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Technology and its Impact on Mental Health Care (J Torous and T Becker, Section Editors)

# Digital Innovations for Global Mental Health: Opportunities for Data Science, Task Sharing, and Early Intervention

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## Abstract

*Purpose* Globally, individuals living with mental disorders are more likely to have access to a mobile phone than mental health care. In this commentary, we highlight opportunities for expanding access to and use of digital technologies to advance research and intervention in mental health, with emphasis on the potential impact in lower resource settings.

*Recent findings* Drawing from empirical evidence, largely from higher income settings, we considered three emerging areas where digital technology will potentially play a prominent role: supporting methods in data science to further our understanding of mental health and inform interventions, task sharing for building workforce capacity by training and supervising non-specialist health workers, and facilitating new opportunities for early intervention for young people in lower resource settings. Challenges were identified related to inequities in access, threats of bias in big data analyses, risks to users, and need for user involvement to support engagement and sustained use of digital interventions.

*Summary* For digital technology to achieve its potential to transform the ways we detect, treat, and prevent mental disorders, there is a clear need for continued research involving multiple stakeholders, and rigorous studies showing that these technologies can successfully drive measurable improvements in mental health outcomes.

## Introduction

Emerging digital technologies, such as smartphones, mobile applications, social media, wearable devices, and web-platforms, have transformed the way we interact with each other and with the world around us. These technologies have become commonplace in the lives of most individuals, having a profound impact on our behaviors, our day-to-day activities spanning everything from shopping to banking or communicating with friends and family, and on our health and well-being [1•]. There is also mounting evidence highlighting how these technologies affect our mood and mental health in both positive and negative ways [2–6], and that technologies can offer new possibilities for improving the availability, reach, and quality of mental health care [6••, 7, 8]. This is especially relevant because few individuals facing mental health challenges around the globe have access to adequate mental health care, yet most now have access to a mobile phone [9].

In this commentary, we highlight three exciting areas where expanding access to and use of digital technologies hold potential for advancing our understanding of mental illness and intervening to improve mental health services. We draw from empirical evidence, largely from higher income settings, yet given that low-income and middle-income countries (LMICs) face a disproportionate share of the global burden of mental disorders [10••], we also consider specific examples relevant to lower-resource settings. We consider new research and preliminary reports of cutting edge applications that have not yet been widely tested or implemented into practice, covering (1) *data science for mental health research and intervention*, (2) *task sharing for building workforce capacity*, and (3) *early intervention for young people in lower resource settings*. We also recognize key challenges towards realizing the potential of digital mental health.

*Data science for advancing mental health research and intervention* New methods spanning data science, computer science, and epidemiology are transforming the way we approach traditional clinical questions related to identifying, monitoring, and delivering services for individuals with mental illness [11•]. Access to large quantities of data through new digital sources including online platforms, social media, online search behavior, and mobile devices, combined with advanced data analysis techniques and large computing power, is making it possible to uncover patterns or trends in human behavior and illness trajectories that were previously not visible. This emerging field, often referred to as digital epidemiology, is supported by an increasing number of studies demonstrating the feasibility and promise of using online sources of big data to study behavioral patterns, monitor disease risk, and inform development of targeted interventions [12, 13], with new emphasis on these digital methods for studying mental health [1•, 7]. The rapid growth in the number of social media users worldwide, accounting for nearly half of the global population in 2019 [9], generates an immense quantity of data spanning all times of the day and from nearly every country. This data can be studied and analyzed, offering unique opportunities to facilitate

the detection and tracking of numerous diseases and public health concerns [14], and now increasingly mental health [1•].

Much of the research using diverse sources of big data and employing various research designs for monitoring onset, progression, and severity of mental disorders has come from higher income countries [15]. This work is especially relevant for lower resource settings, where use of digital technologies continues to increase rapidly [1•, 16]. To date, this research has involved *actively* collecting data by using social media platforms such as Twitter, Instagram, or Facebook to invite subjects to participate in interviews or answer surveys measuring levels of depression, well-being, or suicidal ideation [17]. In another category of studies, researchers have used *passively* collected social media data to identify people with mental health problems based on users' patterns of communication [18], the types of words used to communicate with others online [19], or openly disclosing a mental illness diagnosis online [20]. Social media platforms afford opportunities for studying human behavior and risk factors for mental illness through the extraction of massive quantities of passive data from users. It is possible to extract language from a population of interest who use social media to identify specific patterns of language use and how this relates to a diagnosed mental disorder, potential for worsening of symptoms such as depression or anxiety, or expressions of risk of suicide [17, 18, 21].

Techniques in natural language processing or use of semantic models make it possible to examine sentiment of social media posts (either positive or negative) extracted from Twitter, Facebook, Reddit, or Instagram [22••], as demonstrated by detecting stress and relaxation [23], identifying emotions such as anger, confusion, disgust, fear, happiness, sadness, and surprise [6••], and recognizing expressions of acute stress [24, 25]. These methods can also yield insights into mental disorders [26], such as PTSD [27] and depression [18]. Initial work from computational linguists and psycholinguistics revealed that frequencies of anger words or varied negative emotions, and related patterns of language use, are associated with Twitter users' likelihood of self-reported mental health problems [26, 27].

Social media data can further be used for studying geographic variations in well-being and mental health, such as the effects of scenic landscapes on happiness [28], or identifying negative emotions (e.g., fear, anger, sadness) from analysis of social media posts during traumatic events [29•, 30, 31]. Information on spatial patterns of well-being, emotions, and mental health could be spatially integrated with personal mobility patterns to identify places of significance to individuals (e.g., home, work, commute) [32], and to elucidate potential mental health aspects of both personal characteristics and socio-ecological environmental exposures at multiple geographic locations [33, 34]. Shankardass and colleagues [35•] provide a framework for describing person-place interactions that helps with integrating digital and physical places in the context of well-being, while others have created socio-spatial self-organizing maps to find geographic regions by their latent social attitude (e.g., racism, homophobia) from Twitter [36].

Efforts in the field of human-computer interaction (HCI) have attempted to understand both how mental health is experienced and the interactions that experience can have on technology use [37••]. This includes understanding and predicting how individuals will express mental illness in online and social contexts through analysis of social media and online mental health forums (as described above) [21, 38–42], as well as designing behavioral interventions to ease mental distress [43–45]. Work in HCI has involved use of online data to explore mental health states [46], and analysis of social media data to predict the onset of symptoms of mental illness. For example, analysis of data from Twitter showed over 70% accuracy in predicting onset of postpartum depression [40] and major depressive disorder [47]. Other studies have explored interactions between technology and mental health, including predicting when an individual would come to feel better within an online mental health forum [41], predicting shifts to suicidal ideation using data collected from Reddit [21], or examining linguistic signals of more complex mental disorders such as schizophrenia [39, 48, 49].

The clinical implications of this work are beginning to be seen, such as a greater understanding of alternative methods of addressing opioid addiction [39] or a more nuanced understanding of pre-treatment factors that might predict outcome in the use of antidepressants [42]. Complementing these mainly quantitative analyses, work in HCI has also considered how people express their mental health in different social media contexts [38, 50], and create behavioral interventions based on these understandings, including cognitive behavioral [44] and emotional regulation [45] targeted interventions.

In the sub-discipline of HCI for development (often abbreviated HCI4D), recent work has argued that there are significant opportunities for HCI researchers to work

alongside practitioners to help those experiencing some form of mental illness or mental distress in lower resource settings. Kumar et al. [51] outline the importance of considering individual aspirations when designing HCI4D interventions, focusing on the application of aspiration-based design in resource-constrained contexts. In an aspiration-based design approach, aspirations are separated into tangible goals, with intervention design efforts targeting these specific goals. Building on this work, Pendse et al. [37••] argue that given the lens that mental health can lend to aspirations [52–54], there is a natural area of collaboration between HCI4D practitioners and mental health professionals in using technology to address mental health, both in studies directly focused around mental health, and those that have a high likelihood of having participants with significant mental health issues.

Another important area attracting considerable attention is the potential for artificial intelligence (AI), involving powerful machine learning techniques for discovering patterns in data. These techniques hold potential to maximize in-depth analysis of available data streams, thereby generating new insights and hypotheses about how best to improve quality of care and strengthen health systems [55•]. In one recent study, a digital mental health app used machine learning to increase help seeking and use of crisis services for individuals experiencing acute psychological distress [56]. A comprehensive review of 300 studies, with the vast majority coming from high-income countries, using machine learning for mental health demonstrated that these approaches show benefits for supporting detection and diagnosis of mental disorders, with further efforts needed to show that machine learning tools can improve treatment and improve mental health care delivery [15]. Despite the promise of AI, there are some groups of individuals who may not benefit. This is especially a concern among those who are underrepresented and often coming from marginalized groups, as their mental health care needs would not be reflected in available datasets. This emphasizes the importance of ensuring that machine learning algorithms account for the needs of a diverse target population [55•], which will be especially critical when seeking to apply these approaches in health systems spanning geographically vast regions serving diverse cultures and ethnic, linguistic, and racial minority groups.

*Task sharing for building workforce capacity* Healthcare systems in most countries, especially in lower resource contexts, face significant shortfalls in providing even basic mental health services [57]; a gap that is driven in large part by inadequate workforce capacity to meet growing demands for mental health services [57, 58]. Task sharing involves non-specialist health workers, for example, community health workers, lay health workers, midwives, or nurses, supporting the delivery of evidence-based mental health care, such as brief psychological treatments for common mental disorders in primary care settings [10••, 59••]. Several large-scale studies have demonstrated the effectiveness and cost effectiveness of task sharing approaches in low-resource settings [60–62]. The rapid emergence of digital technologies has demonstrated promise as an important tool for potentially supporting non-specialist health workers across a variety of settings [63]. To date, most efforts have involved using technologies such as mobile phones and text messaging (i.e., SMS) for supporting non-specialist health workers in delivering services for maternal and child health, reproductive health, and treatment and prevention of vector-borne diseases [63, 64]. In a report summarizing over 140 projects involving use of mobile technologies, such as text messaging, among non-specialist health workers in low-resource settings, key clinical functions included facilitating data collection and reporting, supporting health worker decision-making, allowing opportunities for provider training and education, sending alerts and reminders, and improving supervision of and communication between healthcare workers [63].

Consistent with the ways that technology can enhance general health services, a recent review found that technology similarly shows promise for enhancing clinical functions in the delivery of mental health care related to coordination, training and education for health workers, supervision, data collection and sharing, providing alerts and reminders, and supporting decision-making screening and referrals [65•]. Among the relatively fewer projects using digital technologies for supporting task sharing of mental health care in low-resource settings, there have been promising efforts focused on building capacity of non-specialist health workers for treating common mental disorders in primary care or community-based settings [66–69], targeting perinatal depression [70, 71], and supporting care for persons living with schizophrenia by leveraging community contacts [72, 73•]. Digital technology also appears promising as a tool for enhancing the training of non-specialist health workers. A recent study demonstrated that the Technology-Assisted Cascade Training and Supervision system (TACTS), which involves using

digital technology to support in-person training, achieved comparable results as standard instructional approaches for training lady health workers to deliver the Thinking Healthy Program for perinatal depression in a post-conflict area of Pakistan [71, 74••].

The use of technology for supporting community health workers is not without challenges. Despite the excitement and interest in digital technologies, prior studies have found that there are limited uptake and sustained use of digital tools in clinical settings among community health workers and other frontline health workers over time [75, 76]. Digital interventions are rarely implemented within health systems, and even if initial effectiveness outcomes appear promising, few studies have replicated these findings across large samples or diverse settings [77•]. There is also concern that technology could be used to replace the role of non-specialist health workers, as this could potentially undermine the human element in care delivery. The human element is often considered a necessary ingredient in the provision of effective mental health care [7], and supervision and support of non-specialist health workers to manage the workload and burden of care for people with mental disorders are crucial as well. However, there may be ways that technology could enhance many aspects of the patient-provider dyad, as well as the supervision relationship, through facilitated communication between non-specialist health workers and their patients, their patients' family members, and with other health workers and supervisors [59••]. There may also be opportunities for machine learning approaches to provide data-informed insights and feedback directly to non-specialist health workers in the field through mobile devices, and to offer practical support and improve performance [55•]. It will be important to closely involve non-specialist health workers in the development and delivery of digital interventions for mental health care, as they can offer unique perspectives to inform different design elements of these digital programs, including the use of features to motivate health workers to continue using the programs over time, content that is presented at an appropriate level to accommodate low health literacy, and context-specific modifications to ensure that the program is relevant for both the target health workers and their patients [78••].

*Early intervention for young people in lower resource settings* In this last broad topic area, we consider the promise digital technology may hold for promoting mental health among young people [79, 80], especially amidst a global mental health crisis for adolescents and youth [10••, 81]. A growing body of research indicates the potential of digital mental health interventions to improve access and address the stigma associated with seeking traditional mental health services [80, 82–85]. These innovations may have particular relevance for LMICs, which are home to about 90% of the global adolescent population [86], but contain only a small fraction of the world's mental health service resources [87]. In fact, some low-income countries still have no dedicated youth mental health provision at all [88]. Hence, there is a pressing need to identify novel, age- and context-appropriate mental health care solutions that are accessible, cost effective, and scalable [86].

The large mental health care gap in many LMICs sharply contrasts the rapid boom in telecommunications, mobile phone, and internet access [89]. Evidence from diverse low-resource settings shows that young people adopt new technologies and use mobile devices and the internet more frequently than individuals from older age groups, including for the purpose of accessing health-related information [84]. India, for example, has 90% mobile phone penetration, more than 225 million smartphone subscribers, and rapidly increasing rates of internet and social media usage [85]. Despite varied access and gaps in connectivity, especially in rural areas and among women compared with men, digital technology platforms offer unparalleled opportunities to reach vulnerable young people at scale and overcome many of the barriers that exist around conventional service provision [84, 89].

Since an initial description of "e-health" by Eysenbach in 2001 [90], the nature of such digital provision has evolved considerably. Static content delivered via PCs or laptops has been superseded by more advanced technology that allows for greater functionality and adaptability. This increasingly involves the delivery of interventions through applications ("apps") designed for smartphones and other wearable digital devices [91]. For instance, there are now more than 10,000 publicly available mental health apps [92, 93], of which a growing number make use of "serious games," i.e., games that are designed to educate, train, or change behavior as they entertain players [94]. However, few of these interventions to date have been tested and reported in the scientific literature; the available reports are based almost entirely on desktop-computer formats rather than more frequently used technologies such as smartphone apps [95•].

Meta-analyses and systematic reviews of mental health digital interventions for adolescent populations highlight promising findings for feasibility and acceptability [80, 96–99]. However, evidence of efficacy remains limited, especially for interventions evaluated in LMICs and for those focused specifically on youth mental health [95•, 96, 99]. A review of digital technology for treating and preventing mental health problems in LMICs identified 49 studies, though only four studies targeted adolescents and youth [100••]. Among the few studies conducted in low-resource settings, encouraging examples include a randomized controlled trial demonstrating the effectiveness of Internet-delivered cognitive behavioral therapy for anxiety among adolescent girls in Iran [101], the acceptability of a web program for supporting mental health well-being of adolescents in school settings in Thailand [102], and the feasibility of a text message intervention for mental health promotion among adolescent girls in urban slums in Bengaluru, India [103].

There has been a recent emergence of new research in this area, and in particular projects where best practices in person-centered design [104] are being employed for the development of digital interventions for young people in LMIC settings [105]. Techniques like virtual reality and gamification also hold promise, as these approaches can allow individuals to "step into someone else's shoes" and offer opportunities to build empathy and self-reflexivity and invite participants to understand their own behaviors [106]. For example, "Maya" is an online adventure video game developed in Chile for treating depression in adolescents that follows a hero's journey to promote problem-solving, decision-making, and skill building [107]. In another example, *POD Adventures* is a blended problem-solving intervention that deploys low-intensity human support in tandem with a smartphone-delivered game for enhancing ability to cope with stressors among adolescents with or at risk of common mental health problems in India [105, 108].

Digital media, such as social media, could also be harnessed as a means for creating safe and accessible spaces to address issues related to mental health among young people, especially for those who may be reluctant to seek traditional health services, or who may be living in isolation due to experiences of stigma. In an example from India, the national public engagement campaign called "It's Ok To Talk" (www.itsoktotalk.in) [109•] leverages the use of various digital media to emphasize the central role of disclosure in recovery from depression [110, 111]. The program was designed in consultation with young people aged 15–24 years as a social media platform for young people to share their stories of mental health problems and recovery (see Fig. 1). Exploration of the personal narratives shared via this platform offered a window into young people's self-identified priorities and challenges related to mental health needs, and these were subsequently used to inform anti-stigma initiatives and other public awareness activities [109•]. Projects like this offer opportunities to promote broader conversations around mental health for young people, and potentially help reduce stigma, enhance awareness, and encourage help-seeking behaviors.

With the ever-increasing use of digital devices among young people in lower resource settings, the role of technology as a tool for promoting mental health and well-being will become even more significant, especially as gaps in available in-person mental health services remain substantial. As highlighted in these examples using technology for youth mental health in India, there are opportunities to offer individuals safe spaces for sharing knowledge and experiences, and promoting a participatory culture through immersive media and digital devices. These efforts fit with increasing emphasis globally on moving towards early intervention and selective or indicated prevention for youth mental health problems [112, 113•]. By leveraging digital technologies in innovative ways, it may be possible to contribute to sustainable development by offering easily accessible resources and trusted venues for young people, while promoting mental well-being and facilitating opportunities to seek support in times of distress or when experiencing mental health problems.

## Challenges ahead

Several limitations with digital technology for mental health warrant consideration. For instance, one of the most important and persistent challenges facing digital mental health is the significant disparity in access to and use of digital

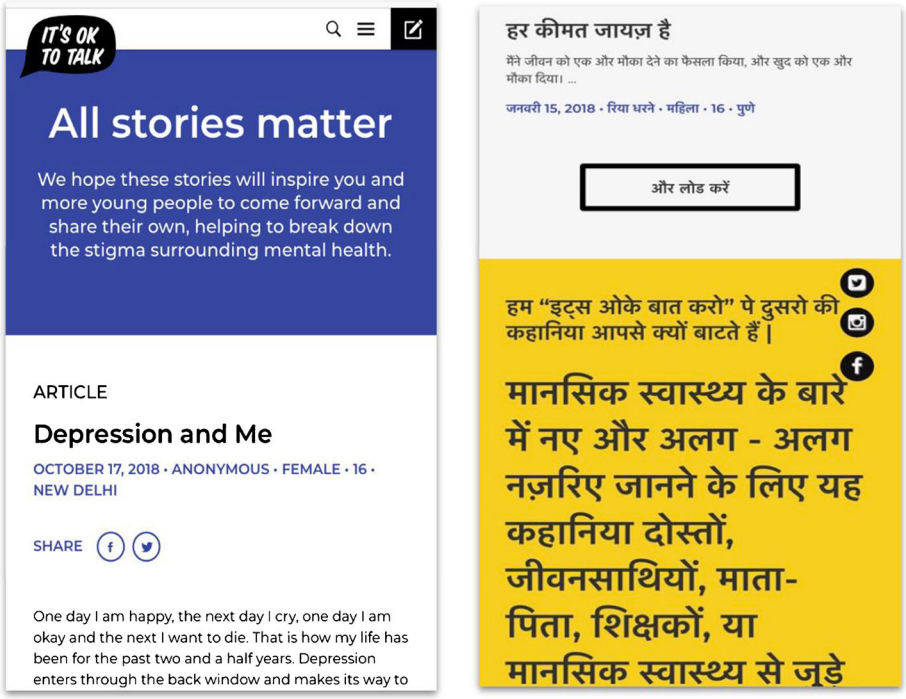


**Fig. 1.** It's Ok To Talk Campaign. This figure is from the national public engagement campaign called "It's Ok To Talk" (www.itsoktotalk.in) [109•]. This effort was launched by the Indian NGO Sangath on the World Health Organization (WHO) World Health Day in 2017, taking inspiration from the theme for that year, "Let us Talk," which emphasized the central role of disclosure in recovery from depression [110, 111].

devices. Researchers have highlighted that these digital inequalities are often overlooked, and that these gaps in access often mirror existing social inequalities [114•]. While there is increasing use of digital devices worldwide, as highlighted in reports cited earlier in this paper [9], the reality in many of the lowest resource settings represents a stark contrast. In addition, across the globe, there are approximately 184 million fewer women who own mobile phones compared with men, which translate to a 10% lower chance for a woman to own a phone than a man [115]. Women are also 26% less likely to use mobile Internet compared with men, while in regions such as South Asia the gap is even more striking, where women are 70% less likely to use mobile Internet compared with their male counterparts [116]. This gap in access among women is alarming given that common mental disorders are over two times more prevalent among women compared with men owing to the impact of trauma, sexual harassment, gender-based violence, and poverty [10, 117].

Gaps in access create obvious limitations for reaching at-risk population groups using mobile apps or other direct to consumer mobile or web-based interventions. When considering the role of data science for advancing mental health, the concerns of omitting large segments of the population are potentially more serious. By automatically excluding a large portion of the population due to social, demographic, or cultural characteristics, it means that these individuals will not be contributing their data or insights to the development of AI algorithms or efforts to tailor digital interventions [55•]. A review

highlighted the lack of variety in big data for mental health, cautioning that available data sources lack many important details representative of different geographic regions, diagnoses, and racial or ethnic diversity in patient groups [118]. Therefore, digital mental health faces potential biases and risk of not being representative, concerns that are especially relevant for lower resource settings where there are a greater proportion of individuals without access to mobile technology because of gender disempowerment, low literacy rates, residing in rural areas, or living in extreme poverty.

Additionally, it is important to recognize that digital technology may contribute to worsening mental health symptoms [6]. Use of online platforms and popular social media present risks for users, including worsening mental health symptoms through prolonged screen time use [119], exposure to hurtful content and hostile interactions with others [120], threats to privacy [7, 11], as well as negative consequences on everyday life due to stigma, impact on personal relationships, and unintended consequences of disclosing personal health information online [121]. If digital technologies such as social media and other online platforms are going to factor into future mental health intervention efforts, especially programs targeting young people, then it will be essential to find ways to encourage safe use of these technologies. This will also necessitate addressing issues related to trust and privacy, where data is typically captured from digital platforms and commercial devices without the consent or awareness of users [1•]. Furthermore, researchers have cautioned that relying on online big data alone is insufficient, and that to effectively inform clinical practices, data captured from digital platforms will need to be combined with real-world patient data to ensure validity and relevance for the target population [122].

Another important consideration is the need to closely involve target users, whether it is an individual living with mental illness, their family or caregivers, or non-specialist health worker or other health system stakeholders, throughout the development, testing, and implementation of digital mental health efforts. Referred to as participatory approaches, target users can share their views and insights through a series of focus groups, interviews, or iterative workshops and prototype testing [123]. This will be essential to ensure that interventions account for differences across cultures, languages, and geographies, and include tailored features aimed at overcoming challenges with low engagement and sustained use of digital mental health interventions in practice [124, 125]. Furthermore, use of digital technologies in mental health needs to be guided by relevant behavioral theories. This can help researchers understand why a target intervention might work in one setting and not another, and could also inform adaptations to interventions as new technologies emerge and replace older ones [126].

## Conclusions

In this commentary, we considered opportunities for digital technology to advance research and intervention in mental health through the emerging field of data science, task sharing for building workforce capacity, and early intervention for young people in lower resource settings (see Table 1). Digital approaches for mental health also represent more than simply using technology and new analytic techniques for research, outreach, or improving care, as it

**Table 1. Summary of digital technologies for advancing global mental health through data science, task sharing, and early intervention**

| Key topic | Opportunity and need | Promising examples | Challenges ahead |
|---|---|---|---|
| 1) Data science for mental health research and intervention | • Large quantities of data from digital sources.<br>• Big data affords opportunities to study human behavior, mental illness risk factors, and intervention.<br>• Machine learning can provide insights to improve health system performance. | • Social media data can yield insights into stress and mental disorders.<br>• Digital data can identify geographic variation in well-being and mental health.<br>• Work in human-computer interaction (HCI) has examined how people express their mental health in different social media contexts. | • Significant disparity in access to and use of digital devices means some individuals will not benefit.<br>• Population subgroups omitted from datasets means their data are not included in design of algorithms.<br>• Digital efforts need to be guided by relevant behavioral theories. |
| 2) Task sharing for building workforce capacity | • Inadequate workforce capacity to meet growing demands for mental health services.<br>• Task sharing involves non-specialist health workers delivering evidence-based mental health care.<br>• Technology shows promise to support task sharing. | • Technology can support coordination, data collection, supervision, and decision-making.<br>• Technology can enhance training and education in mental health care.<br>• Technology can support non-specialist health workers with screening and diagnosis, and guiding care delivery for various mental disorders. | • Limited uptake and sustained use in clinical settings<br>• Digital interventions rarely implemented in health systems.<br>• Concern technology could replace the role of non-specialist health workers and undermine human element of care delivery. |
| 3) Early intervention for young people in lower resource settings | • Global mental health crisis for adolescents and youth.<br>• Gaps in available in-person youth mental health services remain substantial.<br>• Young people more likely to adopt new technologies and use mobile devices and the internet. | • Game-based mental health interventions show promise for adolescents.<br>• Technology for public engagement campaigns and school programs.<br>• Immersive digital media for creating safe and accessible spaces to promote mental health and challenge stigma. | • Varied access to technology (e.g., rural areas and among young women).<br>• Risks of digital technology for young people are not fully understood.<br>• Need to closely involve target users to ensure that research is relevant to their needs. |

involves a considerable culture shift [127]. Mental health providers who have long been accustomed to face-to-face encounters or relying on subjective clinical judgments about symptoms now have opportunities to use digital tools to support care delivery [127]. Whereas for patients, technology can offer more control over their care through access to smartphone apps and self-help programs, on-demand information about their condition, and peer support networks through popular social media [127]. Digital interventions will need to yield returns in the form of clinically meaningful outcomes, improved quality of life for patients, and reduced workload for providers in order to facilitate adoption among policymakers, administrators, clinicians, and service users [55•].

We also highlighted several important challenges, which should be viewed as ways to strengthen future efforts. Digital mental health projects can strive for

inclusiveness towards meeting the demands for evidence-based treatments for mental illness in regions of greatest need. With the increasing use of mobile technologies and social media platforms, the opportunities to overcome geographic and physical barriers to detect, treat, and monitor mental disorders, and bridge gaps in available mental health care may be most significant in lower resource settings [100••]. To achieve this end, continued research is necessary involving multiple stakeholders to explore how these technologies may best support efforts to identify risk factors for mental illness, enable targeted intervention, and support existing health care providers.

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## Compliance with ethical standards

**Conflict of interest**
John A. Naslund declares that he has no conflict of interest.
Pattie P. Gonsalves declares that she has no conflict of interest.
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Giuseppe Raviola declares that he has no conflict of interest.

**Human and animal rights and informed consent**
This article does not contain any studies with human or animal subjects performed by any of the authors.

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Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

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## Publisher's Note