable patients to actively participate in their care, tracking physical activity, heart rate, and other vital parameters, while receiving personalised feedback and recommendations. This fosters a sense of control and promotes healthier lifestyle choices, ultimately improving quality of life. However, trials showing improvement in outcomes are currently ongoing (Yeung et al, 2023).

Remote patient monitoring also empowers cardiologists to track patients' vital signs and symptoms in real-time, facilitating early detection of complications, timely interventions, and potentially allowing cardiologists to dedicate more time to patient-focused interactions. Additionally, by reducing hospital visits and optimising resource allocation, digital health solutions can contribute to long-term cost-effectiveness.

While remote monitoring and data collection from wearable and implantable devices are already significantly embedded in clinical practice, AI holds immense potential to enable risk stratification and data-driven analytics, applied to electrocardiograms, complex imaging (Kadosh et al, 2020), and raw data, aiding in the personalization of treatment plans for individual patient needs

A significant aspect of digitally-enabled cardiology lies in optimising administrative workflows. Healthcare professionals often face an unsustainable adminis-

trative burden, and AI-driven technologies offer promising solutions to streamline these processes.

From AI-driven electronic patient records to appointment prioritisation and AI-driven follow-up scheduling, digital tools can alleviate administrative burdens. Electronic health records (EHRs) facilitate seamless sharing of patient information among healthcare providers, minimising errors and treatment delays (Jung et al, 2022).

Like patients, cardiologists can also benefit from broader access to educational materials. Virtual reality (VR) is now being explored as a tool to educate both patients and clinicians (Choi et al, 2022; Koulaouzidis et al, 2022). AI also offers a powerful toolkit to expedite cardiovascular research.

By analysing vast molecular datasets, for instance, it can accelerate the identification of promising candidates for cardiovascular medications (Kim et al, 2020). Additionally, in clinical trials, natural language processing (NLP) can streamline patient recruitment and data analysis, and uncover insights from medical literature that may lead to new therapeutic targets (Tee et al, 2024).

From a global perspective, three key factors emerge as positive benefits of digital implementation: reducing geographical barriers to increase patient access, cost implications, and environmental impact.

Rural areas often lack specialised cardiology services. Digital health enhances access by enabling virtual consultations and follow-ups, reducing long-distance travel needs, and extending specialised care to underserved regions. Digitalization can also enable remote reporting (e.g., cardiac magnetic resonance imaging or computed tomography), specialised ward rounds, or subspecialty clinics (e.g., inherited cardiac conditions clinics, arrhythmia clinics) where evidence supporting the advantages of in-person delivery may be limited. This is particularly crucial for patients in underserved areas with limited access to traditional in-person care. The potential impact in low- and middle-income countries is even greater, as digital technologies offer a cost-effective alternative to building extensive infrastructure, bridging the gap in specialised care delivery.

Moreover, healthcare services contribute significantly to global greenhouse gas emissions, accounting for 4.6% (Tee et al, 2024). Substantial evidence indicates that virtual consultations can reduce healthcare's carbon footprint, primarily by minimising travel associated with in-person appointments (Pickard Strange et al, 2023). This is promising, however, existing evidence does not fully account for all factors involved in implementing virtual healthcare and its broader carbon emissions across clinical pathways. This limitation needs to be taken into account (Pickard Strange et al, 2023).

The integration of digital tools into cardiology holds great promise, but several challenges must be addressed to ensure successful and equitable implementation. Any change encounters cultural barriers and a natural human resistance to altering the status quo.

From a practical standpoint, implementing digital health solutions involves substantial upfront costs, including hardware and software purchases, staff training, and integration into existing workflows. These financial and logistical hurdles

can be particularly challenging for smaller practices or those with limited resources. Moreover, even with adequate training, the successful adoption of new technologies depends on the digital literacy of both healthcare providers and patients. Limited digital skills can hinder engagement and lead to underutilization of these tools.

While digital tools can streamline care, they can also create new burdens. An overload of data, excessive alerts, and poorly designed interfaces can increase stress on clinicians, contributing to burnout. The strain on physical infrastructure, with increased data storage and network demands, is also a concern.

Data privacy and security are paramount in healthcare. Ensuring the confidentiality and integrity of patient information in the digital realm requires robust cybersecurity measures and adherence to stringent data protection regulations. Policymakers and international legislation are pivotal to consolidate digital changes on a vast scale.

The digital divide remains a significant challenge. Many patients have access to smartphones, reliable internet, or the tech literacy needed to use digital health tools, yet not all of them. This can create inequities in care, particularly for older adults or those in underserved communities.

Even with access, the accuracy of data collected through digital tools can be a concern. Self-reported data (e.g., weight, symptoms) may be inaccurate, and remote monitoring devices may have limitations or malfunctions. The lack of clinical validation for some tools further underscores the need for caution in interpreting their data.

Furthermore, ensuring interoperability between different digital health solutions is paramount. This will prevent data fragmentation and allow for seamless information exchange, maximizing the value of collected data and fostering a truly integrated and patient-centric healthcare ecosystem.

Importantly, while digital tools can enhance care, they cannot fully replace the nuanced judgement and essential human connection that come with in-person assessments by experienced heart failure specialists. Many cardiology conditions are complex and the unique needs of each patient may not be easily streamlined by digital tools alone.

The benefits of digitally-enabled cardiology are undeniable, but the challenges must be addressed proactively to realise its full potential. Collaboration among cardiologists, technologists, policymakers, and patients is key to developing and implementing digital health solutions that are safe, effective, and equitable. Continued research and innovation are essential to push the boundaries of what is possible and unlock new opportunities for improving cardiovascular health.

As we navigate this digital revolution, it is imperative to maintain a patient-centric approach, ensuring that technology serves to enhance the human connection between cardiologist and patient, not replace it. By harnessing the power of digital tools while upholding the core values of compassion, empathy, and trust, we can envision a future where cardiology care is more accessible, efficient, and personalised than ever before.

## Conclusion

The digital transformation of cardiovascular medicine presents both unprecedented opportunities and formidable challenges. For clinicians, these technologies offer powerful tools to enhance diagnostic precision, streamline workflows, and extend specialist care to underserved populations. However, successful implementation requires thoughtful navigation of data governance, validation standards, and the preservation of therapeutic relationships. As we integrate these innovations, our profession must lead in developing frameworks that ensure equitable access while maintaining the humanistic core of patient care. The future of cardiology lies not in choosing between tradition and innovation, but in harmonising their complementary strengths——delivering precision medicine that is equally compassionate and cutting-edge, ultimately benefiting both clinicians and patients.

### Key Points

- Digital tools and AI offer significant potential to transform cardiovascular care, improving diagnosis, monitoring, treatment, and research.
- Personalized medicine, remote monitoring, data accessibility and increased access to specialised care are key benefits for patients.
- Streamlined workflows, reduced administrative burden, and AI-powered diagnostics can enhance efficiency for cardiologists.
- Cost, digital literacy, data privacy, and the digital divide need to be addressed to ensure equitable access to digital health solutions.
- Digital health can increase access to care in underserved areas, improve cost-effectiveness, and reduce the environmental impact of healthcare delivery.
- Technology should enhance, not replace, the human connection in cardiology care.

## Availability of Data and Materials

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

## Author Contributions

TC conceived and wrote the entire manuscript. The author contributed to important editorial changes in the manuscript. The author read and approved the final manuscript. The author has participated sufficiently in the work and agreed to be accountable for all aspects of the work.

## Ethics Approval and Consent to Participate

Not applicable.

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## Conflict of Interest

The author declares no conflict of interest.

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