



Remote monitoring and digital health tools in CVD management

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The COVID-19 pandemic has accelerated the adoption and acceptance of remote monitoring and other digital approaches to cardiovascular disease management across the world. We argue that considerable additional effort is required to ensure appropriate multi-stakeholder involvement in the development, evaluation and best use of an ever-increasing number of digital technologies.

“ COVID-19 has changed the conversation about the value of remote monitoring ”

The COVID-19 pandemic has led to a tech-celeration in health care, with the adoption of telemedicine taking place almost overnight. A general practitioner from London was quoted in *The New York Times*: “We’re basically witnessing 10 years of change in one week. It used to be that 95 percent of patient contact was face-to-face: you go to see your doctor, as it has been for decades, centuries. But that has changed completely”¹. During this health crisis, remote consultation and monitoring, including the use of mobile-health (m-health) tools and wearables, became essential to replace (or at least to support) the traditional face-to-face interaction between patients and clinicians. Reimbursement rapidly changed in many countries to support this digital transformation. It is, so far, unclear whether and to what extent health care will revert to the old ways of working once the pandemic is subdued, or whether it will continue to embrace the challenges and opportunities that being liberated from the need for co-location of patient, data collection and decision-making bring.

Remote cardiovascular monitoring

Collecting data remotely from persons with, or at risk of, cardiovascular disease (CVD) is now technically straightforward. Symptoms, body weight, activity, blood pressure, pulse rate and regularity, heart sounds, respiratory rate, an electrocardiogram, oxygen saturation and sleep quality can all be assessed by a variety of stand-alone technologies. These technologies include an increasing array of wearables, such as a watch or patch². Advances in point-of-care testing further augment the ability to manage patients in out-of-hospital settings.

Patients with heart failure or a history of failed sudden cardiac death might have cardiac implantable electronic devices (such as a defibrillator), which can provide almost continuous streams of information on many physiological variables. Traditional or machine learning algorithms can support the identification of those with, or at risk of, clinically important events. Preventive clinical interventions from afar — informed by remote monitoring — can speed

up actions such as reinforcement of patient adherence to medications, modifications to drug therapy or early clinical face-to-face review. Home delivery of medications (such as Amazon’s PillPack) can close the loop from monitoring to treatment.

Increasingly, patients are being engaged in the management of their own health via patient-facing interfaces such as smartphone apps. This increased use of digital health tools heralds a future heavy with digitally supported self-management, with the health-care team getting involved only when needed. Health policy makers are enthusiastic about the potential of this more personalized approach, with the promise of better health outcomes for their citizens at lower health-care costs.

Opportunities and challenges

Remote monitoring in itself will not affect patient outcomes without influencing patient treatment or behaviour. An example of a closed-loop system that monitors and treats patients remotely is the patch technology for continuous blood-sugar monitoring connected to a wearable insulin pump for patients with type 1 diabetes mellitus. Even simple home blood-pressure monitoring coupled with a smartphone app for clinical decision support might improve blood-pressure control³. Cardiac rehabilitation can also be facilitated by digital tools, allowing patients to be remotely supported in their journey to fuller health, with gamification and feedback on their actual behaviours⁴.

The picture is not all rosy. In complex conditions, such as heart failure, it has been difficult to consistently demonstrate the added value of remote monitoring in terms of superiority in outcomes⁵. However, COVID-19 has changed the conversation about the value of remote monitoring, with increased focus on the benefits that come with less travel and inconvenience for patients and less social interaction. Perhaps achieving the same results as usual care is sufficient.

With a future that is likely to involve an order of magnitude more data that might be relevant to clinical decision-making, making sense of the data will require

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supplementation of human intelligence with artificial intelligence. The ethics of using artificial intelligence in medicine are often questioned, and more clinical involvement in the discussions is urgently required⁶.

Call for action

If we accept that the future will (by necessity and design) be more digital, then the entire multi-stakeholder health-care ecosystem needs to embrace this digital transformation. A 2019 survey of members of the ESC reported that most cardiologists are (at best) “fairly” familiar with digital health tools but many have little if any experience of m-health tools or wearables⁷. Regulatory and liability issues are often stated to be important barriers to implementation of digital tools⁸, but the COVID-19 pandemic has shown that when the need is clear, these barriers seem to be surmountable. We must provide more education and support for health-care professionals as the world digitalizes, jobs change and new roles emerge⁹. Digital literacy also needs to be supported for our citizens, given that recent surveys suggest that digital literacy is surprisingly poor even in wealthy countries.

Electronic medical records, although essential to an integrated digital approach that captures all data for clinical management, have often been designed without meaningful clinical engagement, with the end result being inefficient workflow. This needs to change. Barriers to incorporating data from non-traditional sources (such as wearables or apps) can foster a disconnect between patients and clinicians as both sides seek to reach shared decisions that are based on all relevant sources of information.

Regulatory issues are complex, with political pressure to deliver on investment and demonstrate the potential value of digital technologies but, most importantly, to protect citizens from harm. Data privacy and consent are difficult issues in the digital world. In the USA, the FDA has set up a Digital Health Center of Excellence with the stated aim of “empowering stakeholders to advance health care by fostering responsible and high-quality digital health innovation.” In the European Union, the new Medical Device Regulations are arguably likely to increase the barriers to entry for digital technology, with most seeking to be labelled as merely “health and lifestyle” tools.

Reimbursement authorities have a difficult task ahead. They wish to facilitate access to meaningful innovation, at reasonable (or at least manageable) cost. Technology developers often expect reimbursement decisions to be made merely on the basis of proof of the feasibility of measurements in small pilot studies, without robust demonstration of the added value. In England, the National Institute for Health and Care Excellence has set out a different approach, with a proportionate ask for evidence depending on the cost and likely risks and benefits of the technology within a patient pathway¹⁰.

Many digital tools are developed by ‘Big Tech’ with an eye on wealthy consumers. This focus can exacerbate the ‘digital divide’ in which those without discretionary income or with poor access to, for example, high-speed Internet or personal computers are excluded, with less chance to benefit from innovation.

Conversely, smartphone-based apps can support health decision-making in geographical areas with poor access to health care due to distance, travel difficulties or lack of health-care staff. Smartphone access is almost universal in young populations, but access is variable among older sections of some, but not all, societies.

Professional medical societies have pivotal roles in promoting digital literacy, including the implementation of evidence-based digital redesign and innovation and should act as conduits to meaningful engagement with other key stakeholders.

Conclusions

Digital health, including remote monitoring and other digital tools, are part of the new normal for health care. Society expects clinicians and health-care systems to keep pace with change and to make sense of the information available that might help to improve the prevention, diagnosis and treatment of disease. Digital innovation has enormous potential for good, but all stakeholders — health-care professionals and systems, technology developers, regulators, reimbursement authorities and, most of all, our citizens — need to be involved in the discussions about our digital future. The choices we make now will affect the health outcomes and experiences of care for generations.

1. Mueller, B. Telemedicine arrives in the U.K.: ‘10 years of change in one week’. *The New York Times* <https://www.nytimes.com/2020/04/04/world/europe/telemedicine-uk-coronavirus.html> (2020).
2. Krittanawong, C. et al. Integration of novel monitoring devices with machine learning technology for scalable cardiovascular management. *Nat. Rev. Cardiol.* **18**, 75–91 (2021).
3. McManus, R. J. et al. Home and Online Management and Evaluation of Blood Pressure (HOME BP) using a digital intervention in poorly controlled hypertension: randomised controlled trial. *BMJ* **372**, m4858 (2021).
4. Subedi, N., Rawstorn, J. C., Gao, L., Koorts, H. & Maddison, R. Implementation of telerehabilitation interventions for the self-management of cardiovascular disease: systematic review. *JMIR Mhealth Uhealth* **8**, e17957 (2020).
5. Klersy, C. et al. Effect of telemonitoring of cardiac implantable electronic devices on healthcare utilization: a meta-analysis of randomized controlled trials in patients with heart failure. *Eur. J. Heart Fail.* **18**, 195–204 (2016).
6. Arnold, M. H. Teasing out artificial intelligence in medicine: an ethical critique of artificial intelligence and machine learning in medicine. *J. Bioeth. Inq.* <https://doi.org/10.1007/s11673-020-10080-1> (2021).
7. Asteggiano, R., Cowie, M. R., Richter, D., Christodorescu, R., Guasti, L. & Ferrini, M. Survey on e-health knowledge and usage in general cardiology. *Eur. Heart J. Digital Health* (in the press).
8. Frederix, I. et al. ESC e-Cardiology Working Group position paper: overcoming challenges in digital health implementation in cardiovascular medicine. *Eur. J. Prev. Cardiol.* **26**, 1166–1177 (2019).
9. Topol, E. The Topol review: preparing the healthcare workforce to deliver the digital future. *Health Education England* <https://topol.hee.nhs.uk/> (2019).
10. National Institute for Health and Care Excellence. Evidence standards framework for digital health technologies. <https://www.nice.org.uk/Media/Default/About/what-we-do/our-programmes/evidence-standards-framework/digital-evidence-standards-framework.pdf> (2019).

Competing interests

M.R.C. is chair of the Digital Health Committee of the ESC. He has received research funds and consultancy fees from Abbott, Boston Scientific and Medtronic. He provides consultancy advice to AstraZeneca as Chief Physician–Scientist (heart failure). C.S.P.L. has received research support from AstraZeneca, Bayer, Boston Scientific and Roche Diagnostics; has served as consultant or on the Advisory Board, Steering Committee or Executive Committee for Actelion, Amgen, Applied Therapeutics, AstraZeneca, Bayer, Boehringer Ingelheim, Boston Scientific, Cytokinetics, Darma, Janssen Research & Development, Medscape, Merck, Novartis, Novo Nordisk, Radcliffe Group, Roche Diagnostics, Sanofi, Us2.ai and WebMD Global; and serves as co-founder and non-executive director of Us2.ai.

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