

Digital health approaches for cardiovascular diseases prevention and management: lessons from preliminary studies

Recent advances in digital health technologies including electronic and mobile health platforms (eHealth and mHealth), telemedicine, wearable devices, sensors and artificial intelligence (AI) provide opportunities to improve access to and delivery of healthcare (1). Digital health services currently employ the use of digital technologies for the provision of health education and awareness (i.e., text messaging), remote monitoring and support (i.e., telerehabilitation), disease prediction (i.e., AI), and vital signs monitoring (i.e., wearable devices) (2). However, digital technologies have also been used as diagnostic tools—for example, machine learning and deep learning approaches for the detection of diabetic retinopathy and skin cancers (3). Along with the large datasets generated by electronic health records and medical devices, the global market for digital health has increased steadily over the past few years and projected to reach from USD \$106 billion in 2019 to USD \$639.4 billion in 2026 (4). These big data provide opportunities to understand disease trends, gain insights in patients' health, better predict future health outcomes and support individual care.

Cardiovascular diseases (CVD) has been at the forefront of digital health innovations. A systematic review and meta-analysis of 51 articles assessing the benefit of digital health on CVD showed that digital health interventions significantly reduced CVD outcomes (Relative Risk 0.61, 95% CI, 0.46–0.80) with concomitant reductions in weight (–2.77 lb, –4.49 to –1.05 lb) and body mass index (–0.17 kg/m², –0.32 to –0.01 kg/m²) compared with usual care (5). In the six studies, 10-year risk percentages were also significantly improved (–1.24%; –1.73% to –0.76%). A recent individual patient data meta-analysis reported that text messaging program had a modest impact on blood pressure and body mass index (6). A systematic review of 14 articles assessing the cost-effectiveness of digital health interventions for CVD showed that all studies were cost-effective (7). Digital technologies offer significant opportunities for CVD prevention by promoting lifestyle change and adherence to healthy behaviours (8), early diagnosis, individualised management/supportive care and clinical decision support (9). Given the importance of technologies for the prevention and management of CVD, this special series is focused on recent developments in digital health for CVD. Five papers are presented in the series and are summarised below.

A mHealth tele-imaging platform using WhatsApp

Several recent studies have demonstrated the use of mHealth as a tele-imaging platform in dermatology (10), oral medicine (11), pathology (12) and radiology (13). In this special series, Giansanti *et al.* reported on the exchange of hemodynamic images in cardiology using WhatsApp with a client-server-architecture. The WhatsApp system was pilot tested in a clinical setting using five dynamic images using standardised hospital procedures. The system was evaluated by five experts in interventional radiology who ranked the system high for easy to use, utility and speed, and average for image quality and technology. The use of WhatsApp for exchanging cardiology images might be useful in future telemedicine practise.

Smartphone-based survey on AI in cardiology

AI is a promising tool in cardiology, and offers several utilities including automated image interpretation, data extraction and quality control, and clinical risk prediction (14). Giansanti *et al.* investigated the role of AI in cardiology among 30 cardiologists. Their results indicate that cardiologists have a high desire to invest in AI and use AI in several fields of cardiology, but have low confidence in the use of AI and quality control procedures. In addition, cardiologists have a strong belief that ethical issues are hampering the diffusion of AI. Despite the potential of AI, it requires further refinement and evaluation before it can be used in cardiology practice.

Self-service health check-up stations for screening atrial fibrillation (AF)

AF is one of the most common causes of ischemic stroke, leading to premature deaths and disabilities. Early detection of

AF and treatment could prevent the majority of stroke events. To detect clinically significant AF, considerable amounts of monitored data may be required (15). In a review article, Boulos and Haywood introduce the concept and potential benefits of opportunistic AF screening and detection in a community setting using the latest generation of affordable digital ECG capture and interpretation solutions integrated into easy-to-use “self-service health check-up stations”. Future studies are needed to demonstrate the effectiveness and cost-effectiveness of such check-up stations for AF detection.

mHealth intervention for dietary behaviour

mHealth programs have shown to improve health outcomes in diabetes (16), CVD (6,17-19), chronic obstructive pulmonary disease (20), depression (21), promote physical activity and dietary behaviour (22-24). However, mHealth programs for dietary behaviour for diabetes in low- and middle-income countries (LMICs) are scarce. In a post-hoc analysis from a randomised controlled trial (RCT), Islam *et al.* described the effects of a 6-month text messaging lifestyle program on dietary behaviour in people with type 2 diabetes in Bangladesh. In a previous study, the authors reported that the program was effective and cost-effective for diabetes care (25,26), however the post-hoc analysis showed no significant effect on dietary behaviour. Targeting dietary behaviours in diabetes mHealth interventions could possibly further improve glucose control. With increasing prevalence of diabetes and hypertension (27-30) and mobile phone use (31), mHealth can be an adjunct approach to support patient care in LMICs (32). Further studies with targeted messages for dietary behaviour are recommended.

A clinical decision support system (CDSS) for non-communicable diseases (NCDs)

LMICs have the highest prevalence and death rates of NCDs, including CVDs (33,34). Challenges in LMICs for NCD programs include shortages of qualified practitioners, lack of competencies among the health workforce, lack of proper referral and poor health infrastructures. Task shifting by Community Health Workers (CHWs) has been proven to be a practical approach for many health conditions (35). Zaman and colleagues describe the protocol for an RCT testing a CDSS and the associated community-based management program for people with NCDs in India. The study will examine whether the program is user-friendly, easy-to-comprehend, easy-to-deliver, workflow-oriented, and comprehensive and result in better management of hypertension and co-morbidities than usual care.

The way forward

This special series on *Digital Health for Cardiovascular Disease* highlights the potential application of digital health technologies for the prevention and management of CVD. Collectively, these studies highlight the potential of smartphone apps (e.g., WhatsApp), text-messaging approaches, as well as AI and decision instruments (e.g., CDSS) to enhance CVD management. Nevertheless, numerous challenges hinder the adoption of these technologies, including data quality and robustness, patient safety, ease of use, privacy concerns, and accessibility. Research is needed to advance our understanding of how new digital solutions (e.g. wearable devices, social media) can support prevention and management of CVD (36,37), as well as to improve our understanding of how to implement effective programs at scale, and into everyday practice. As healthcare continues to advance, we need to ensure that we remain conscious of our ultimate goal to support the wellbeing of people with CVD to lead a healthier and productive life.

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