Digital health to end tuberculosis in the Sustainable Development Goals era: achievements, evidence and future perspectives

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Until 2015, the United Nations Millennium Development Goals provided a framework for countries to work towards targets aimed at improving health. Major progress was achieved globally as a result of this drive. Important challenges, however, persist for both communicable (*e.g.* tuberculosis (TB) and HIV) and noncommunicable (*e.g.* tobacco use) health problems. The Sustainable Development Goals (SDGs), which now guide the global development agenda until 2030, approach these health problems more holistically [1]. The "integrated and indivisible" nature of the SDGs requires action across all layers of society. To achieve the health-specific Goal 3 ("Ensure healthy lives and promote well-being for all at all ages"), countries also need to act on the other 16 SDGs, such as poverty (Goal 1), malnutrition (Goal 2), gender-associated inequalities (Goal 5), investment in information and communications technology and in research by the public and private sectors (Goal 9), transparency, accountability and nondiscriminatory laws (Goal 16), and cross-sectoral collaboration and partnerships (Goal 17).

This editorial highlights how digital technologies can be key accessories to the attainment of SDG targets critical for health, as patients and caregivers worldwide depend increasingly on internet and computing for

FIGURE 1 World Health Organization/European Respiratory Society technical consultation on digital health for tuberculosis (February 7–8, 2017).

daily activities. For instance, within Goal 3 itself, digital technologies could enhance the delivery of information needed to train the health workforce (target 3.c), to prevent disease and enable healthy behaviours (targets 3.a and 3.4), and to increase access to essential healthcare services and goods (target 3.8). These interventions commonly involve "apps" on mobile devices to help patients and healthcare providers communicate *via* voice, text or video to improve treatment adherence, to allow clinicians to access medical records and to deliver electronic learning (*e.g.* on clinical guidelines).

TB, the leading single infectious cause of death in the world (1.8 million estimated deaths in 2015 [2]) has its determinants firmly rooted in social and health factors. It thus provides an illustrative example of how digital health interventions targeting a major disease need to be inclusive and adopt a multisector approach to prevention and care. Apart from the benefit that digital interventions can have on efforts to curb TB more effectively and efficiently, they could also serve as a "flagship" for other disease programmes to follow given the ubiquity of TB in global geography and in many aspects of public health. In 2014, the World Health Organization (WHO) elaborated its End TB Strategy in response to a World Health Assembly Resolution urging Member States to end the worldwide epidemic of TB by 2035 [3]. Similarly to the SDGs, to which it is aligned, the End TB Strategy requires novel approaches to be implemented broadly for its ambitious objectives to be realised [4]. Digital technologies play a pivotal role on different fronts in helping achieve these targets, such as in helping patients and carers improve the treatment experience or to automate the management of health information. In 2015, the WHO Global TB Programme, the European Respiratory Society and a task force of global experts (see Acknowledgements) developed a collaborative agenda for action to promote the wider use of digital health in support of the End TB Strategy [5]. Target product profiles were produced that describe the essential features that priority concepts in digital health must have to enhance patient care, surveillance, programme management or human resource development [6].

Over the past decades, patients and caregivers have benefited variably from digital technologies to combat TB. Unprecedented investment in electronic solutions has occurred, in particular for the recording of disaggregated data for TB surveillance, for connecting diagnostic devices and to support patients on TB treatment. These have been successfully scaled up even in large countries like India and China with a large burden of TB [7, 8]. While several of these endeavours have borne results, many have not been implemented sustainably at a large scale. Evidence of impact has often been inconclusive, context-specific or narrow in scope (*e.g.* focused on effectiveness more than quality of life and patient-important dimensions). This limits its extrapolation to settings with conditions that deviate from those where the studies were conducted. The knowledge base is nonetheless steadily growing, and will hopefully help practitioners decide when and how best to apply such technologies [9–13].

Healthcare practice appears to be on the cusp of a transformative change. Disruptive technological developments, such as personalised medicine, and the integration of artificial intelligence and machine learning into clinical tools, are on the horizon [14]. Continued advances in both software performance as well as access to broadband internet and hardware are destined to benefit more people worldwide. These concurrent developments will make digital interventions more scalable *via* mobile electronic devices, across all dimensions mapped out by the digital "agenda for action" for TB [5]. Products created to improve tuberculosis patient care, surveillance, programme management or human resource development could be adapted to the management of other health conditions.

However, unless access to the internet in low-resource settings and in rural areas improves, there is a risk that today's societal inequities become entrenched even further, forfeiting much of the "digital dividends" that could be reaped [15, 16]. The roll-out of game-changing technologies will also make new demands for appropriate legal and infrastructural frameworks to address security, privacy, access and management of confidential data.

Digital health for TB is expected to feature prominently in a landmark ministerial conference titled "A Multisectoral Response to Ending TB in the Sustainable Development Era", being held in the Russian

Federation in November 2017 ahead of a high-level meeting of the United Nations General Assembly on the same theme in 2018 [17]. Bold outcomes are anticipated from these meetings. Amongst others, these could include the creation of a "facility" to catalyse the further development and large-scale implementation of innovative digital technologies matched to the health priorities of national programmes, and the promotion of research on their impact. Such radical change will be critical to achieve the targets of the End TB Strategy and the SDGs.

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