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

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Digital Technology to Enhance Clinical Care of Early Psychosis

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Abstract

Purpose of review Despite considerable evidence supporting the clinical benefits of early intervention for psychosis, issues remain with access and maintenance of long-term recovery. As digital technology has advanced rapidly over recent decades, so too has recognition for its capacity to address the challenges in providing care for those with mental ill health. The current report provides an overview of research focusing on the use of digital technologies to enhance clinical care of people with early psychosis.
Recent findings Research suggests that people with early psychosis use technology in a similar fashion to those in the general population, and there is interest in its use for mental health. Studies have primarily focused on smartphone apps and online interventions targeting self-management, psychosocial functioning, and supporting case management. Findings support feasibility and acceptability; however, evidence for the efficacy of digital approaches is yet to be established in early psychosis populations.
Summary Whilst promising, findings in early psychosis are currently limited to a small number of studies at primarily pilot stages. More broadly, a number of challenges have been highlighted in digital mental health literature, including quality standards, the slow pace of research evaluation, difficulties with implementation and ethical considerations.

Introduction

The first episode of psychosis represents a critical period for early intervention [1], with duration of untreated illness one of the strongest predictors of poor outcomes [2, 3]. Persisting psychotic conditions such as schizophrenia represent a significant economic burden on health care worldwide [4], and on an individual level are associated with reduced quality of life [5] and psychosocial functioning [6]. Efforts to interrupt the trajectory of psychosis through early intervention have occurred [7, 8], with over 50 specialist clinics established around the world [9]. Clinical trials have supported the benefits of early intervention for reducing symptom severity, increasing functional recovery and preventing hospitalisation [10]. However, limited funding and resources are common obstacles to the successful delivery of early intervention services, contributing greatly to delays in access [11]. In addition, many individuals require longer-term care than is typically available and as a result, maintenance of long-term recovery is often disrupted by intermittent relapse [12].

Digital technology has potential to bridge the gap in mental health care by increasing access and supporting the delivery of services [13–15]. Advances in technologies such as the internet, smartphones, computers and wearable sensors offer unprecedented opportunities to provide accessible, flexible and personalised mental health care [16]. This report provides an overview of the use of digital technologies in early psychosis populations and how they might be used to enhance clinical care of these individuals. Recent examples from cutting-edge studies are highlighted, as well as issues related to the research and implementation of technologies within routine clinical services. This literature provides an introduction to professionals regarding the potential of digital technology, with interested readers directed towards more exhaustive systematic reviews and meta-analyses, which have focused on persisting psychosis and mental ill health more broadly [17, 18, 19•, 20–24].

Use and attitudes towards technology in early psychosis populations

Young people are native adopters of digital technology. In the USA, approximately 95% of teenagers aged 13–17 and 94% of young adults aged 18–29 own or have access to a smartphone [25]. Amongst teenagers, internet use has increased dramatically, with 45% reporting "almost constant" use. Research in early psychosis populations in Western countries have found that ownership and usage rates appear comparable to equivalently aged young people in the general population, though sample sizes have been small. Lal et al. [26] surveyed 67 users of an early psychosis service, finding 88% had access to a smartphone, though not all were connected to the internet. Seventy-one early psychosis service users were surveyed by Abdel et al. [27], with 92% of the sample regularly using a smartphone. Amongst broader psychosis populations, use of technology also mirrors that of the general population, with meta-analysis estimating smartphone ownership rates of 81% [28•]. Research in low- and middle-income countries is scarcer; however, access to technology is also increasing rapidly in these nations [29], providing a platform to address the considerable gap in mental health care [30].

People with psychosis have shown interest in using digital technology for their mental health. Torous, Friedman and Keshavan [31] surveyed 320 psychiatric outpatients across multiple clinics in the USA, finding that 70.6% were interested in using smartphones to monitor their own mental health symptoms. Firth et al. [28•] identified seven studies which collected opinions on the use of digital technology for mental health amongst schizophrenia samples, finding that 51–60% were in favour of using technology for a variety of purposes, including keeping

track of mental health, receiving information, being reminded of appointments and facilitating contact with health professionals. Amongst those with early psychosis, social media appears a highly popular function, offering a medium for social connectedness that may be difficult in everyday life [32]. One study found that close to 100% of a sample of 80 individuals with early psychosis used social media regularly, on average for 2 h per day, and more often when experiencing symptoms [33]. Further, around 75% were interested in receiving professional mental health support via social media.

Attitudes towards the use of technology for mental health amongst 21 individuals with early psychosis were examined in a qualitative study by Bucci et al. [34]. Technology was seen as having potential to augment routine services by creating a more consistent and less stigmatising way of accessing treatment that extends beyond the clinical setting and into everyday life. Whilst attitudes were overall positive, participants reported concerns over security and privacy, and generally emphasised the importance of technology to support rather than replace clinical services. This mirrored the findings of another qualitative study conducted by the group examining the attitudes of staff within a public mental health service [35]. Attitudes were mixed amongst the 20 service providers, which the authors summarised as "cautiously optimistic", with emphasis on the importance of technology being used as an adjunct to regular care. Finally, a survey of attitudes from family members of young people with early psychosis was examined in a series of focus groups conducted by Lal et al. [36]. Family members were generally in favour of the use of digital technology to support the young person with psychosis, however felt there was a need for guidance to prevent issues such as excessive use and accessing inaccurate, misleading or harmful information online.

Together, these findings indicate that people with experiences of both early and persisting psychosis use technology in a similar fashion to those in the general population and there is interest in its use for mental health. This challenges an early perception that these individuals are "digitally excluded" from the growing developments in technology for health and wellbeing [37], although technology use and interest do vary [38]. There is also apparent support from service providers and family members for using technology for mental health, though there are also legitimate concerns.

Opportunities to enhance care for early psychosis

This section provides a brief overview of the ways in which digital technologies might be used to support clinical services and promote self-management of mental health for early psychosis. Table 1 summarises findings from key research studies in early psychosis populations specifically. The limited number of RCTs and dominance of pilot and feasibility studies indicates the early stage of this research.

Enhancing clinical services through adjunctive use of technology

By supplementing standard therapies with digital technologies, it may be possible to reduce the treatment time and costs associated with less therapist involvement whilst also improving the efficacy of therapeutic components [22]. The combined use of digital technology with standard treatment formats is

Table 1. Summary of findings from key research studies examining digital technologies for early psychosis

Study	Intervention	Study design	Findings
HORYZONS [39]	Web-based platform with psychosocial intervention (psychoeducation, EWS, stress management, depression and social anxiety), social networking and professional (clinical and vocation) moderation components	Pre-post uncontrolled pilot study, 20 participants with FEP accessed HORYZON over 1 month	No dropouts; 60% used system for full 1 month, 75% reported positive experience, 90% would recommend to others; social networking most popular feature; no adverse events; significant, moderate-large improvement in depressive symptoms, no significant improvement in overall symptom severity or anxiety.
MOMENTUM [40]	Web- and mobile-based platform with psychosocial intervention (strengths, mindfulness, social functioning), social networking and peer/professional moderation components	Pre-post uncontrolled pilot study, 14 participants with UHR for psychosis accessed MOMENTUM over 2 months	1 drop-out; 72% used system 7 times or more; 100% found it safe and would recommend to others; 93% found it helpful; social networking most popular feature; no adverse events; significant, moderate-large improvements to social functioning, subjective wellbeing, mindfulness skills, and subscales of social support, no change in UHR status, self-efficacy, self-esteem, loneliness, depression or stress
Actissist [41]	Mobile app delivering CBT for early psychosis. Users can access content on demand and prompted to complete questions about symptoms three times per day, with intervention statements presented depending on responses	Pilot RCT, 36 participants with early psychosis, 24 allocated to use Actissist over 12 weeks and 12 to use a symptom-monitoring app (active control)	27% drop-out, equal across groups; 'voices' most popular domain; 75% used app at least once per day; 75% completed minimum criteria for questionnaire completion; 90% recommended app to others; no adverse events; large effect sizes favouring treatment group for psychotic symptoms, functioning and mood, not maintained at follow-up
Personalized real-time intervention for motivation enhancement (PRIME) [42]	Mobile app involving selection and monitoring of goals, with daily 'challenges', social networking component, and an online 'coach' offering real-time interaction to	RCT, 43 participants with early psychosis, 22 allocated to use PRIME app over 12 weeks and 21 to waitlist group	26% drop-out, equal across groups; high satisfaction with app; most used feature interaction with coaches, least popular symptom monitoring; average usage

Table 1. (Continued)

Study	Intervention	Study design	Findings
	encourage motivation using therapeutic principles		4 days per week; significant improvements (unrelated to app use) maintained at follow-up in treatment relative to control in self-reported depression, defeatist beliefs, self-efficacy and trend towards motivation/pleasure negative symptoms, improvements in subscales of social motivation post-trial, not maintained at follow-up. No significant improvements in psychotic symptom severity, quality of life or functioning
Heal your mind (HYM) [43]	Mobile app for CBT-based monitoring, with entries viewed by case manager who can provide real-time feedback through an interactive module	A survey of 24 clients from an early psychosis service who were already using the HYM within routine care	81.3% clients chose to use the app; 66% used at least once per week; interactive module used most frequently (100%) and reported as most helpful (79.2%); 83% reported app easy to use, 80% satisfied and 71% reported help from app; 46% reported app useful for monitoring symptoms in real time; nil adverse events
+Connect [44]	Mobile app based on positive psychology principles to reduce loneliness, with peer and expert videos, mood tracking and gamified challenges	Pre-post uncontrolled pilot study, 12 participants with early psychosis experiencing high levels of loneliness used the +Connect app for 6 weeks	16% drop-out; app used on 95.5% of days; 80% reported app useful, 90% enjoyed using app; least engagement and satisfaction with gamified challenges; 70% satisfied with app; 90% reported app helped to improve social confidence, connection and life satisfaction. Nil adverse events. Preliminary analysis suggests reduction in loneliness over course of intervention, maintained at follow-up.
ACT-DL [45]	Mobile app used in conjunction with group acceptance and commitment therapy to promote use of exercises in	Pre-post uncontrolled trial, 16 participants at risk mental state for psychosis who completed the full	100% participants used the app to guide exercises, 38% engaged with exercises without the app. App

Table 1. (Continued)

Study	Intervention	Study design	Findings
	daily life. Users access activities on demand and prompted to complete questions about symptoms eight times per day, with exercises suggested depending on responses.	intervention of 5 therapy sessions over 6 weeks	reported to be moderately useful and assisted in applying exercises to daily life and improving awareness of feelings
Ginger.io mobile platform[a] [46]	Mobile app collecting active (daily and weekly questionnaires about symptoms) and passive (e.g. movement data), with summaries viewable by case managers on a web-based 'dashboard' and alerts sent when responses indicate clinical worsening	Pre-post uncontrolled trial, 76 participants with early psychosis or UHR status used the app for 14 months	34% drop-out; questionnaire completion rates moderate-high (69% daily, 77.3% weekly); 97% reported app easy to use; 83% open to continued use; 46% reported app helped to remember medication; 42% reported app helped to manage symptoms; validity of app questionnaires supported by comparison to in-person ratings
Lifedata mobile platform[a] [47]	Mobile app involving completion of daily and weekly questionnaires focusing on symptoms and functioning, with summaries viewable by case managers on a web-based 'dashboard'	Pre-post uncontrolled trial, 61 participants with early psychosis used the app for 5 months along-side 20 case managers	33% service users dropped out, 50% case managers dropped out due to position changes; questionnaire completion rates low-moderate (41% daily, 39% weekly); 50% sessions with case manager used dashboard; 66% service users/85% service providers open to continued use; 61% service users/85% service provers would recommend to others/clients; technological issues encountered. Estimated cost per client US $249.39.

EWS early warning signs, *FEP* first episode psychosis, *UHR* ultra-high risk for psychosis, *CBT* cognitive behavioural therapy, *RCT* randomised controlled trial
[a]Mobile platform not purpose build for study, available for researchers to program

referred to as *blended therapy*. Mobile devices such as smartphones can be used to connect clinicians with their patients in real-world settings, assist in monitoring and recording relevant clinical information in daily life and prompt the use of intervention strategies, such as medication or coping reminders, at the moment they are needed. Within-session tools such as tablet computers have been shown to aid communication of health-related information in an engaging format [48, 49], and communication technologies such as video

conferencing have been used to overcome geographical barriers by delivering services remotely [50].

Assessing experiences as they arise in their natural environment is an attractive use of technology which has broad clinical application [15, 51]. *Ecological momentary assessment* (EMA) typically involves the use of smartphone apps to deliver multiple alerts per day over several days requesting completion of electronic questionnaires on the device (e.g. [52]). A similar approach referred to as passive sensing involves the collection of mobile data such as geolocation or physiological recordings (e.g. heart rate, skin conductance) without active input required by the individual (e.g. [53]). Measuring clinical phenomena in real-time, real-world contexts can provide accurate insight into complex experience [54]. Analysis of EMA data can support clinical formulation by revealing dynamic patterns in clinical processes over time [55, 56]. Clinicians might also use EMA to track treatment response, identify at-risk mental states and inform highly tailored interventions [51]. As described in Table 1, Kumar et al. [47] and Niendam et al. [46] demonstrate how EMA can be used to monitor symptoms and functioning in the context of an early intervention service for psychosis.

Mobile devices have also been used to deliver interventions in daily life, an approach termed *ecological momentary intervention* (EMI [57];). This includes simple prompts such as medication reminders to more complex therapeutic messages, which might be tailored based on intervention targets determined within therapy sessions or clinic appointments. The combined use of EMA and EMI has shown promise as tools to promote generalisation of intervention strategies to daily life for psychotic symptoms [55] and emerging psychosis [45], and EMI has been used to support self-management of psychosis [41, 58–61]. Current findings support the feasibility and acceptability of these approaches in psychosis; however, further RCTs are needed to establish efficacy, and their use in early psychosis has been limited.

vA major target of early psychosis intervention is the prevention of relapse. Whilst this is typically achieved when individuals are receiving treatment, research has shown that up to 53% relapse within 3 years of the first episode [62]. In considering ways to maintain access to treatment beyond the limited provision of standard early intervention services, a stepped care approach involving the use of digital technologies has been proposed. Described in Table 1, Alvarez-Jimenez et al. [39] developed an online intervention called HORYZONS, aimed at maintaining the benefits of early intervention beyond the end of treatment. Early results were promising, with a full-scale RCT having been recently completed [40]. Ongoing use of digital interventions such as this may offer an empowering and cost-effective way for individuals to maintain gains post-discharge from early intervention services by self-managing their mental health. A further possibility may be the use of an online or mobile self-management system to monitor and respond to signs of relapse, with preliminary findings showing that people with psychosis are willing and able to do this [53, 63, 64]. Services might use this as a stepped care decision-making tool, with signs of relapse triggering escalated intervention, though ethical considerations regarding access and use of personal data is an ongoing area of concern in this space [65].

Whilst yet to be trialled in early psychosis, the use of virtual reality (VR) has shown promise as a therapeutic medium for delivering psychological interventions for people with psychosis [66]. With this technology, individuals wear a headset

which displays a three-dimensional, interactive environment that they can use to explore and practice therapeutic skills. For example, Freeman et al. [67] found that virtual reality-based cognitive therapy focusing on dropping safety behaviours was effective for reducing persecutory delusions. VR has also been used in psychosis to deliver cognitive remediation (e.g. [68],), exposure therapy (e.g. [69],), skills training (e.g. [70],) and assess cognition (e.g. [71],). A related technology termed augmented reality (AR), whereby computer-generated images are superimposed onto real-world environments, has been used effectively to treat auditory verbal hallucinations [72]. The use of VR and AR as a within-session therapeutic tool to facilitate therapeutic learning may be a powerful and engaging medium for younger people with psychosis, who appear interested in using such environments for this purpose [73].

Enhancing self-management and social functioning through independent use of technology

Technologies which support independent self-management of mental health can empower individuals to lead their own recovery whilst also reducing the need for mental health services. Smartphone apps are particularly promising as they tend to be carried on the person, providing a means of accessing interventions in daily life. A systematic review by Firth and Torous [23] identified five smartphone apps for psychosis that had been evaluated in research. The apps varied in their aims, from symptom monitoring and self-management to promoting physical activity. Although primarily pilot and feasibility studies, findings suggested that overall people with psychosis appear willing and able to use apps safely to achieve a variety of aims, with evidence for improved outcomes. More recently, smartphone apps for early psychosis have been developed and evaluated. The PRIME [42], Actissist [41], Heal Your Mind [43], ACT-DL [45] and +Connect [44] summarised in Table 1 are current examples, with findings showing that they are engaging, acceptable and potentially clinically effective. Online interventions also offer a platform for accessing interventions on demand, including the HORYZONS [39] and MOMENTUM programs [40]. These platforms offer interactive features designed to help people manage symptoms, achieve personal goals and improve social functioning. They have potential to be used independently or in conjunction with services to provide additional support in daily life outside of the clinical context. This offers an opportunity to address the critical challenge of maintaining clinical and social benefits of early intervention services and psychological interventions more broadly [74, 75].

Social media is particularly popular amongst young people with psychosis [26, 27, 32–34] and is a highly rated feature amongst existing digital interventions [39, 40, 44]. Abdel-Baki et al. [27] found that over two thirds of early psychosis service users regularly relied on social networking sites such as Facebook to stay in touch with friends and family, and to engage in group discussions online. This suggests that young people with early psychosis rely on the digital world as a means of social connectedness in the same way as their peers without psychosis [32]. The mobile app evaluated by Lim et al. [44] demonstrated how digital technologies can be used to reduce loneliness. The MOMENTUM program developed by Alvarez-Jimenez et al. [40] was a theory-driven intervention specifically designed to improve social functioning by enhancing self-determination (self-confidence, autonomy, relatedness), self-efficacy and positive emotions with targeted therapeutic content. Given loneliness, social isolation and stigma are commonly experienced

by those with early psychosis [76–78], and social functioning is a strong predictor of long-term outcomes [62], the capacity for digital technologies to facilitate social connections and peer support has become an important focus in digital mental health research. However, individuals vary in preferences for different components, with social networking having potential to be burdensome or unimportant for some. More research is needed to develop tailored interventions which optimise individual preferences.

Enhancing clinical precision through use of technological data

Digital devices are capable of recording large amounts of data from users, which may be used to characterise individual illness profiles and monitor and respond to clinically relevant changes over time. *Digital phenotyping* [79, 80] is a relatively new area of research concerned with the use of technology-based data to characterise mental health conditions and inform tailored intervention. Torous et al. [81] developed a smartphone app which collected passive (e.g. call and messaging logs) and active (e.g. self-reported symptoms) data from users. Patterns in the data were generated into individual digital phenotypes and presented on a web-based system. Clinicians might use such a system to better characterise individual client experiences, inform more personalised and tailored treatments and monitor changes in illness states to aid clinical decision-making. Another study conducted by Ben-Zeev et al. [53] analysed smartphone data to produce personalised digital indicators of relapse in people with psychosis, highlighting the potential of mobile devices to aid relapse prevention. However, many important questions are yet to be answered regarding the use of digital phenotyping, including the reliability of prediction models based on the data and ethical considerations pertaining to the recording and use of personal data [82].

Challenges

Evidence base and quality standards

It is estimated that around 325,000 mobile health apps are currently available across different platforms [83], of which a very small number have sufficient evidence base to reliably use and recommend in routine clinical settings [84, 85]. This discrepancy can be largely attributed to the mismatch between consumer demand and the typical bench-to-bedside timeline of 17 years for medical treatments to become available [86]. The advancement of technology is outpacing research dramatically, and the consequence of this is the proliferation of untested and possibly harmful technologies which are readily accessible by consumers. For this reason, a major research priority in digital mental health has been to establish more rapid and efficient methods of developing, evaluating and implementing technologies [87, 88]. There is also a lack of gold standards for evaluating the quality of existing technology [65, 89], although recent tools have been developed, such as the Mobile Application Rating Scale (uMARS [90•];) and an evaluation framework designed by the American Psychiatric Association [91]. Clinicians and patients might use these tools to navigate available technologies and make informed decisions about their use.

As part of the ongoing establishment of evidence for mental health technologies, research should focus on identifying the therapeutic mechanisms to determine not only *if* these technologies can improve outcomes, but also *how*. Understanding the specific role of technology in driving outcomes will be aided by the use of active control groups matched on the use of technology, controlling for the proposed *digital placebo effect* [92]. Additionally, research should examine the relationship between therapeutic targets and usage of the technology, aiding in the optimisation of features and 'dose'. This was examined by Schlosser et al. [42], who found that the improvements in clinical outcomes following use of the PRIME app were not related to how much participants used it, raising questions about how the intervention worked.

Implementation

Another challenge in digital mental health research has concerned implementation [93–96]. Studies have highlighted difficulties in using digital technologies within routine clinical settings [47, 97], and low rates of user uptake and ongoing engagement are well recognised within the literature [98, 99]. In the context of early psychosis services, staff have expressed concerns regarding inequality in patient access to technology, maintaining professional boundaries, unclear ethical responsibilities, time limitations, the threat of technology replacing face-to-face services and discomfort, distrust or unfamiliarity with technology [35, 100]. To address these issues, some researchers have called for a greater focus on implementation from initial stages of development. For example, Mohr et al. [95] argue that digital interventions may not be effective in real-world settings given current approaches to evaluation. To overcome this, the authors recommend that technologies be developed and evaluated within the clinical setting or context in which is it intended. Hybrid models which blend testing effectiveness along-side implementation simultaneously are optimum for speeding the development of technologies that are likely to be more effective in real-world settings [101]. This requires a more coordinated effort between researchers, service providers and services users, to work together to identify the ways in which technology might fulfil specific needs, rather than simply adapting existing services to digital formats [102].

Privacy and security

A dominant topic within the mental health literature has concerned ethical standards of commercially available technologies, particularly smartphone apps [103•]. Because a large amount of user data can be collected via these apps, a typical business model employed by app companies involves the use of this data for commercial purposes [104]. Privacy of personal data is a major concern amongst app users, which is rational given the quality of privacy policies of most common apps is very poor [105]. The security of data stored online is also not guaranteed, meaning there is an inherent risk when recording any form of personal information in digital form [106]. Given these concerns, there has been some recent movement towards the regulation of health-related technologies to facilitate user protection [89, 106, 107]. Finally, whilst the use of data from smartphone apps and other mobile technologies have obvious

clinical potential, this raises a number of new ethical responsibilities for mental health professionals. Clinicians must ensure that patient preferences about the use of their data are respected and that decisions about the use of technology in their clinical care are informed, uncoerced and may be revised at any time [103•, 108].

Conclusion

This report has provided an overview of the use of digital technologies in early psychosis populations and ways in which they can be used to enhance clinical care for these individuals. Young people represent the dominant demographic of people with early psychosis, and it is clear that they have already adopted digital technology as part of their everyday lives. The opportunity to leverage these technologies to assist with illness self-management, promote recovery and support the delivery of services has been demonstrated within the literature; however, more large-scale studies are clearly needed as well as models of evaluation that take into account the fast pace of technological development and place importance on implementation. Findings are promising, though concerns regarding quality standards, barriers to implementation and ethical implications are an ongoing focus of research.

Compliance with ethics guidelines

Conflict of interest
Imogen H. Bell declares that she has no conflict of interest. Mario Alvarez-Jimenez 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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