Leveraging Personal Technologies in the Treatment of Schizophrenia Spectrum Disorders: A Scoping Review

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Abstract

Background: Digital mental health is a rapidly growing field with an increasing evidence-base due to its potential scalability and potential impacts on access to mental healthcare. As well, in the context of under-funded service systems, leveraging personal technologies to deliver or support specialized service delivery has garnered attention as a feasible means of improving access. Digital health relevance has also improved as technology ownership in individuals with schizophrenia has improved and is comparable to that of the general population. However, less digital health research has been conducted in groups with schizophrenia spectrum disorders (SSDs) compared to other mental health conditions, and overall feasibility, efficacy, and clinical integration remain largely unknown.

Objective: To describe the available literature investigating the use of personal technologies (i.e., phone, computer, tablet, wearables) to deliver or support specialized care for schizophrenia examine opportunities and barriers to integrating this technology into care.

Methods: Given the size of this review, we employed a blended approach from both scoping and systematic reviews. We searched three major databases with search teams related to schizophrenia spectrum disorders, various personal technologies, and intervention outcomes related to recovery. We included studies from the full spectrum of methodologies, from development papers to implementation trials. Methods and reporting follow PRISMA guidelines.

Results: This search resulted in 999 studies, which, through review by at least two reviewers, included 92 publications. Included studies were published in a range of mainly developed countries from 2010-2023. Most examined multi-technology interventions (n=40) or smartphone applications (n=25), followed by SMS text messaging (n=16) and internet-based interventions (n=11). No studies used wearable technology on its own to deliver an intervention. Regarding the stage of research in the field, the largest number of publications were pilot studies (n=32), followed by randomized control trials (RCTs, n=20), secondary analyses (n=16), RCT protocols (n=16), development papers (n=5) and non-randomized/quasi-experimental trials (n=3). Most studies did not report on safety indices (60%) or privacy precautions (70%). Included studies tend to report consistent positive user feedback regarding the useability, acceptability, and satisfaction with technology; however, engagement metrics are highly variable and report mixed outcomes. Further, efficacy at both the pilot and RCT levels report mixed findings on primary outcomes.

Conclusions: Overall, the findings of this review highlight the discrepancy between the high levels of acceptability and useability of these digital interventions, mixed efficacy results, and difficulties with sustained engagement. Authors highlight trends and common patterns that may underscore this observation in the field; however, as this was a scoping review, a more in-depth systematic review or meta-analysis may be required to better understand the trends outlined here. Clinical Trial: NA

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Abstract

Background: Digital mental health is a rapidly growing field with an increasing evidence-base due to its potential scalability and potential impacts on access to mental healthcare. As well, in the context of under-funded service systems, leveraging personal technologies to deliver or support specialized service delivery has garnered attention as a feasible means of improving access. Digital health relevance has also improved as technology ownership in individuals with schizophrenia has improved and is comparable to that of the general population. However, less digital health research has been conducted in groups with schizophrenia spectrum disorders (SSDs) compared to other mental health conditions, and overall feasibility, efficacy, and clinical integration remain largely unknown.

Objective: To describe the available literature investigating the use of personal technologies (i.e., phone, computer, tablet, wearables) to deliver or support specialized care for schizophrenia and examine opportunities and barriers to integrating this technology into care.

Methods: Given the size of this review, we employed a blended approach from both scoping and systematic reviews. We searched three major databases (i.e., PsychINFO, Embase, and Medline) with search teams related to schizophrenia spectrum disorders, various personal technologies, and intervention outcomes related to recovery. Included studies were conducted with individuals experiencing schizophrenia spectrum disorders and leveraged personal technologies (i.e., cellphones, tablets, laptops/computers) to deliver interventions which targeted outcomes related to independent symptom management, symptom and functional recovery or service engagement. A wide range of study designs (i.e., design and development studies, protocols, pilot, non-randomized and randomized trials, and qualitative investigations) were included to ascertain a fulsome understanding of the state of research in this area. Methods and results follow PRISMA guidelines.

Results: This search resulted in 999 studies, which, through review by at least two reviewers, included 92 publications. Included studies were published in a range of mainly developed countries from 2010-2023. Most examined multi-technology interventions (n=40) or smartphone applications (n=25), followed by SMS text messaging (n=16) and internet-based interventions (n=11). No studies used wearable technology on its own to deliver an intervention. Regarding the stage of research in the field, the largest number of publications were pilot studies (n=32), followed by randomized control trials (RCTs, n=20), secondary analyses (n=16), RCT protocols (n=16), development papers (n=5) and non-randomized/quasi-experimental trials (n=3). Most studies did not report on safety indices (60%) or privacy precautions (70%). Included studies tend to report consistent positive user feedback regarding the useability, acceptability, and satisfaction with technology; however, engagement metrics are highly variable and report mixed outcomes. Further, efficacy at both the pilot and RCT levels report mixed findings on primary outcomes.

Discussion: Findings should be interpreted in light of several limitations. Though there was an adequate number of RCTs overall, there was not enough consistency across outcomes, the technology used, or primary aims (i.e., feasibility vs. efficacy) to conduct a meaningful meta-analysis of overall effectiveness. Further, this review is limited to personal technologies and personal mental health recovery. Technologies may be used for other aspects of recovery, comorbid conditions, and with adjacent populated (i.e., for clinicians and caregivers) that were not included here. Overall, the findings of this review highlight the discrepancy between the high levels of acceptability and useability of these digital interventions, mixed efficacy results, and difficulties with sustained engagement. Authors highlight trends and common patterns that may underscore this observation in the field; however, as this was a scoping review, a more in-depth systematic review or meta-analysis

may be required to better understand the trends outlined here.

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Protocol Registration: We were unable to pre-register this review due to COVID restrictions.

Introduction

Research on digital mental healthcare in groups with serious mental illness (SMI), including schizophrenia spectrum disorders (SSDs), has grown slowly compared to other mental health conditions like anxiety and depression.[1], [2] Historically, this has been due to concerns about the ability to afford and use technology (i.e., device ownership, access to the internet and cellular data plans), understand the limitations of the technology (i.e., privacy, crisis planning, digital literacy), and make effective gains from digitally delivered content.

Recent research shows that cellphone and smartphone ownership and internet access are high in SMI populations with and without psychosis, [3], [4] and have shown to be an adequate means of service delivery over the pandemic. Leveraging personal technologies (i.e., laptops, tablets, smartphones, and wearable technologies) has also been framed as a critical measure to address access to specialized mental health care in remote and marginalized populations as access to smartphones and the internet is improving in these populations.[5], [6], [7] Additionally, it has the potential to address barriers to stigma, time, and cost that limit the frequency and duration of available mental healthcare.[8], [9] Given the potential to overcome such significant barriers, experts predict the use of personal technologies to deliver or assist with mental healthcare to continue to grow and hope to capitalize on the burst of enthusiasm brought about by the pandemic.[10], [11], [12]

Though technologically delivered and assisted care is steadily gaining credibility and acceptability among mental healthcare professionals, there remain questions about the efficacy of digital mental healthcare and the safety and limitations of technologically delivered care in SSDs.[13] Research has found that out of the publicly available technology advertised for mental healthcare, only 3% have scientific evidence supporting their use.[14] In schizophrenia and psychosis, a commercial review found that only six publicly available apps out of 700 were supported by scientific evidence, and many contained stigmatizing themes and misinformation.[15]

To this end, it is critical to identify evidence-based digital mental health tools available for use on personal technologies by individuals with SSDs and evaluate the state of research in the field and readiness for implementation. Previous reviews in this area have tended to focus on one technical modality (e.g., mobile applications[16], SMS text messaging[17] or one aspect of recovery (e.g., relapse prevention[18]) but have yet to examine the field collectively across technological platforms, treatment targets, and therapeutic approaches to provide a high-level snapshot of the extant literature.

Current Study. The current study is a scoping review examining the use of personal technologies to deliver digital mental health interventions in the treatment of SSDs. The overarching aim is to examine the state of the existing evidence supporting digital health tools for individuals with SSDs. Specifically, we identify gaps in the literature and explore the next steps for future research as the field moves toward implementation. To this end, we examined studies across stages of research, from development papers to implementation studies, using various types of commonly owned personal technologies that may be used to support clinical outcomes and recovery in populations experiencing SSDs. Personal technologies were chosen as the target technology for this review, as it can be argued that this may be the most efficient way to increase access to specialized information and care for individuals who cannot access traditional care consistently. It is also plausible that personal technologies may be the most accessible and cost-effective technological aid to traditional care.

Methods

Given the complex and broad nature of our research question, our results are presented in alignment with a scoping review methodology focusing on a description of the state of research and identification of key concepts and gaps[19], [20]. Our methods are structured according to PRISMA principles endorsed by the Cochrane Collaboration[21] and the scoping review reporting framework.[22]

Inclusion Criteria. Included studies were published in English, examined the use of digital health tools in populations with SSDs and were published between 2010 and 2023, given the evolution of technology during this period. PICO Principles guided the formulation of the inclusion criteria by using the categories Population, Intervention, and Outcome of Interest (Control Type was not applicable as we included a range of study types; see Table 1 for details). Studies were excluded if no full text was available (e.g., editorials, conference presentations), if not published in English, examined in a population with health challenges other than SSDs (e.g., depression, substance use, physical health conditions, etc.), did not use technology to deliver an intervention, or did not examine clinical targets related to SSDs. We also did not include studies that examined the pivot to virtual care during the COVID-19 pandemic and virtually delivered care more broadly, as the only technological component was video conferencing or telephone delivery of treatment as usual (TAU). Included studies sought to enhance the delivery of treatment as usual (i.e., technologically-supported TAU) or deliver adjunct interventions (i.e., interventions not included in TAU).

Table 1: Study Inclusion Criteria Following PICO

Population Diagnosis	Type of Technology	Outcome Target	Study Methodology
• Schizophrenia • Schizophreniform • Schizoaffective • Psychotic Disorder Not Otherwise Specified • Psychosis	• Mobile Applications • Text Messaging • Web-Based • Video Conferencing • Wearables • Blended Interventions	• Symptoms • Functioning • Service Engagement • Illness-Management	• Randomized Controlled Trials • Pilot Trials • Qualitative Studies • Feasibility Studies • Protocol Papers

Search Strategy. Three core databases were searched: PsychINFO, Embase, and Medline. Additionally, Cochrane and PROSPERO databases were searched for existing reviews and protocols. References of resulting included studies were hand-searched.

Search strategies used for general databases:

a. Population: Psychosis OR Schizophrenia OR Schizoaffective OR Schizophrenia Spectrum OR Psychotic Disorders OR First-Episode Psychosis OR Early-Episode Psychosis
b. Intervention: SMS OR Short Message Service OR SMS-Survey OR Texting OR Text Message OR SMS Based System OR SMS Reminder OR Text Message Reminder OR Digital Health OR Telehealth OR Mobile Apps OR Mobile Applications OR Mobile Health OR eHealth OR mHealth OR Wearable Technology

Search strategies used for databases powered by OVID: schizophrenia spectrum.mp. OR psychotic disorder.mp. OR exp psychosis/ AND (sms or short messag* service* or texting or text messag*).mp. OR (mobile apps* or smartphone app* or telehealth) OR (eHealth or mHealth or mobile health or internet intervention or web-based treatment or web-based intervention or wearabl*).mp.

Reviewer Protocol. Studies resulting from the initial search were exported into a reference manager (EndNote)[23], where the initial de-duplication occurred and then transferred into an online review management system where the system again identified duplicates (Covidence).[24] This platform also allowed for the independent review of each study for inclusion. Authors (JD, MI, LT, AZ, TA) conducted the review for eligibility using the title, abstract, followed by a full text review. Review conflicts were reviewed by the first author (JD) and team and, if needed, by the last authors (SK and GF). At least two reviewers reviewed each publication at each stage.

Data Extraction. Authors (JD, MI, LT, AZ, TA) were responsible for data extraction. One author extracted data from each manuscript and was cross-checked by another author. Discrepancies were brought to the larger team to determine the appropriate data to be extracted. Both qualitative and quantitative data were extracted from the included studies. First, methodological information was collected, including research design and publication type, sample size, diagnostic group, length of study and outcome measures. Second, intervention information was collected on the digital intervention target, the type of technology used, the evidence-based approach used, and the length of the intervention. Third, study outcome data were extracted, including qualitative/descriptive and quantitative data regarding primary outcome(s). Both qualitative and quantitative data are reported descriptively.

Analysis. The reported results are descriptive, in line with scoping review methods and provide a high-level overview of key findings. Extracted data is charted according to the type of technology used, followed by subcategories regarding the stage of research (e.g., development, pilot feasibility/efficacy, effectiveness and implementation trials), themes, and issues uncovered through data synthesis. Of note, we distinguish between blended care and multi-technological interventions. Blended care is defined as integrating technology into traditionally delivered care (i.e., in-person) [25]; whereas we define multi-technology interventions as utilizing more than one technological platform and may be integrated with traditional or virtual care. Further, given the large number of included studies, findings report on primary outcomes. A more detailed review would be required to investigate secondary and tertiary findings. Primary outcomes pertaining to feasibility use highly varied measures; thus, we provided a high-level description of outcomes. For a detailed understanding of feasibility, see the original citation.

Results

[Figure 1 to go here]

Our search yielded 999 studies, of which, through careful review, 92 studies were included (see Figure 1 for details of the search exclusion) investigating approximately 50 unique interventions. It is difficult to know the exact number of unique interventions as this is not always clearly reported. Included studies were published in a range of countries, predominately in North America (n= 40), Europe (n= 33), Australia (n=13), and East Asia (n= 7). Studies were published from 2010 until 2023, with the majority published between 2018-2020 (n=50, see Figure 2).

[Figure 2 to go here]

We primarily examined results through the intersecting lens of technology type and stage of research (i.e., study design and aim). In terms of the type of technologies used to deliver the interventions in the included studies, there are 11 articles examining web/internet-based interventions, 25 articles examining smartphone applications, 16 articles examining short message service (SMS)-text messaging, and 40 used multiple types of technology to form the intervention. No included studies used wearable technology to deliver an intervention. Studies included here that utilized video conferencing/phone calls did so in combination with other types of technologies and are thus counted under multi-technology interventions.

Regarding the stage of the included research, there are five qualitative studies investigating development and patient experiences, 32 pilot trials (26 open trials and 6 RCTs), 13 protocol papers, 23 conducted RCTs, 16 secondary analyses (both quantitative and qualitative), three non-randomized trials, and no implementation trials. Given the number of secondary analyses, it is important to note the number of unique technologies being studied (n≈50) to reflect a potentially more accurate picture of the spread of digital mental health that is leveraging personal technologies in this population. Several unique technologies (n=19/50) are investigated in more than one publication, multiple with published protocols suggesting ongoing investigations using these interventions. Contextually, it is important to note that all included trials recruited from mental healthcare clinics and institutions providing traditional (in-person) care, and as such, all interventions included in this study can be considered blended or integrated to varying degrees with traditional care.

[Figure 3 to go here]

Overall Feasibility

Factors of feasibility in included studies vary, such as measures of acceptability, usability, technology engagement, and user feedback. The vast majority of included studies report high levels of acceptability and useability. Technology and user feedback are mixed and reveal several high-level themes. First, technology engagement tends to decrease over time regardless of technology type. Second, many studies report self-reflection and therapeutic rapport as positive features of using these technologies. Third, various types of prompts were used with varying success to enhance engagement.

Safety and Privacy Outcomes. Across all technologies and all study designs, 60% (n=55) did not report on any safety indices at all. The most common indicator (n=31) of safety used was reporting serious adverse events (SAE) and adverse events (AE). Most reported that no SAE/AE's were related to the technological intervention, and if there were any present, gave a short description of the SAE/AE. Further, the vast majority of the studies (n=64, 70%) did not comment on the privacy measures taken by the study team or built into the technology used to deliver the intervention.

Overall Efficacy

In examining original (i.e., not secondary analyses) randomized control trials with efficacy as a primary outcome (16 RCTs, one pilot study; outlined in Table 2). Regarding methodology, most RCTs use TAU (n=10) as their comparison group, with others using varying active comparisons, including phone calls, films, sham apps, and other therapies. RCTs most commonly reported using single-blind designs (n=7); however, two were double-blinded, and eight did not use blinding procedures for their assessors or participants. Approximately 52% (n=9) of trials show a positive change (i.e., improvement in target) over the course of the intervention in favour of the technology, with another showing positive change in one primary outcome but not both [26] and another showing no overall change but a change in the positive symptom subscale scores. [27] Compared to the control, 47% (n=8) show significant group differences in their primary outcome, with the same two studies reporting significant group differences in part of their primary outcomes. [26], [27] Only four studies reported effect sizes, with 3 being interpretable as medium to high and one as low. [28], [29], [30], [31] The type of effect sizes reported were inconsistent across studies and thus were interpreted as low, moderate, and high based on suggested interpretation guidelines for each type of effect size to aid in comparison. A more detailed examination of efficacy, which includes all study types with primary efficacy outcomes, can be found in the sections below.

Detailed results are outlined below and focus on the stage of research and notable results. Key gaps and future directions are explored in the discussion. A summary of the included studies can be found in the Supplemental Files (S1).

Multiple-Technology Interventions

The largest proportion (n=40) of the included studies investigated interventions that leveraged multiple types of personal technologies. Multiple distinct personal technologies within one intervention were identified if (1) they served distinct purposes or (2) two distinct modes of communication/intervention delivery. For example, an ecological momentary assessment (EMA) approach embedded with a mobile application would be considered two distinct technologies as an EMA collects information, whereas the mobile application shares information. In contrast, an addition of modules to an already existing web platform serves the same purpose as the original web platform and would count as one technology. Most commonly, interventions combined the use of a smartphone application and a webpage that could be accessed by either a clinician or peer support,[29], [32], [33], [34], [35], [36], [37], [38], [39], [40] with some additionally combined with targeted in-person intervention sessions.[33], [41] Other technology combinations included smartphone applications to deliver resources with added ecological momentary assessment and intervention (EMA/I) approaches (i.e., using EMA technology to both collect information and deliver an intervention such as skill prompts)[42] plus a webpage[43] or wearable technology[44] to help users self-manage their mental health. Other combinations still included using a smartphone application and/or webpage in combination with communication technology like SMS text-messaging,[29], [45], [46] phone calls, video conferencing[47] and email.[48] Lastly, two interventions engage various communication strategies such as SMS-text messaging and phone calls,[49], [50] and a smartphone app, SMS-text messaging, and telemedicine.[51]

Table 2. Included Original Randomized Control Trials with Primary Efficacy Outcomes

Note: RCT = Randomized Control Trial, SZ = Schizophrenia, SZA = Schizoaffective Disorder, BD = Bipolar Disorder, MDD = Major Depressive Disorder, SSDs = Schizophrenia Spectrum Disorder, FEP = First Episode Psychosis, TAU = treatment as usual, NR = not reported, NA = not applicable.

Research investigating interventions leveraging multiple personal technologies included two development papers,[52], [53] fourteen pilot studies,[46], [54], [55], [56], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66] six RCT protocols,[41], [67], [68], [69], [70], [71] eight RCTs, [29], [72], [73], [74], [75], [76], [77], [78], [79], [80] nine secondary analyses,[72], [73], [74], [75], [76], [81] and one non-randomized trial.[82] Targets of the muti-technology interventions included illness self-management (n=5),[32], [44], [53], [83], [84] relapse prevention (n=3), [37], [39], [82] medication adherence (n=2),[43], [49] general symptom severity (n=2),[29], [38], [40] social functioning (n=1),[51] motivation (n=1),[45] coping with auditory hallucinations(n=1),[42] negative symptoms (n=1), [46] and cognitive function (n=1).[85] Evidence-based approaches are reported by 13 of these interventions, including CBT (n=3), peer support (n=1), cognitive remediation (n=1), Information Motivation Behavioural (IMB) skills (n=1), Connectedness, Hope and Optimism, Identity, Meaning, Empowerment (CHIME) (n=1), Social Cognitive Theory (SCT) (n=1), and mixed approaches (n=6). For all studies (n=29) that investigated any of the 15 multi-technology studies, the trial lengths ranged from 1 visit to 60 months, with a mode of 3 months.

Feasibility. Studies (n=23) investigating feasibility-related variables as the primary outcome report varying measures of engagement, including study retention, intervention retention, and various means of measuring technology engagement (e.g., number of logins per time period, number of tasks completed, number of responses, etc.). Regarding study retention, included studies report good retention rates of 78-100%. [28], [54] However, technology/intervention retention tended to decrease over time and was 42-52% at the end of the intervention periods. [54], [60] Technology use over time also tended to decrease over time regardless of the measurement. [28], [54], [60] Despite this, studies report high levels of response/completion throughout the study period (70-84%). [55], [56], [58], [59] One study reported a relatively low response rate (22%); however, this represented a homework completion rate of at least once per week. [46] Another study reported on clinician engagement with the connected clinician portal (67% login rate), which was much lower than patient engagement (80% response rate). [59] Some studies reported on factors impacting intervention engagement, which included low mood/depression, [72], [73] negative symptoms and low motivation, [73] and fluctuations in wellness. [76] Technological factors were also reported to impact engagement. Specifically, ease of navigation, accessibility of resources, the fit of technology [73], [76] and concerns regarding privacy [74] impacted engagement, whereas coaching facilitated engagement [55], [77] as long as it didn't feel too scripted. [55] Overall, patients tended to endorse the technologies as easy to use, helpful, and were satisfied with the technology/interested in continued use. [54], [55], [58], [59], [86]

Of note, seven feasibility studies focused on one intervention [53], [62], [64], [65], [66], [79], [87] in varying populations (i.e., psychotic and mood disorders), in different contexts (i.e., outpatient, assertive community treatment, VA hospital), with different comparison groups and augmentations (i.e., the addition of video content, phone calls from interventionists). Throughout these studies, participants and clinicians rate the acceptability and useability of the intervention as high. Participants could access the app at any time, and the app sent out prompts and phone calls to support app engagement. Participants responded to the majority of prompts (64-67%) [65], [66] and phone calls (94%) from the mobile case manager/interventionist.[66] Despite this, patient app engagement over time declined in the studies that measured use over time [64], [65] but reported better engagement over time compared to an in-person group. [65] One study reported on cost-effectiveness and found that the technologically supported intervention was significantly less costly with no significant differences in efficacy compared to a fully clinician-delivered intervention. [80]

Efficacy. Studies examining the efficacy of multi-technology interventions as a primary outcome (n=10). [29], [40], [50], [61], [75], [81], [82], [88], [89], [90] The included studies reported mixed findings across a wide range of specific outcomes. One study examining self-guided CBT did not report an overall significant difference in symptom severity compared to TAU. [29] Another study investigating technology-assisted, clinician-delivered CBT for paranoid thinking found that the intervention significantly reduced paranoia across three measures at the end of a three-month intervention compared to TAU. [89] Studies investigating social-cognitive-functional domains reported significant impacts on aspects of global cognition, attention, [28] motivated behaviours (i.e., anticipatory pleasure, improved effort expenditure for future social interaction), [88] improvements in affective symptoms, [40] the identification of correct answers and cognitive fatigue, [75] and social functioning. [61] A smartphone application paired with a clinician portal alert system (i.e., alerts are prompted when there is a concerning change in symptoms, functioning, or engagement that suggests the need for clinician intervention) reported significant reductions in relapse, rates of hospitalization and urgent care needs. [82] An intervention comprised of biweekly clinician phone calls and weekly SMS check-ins showed improvements in medication adherence compared to controls [90] ; however, did not show improvements in other areas such as global functioning or quality of life. [50]

Smartphone Applications

Research investigating the use of smartphone applications included 25 unique publications, of which two were development papers, [91], [92] eight were pilot studies, [91], [93], [94], [95], [96], [97], [98], [99] one non-randomized study, [100] six protocol papers for RCTs, [101], [102], [103], [104], [105], [106] three were RCTs, [30], [107], [108] and five secondary analyses. [109], [110], [111], [112], [113] The average length of interventions is four months (range = 1 visit to 12 months, mode = three months, 12 months). The pilot feasibility studies tend to be 1-2 months, pilot efficacy trials 2-6 months, and randomized trials 3 or 12 months, including protocols. Sample size within trials is also highly variable (mean = 41.65, median = 31, range = 8–229).

The majority of the included smartphone interventions are positioned as adjunctive to traditional, clinician-delivered mental healthcare or TAU and typically function to deliver specialized information to individuals via there smartphones to extend clinical resources beyond the clinic to be accessible in real time. Targets of included smartphone interventions include illness self-management,[91], [95], [103], [107] medication adherence,[30] symptom severity, [96], [101], [105], [108] including specific domains such as auditory hallucinations, [99], [106] social skills, [94], [97] and metacognition (i.e., improved awareness and understanding of one's own thought processes). [100] Most applications report evidence-based foundations therapeutic approaches, most commonly Cognitive Behavioural Therapy (CBT, n=7), [91], [93], [96], [98], [99], [105] followed by Social Skills Training (SST, n=1), [92], Positive Psychology (PP, n=1), [97] and Acceptance and Commitment Therapy (ACT, N=1), [108] Metacognitive Intervention for Schizophrenia (MSI-S, n=1)[100] or report mixed approaches (n=3). [103], [107] However, some (n=3) [30], [95], [106] do not report following a specific evidence-based approach or omit this information. Two were specifically blended with in-person care. [99], [108] Smartphone interventions typically have features based on the aforementioned evidenced-based approaches, such as instructions on how to use skills, tracking symptoms, treatment engagement and goals, and other psychoeducational resources.

Feasibility. There were twelve studies that reported primary outcomes related to the feasibility of apps. [93], [95], [96], [97], [98], [99], [107], [108], [109], [110], [111], [112] All studies report high levels of acceptability, useability and satisfaction. Studies using a prompt or EMA system reported medium to high response rates of 33-81%. [99], [108], [109] Studies reporting on task/module completion also reported medium to high completion rates of 42-95%. [93], [96], [97], [108] Two studies reported that engagement with apps decreased over time, [107], [110] one of which study reported that 50% stopped using the app within three months. [107] Facilitators of app engagement were functions allowing synchronous communication with clinicians, [96] integration of face-to-face sessions, [112] stronger therapeutic alliance, [110] whereas barriers to engagement were lack of clinician support using the app, concerns regarding therapy, [107] feeling the app wasn't personable, or there were too many sessions/prompts. [96], [98] Some studies found participant factors associated with app engagement, such as age, employment status, race, and smartphone ownership. [109], [110]

Efficacy. Four studies examined the efficacy of interventions delivered via smartphone applications. [30], [94], [100], [114] One study examined apps delivering self-guided CBT.[114] Regarding overall symptom severity, a pilot study found significant changes across recovery and symptom outcomes. [114] Another pilot study examined the delivery of self-guided social skills training and found a moderate impact on social functioning at the end of the intervention; however, it found that gains were not maintained at a 3-month follow-up. [94] A non-randomized control comparison study found that a smartphone-delivered metacognitive therapy augmented by weekly mentoring sessions found positive impacts on metacognition, delusions, general pathology, and negative symptoms. [100] Lastly, an RCT examined the effect of medication reminders sent through a smartphone app and reported that compared to TAU, those receiving reminders showed significantly better medication adherence, with large effect sizes reported. [30]

SMS Text Messaging

In this review, 16 studies were included in which an intervention using SMS text messaging was investigated. Of the 16 papers, one was a development paper, [115] two were protocol papers, [116], [117] four were pilot trials (i.e., two were open trials[118], [119] and two were pilot RCTs [120], [121]), six were RCTs, [26], [27], [31], [122], [123], [124] and three were secondary analyses. [125], [126], [127] No implementation studies were found. The sample sizes varied greatly between 14 and 1139 (mean=181, SD=274.7, median 59); however, most were under 100 participants (n=10). The length of the intervention varied from 1 to 18 months, with a mean of four months and a mode of six months.

Interventions using SMS text messaging targeted a variety of outcomes, mainly in the form of reminders, such as medication adherence (n=4),[26], [31], [119], [122] appointment attendance (n=1),[116] and relapse and rehospitalization rates (n=1).[27] Beyond service engagement, some studies aimed to support clinical outcomes such as auditory hallucinations,[119] social skills,[119] goal attainment, [123] and general support.[118], [120], [124], [125] Most SMS-based interventions were framed as adjunctive care, and only one was intentionally blended with traditional care. [120] The majority of SMS-based interventions did not report to follow a specific evidence-based approach. One intervention was based on CBT[119] and another on Self-Determination Theory[124].

Feasibility. Five studies report on feasibility as the primary outcome. Studies report high text-message response rates (69-87%), [118], [120], [121], and high levels of satisfaction, ease of use, and helpfulness of SMS text messages. [120], [121], [127] One study even found that therapeutic alliance was higher with the SMS text message interventionists compared to participants' community-based clinicians. [118] Another study explored areas that participants found useful to discuss with SMS text message interventionists, including mental health symptoms, coping strategies, lifestyle/well-being, social/leisure activity, motivation, and independent living skills. [126]

Efficacy. The reported efficacy of SMS text messaging interventions seems to vary depending on the outcomes measured. Most studies investigating SMS interventions aimed at medication adherence are associated with greater rates of adherence[31], [122], [125], [128], especially among individuals with schizophrenia who were living independently.[128] Effects on medication adherence may be bolstered by the addition of phone check-ins by clinicians.[129] However, drop-off effects may occur once the reminders are no longer delivered [130]. Medication adherence is measured using objective measures (i.e., pill counts) in three studies [31], [125], [129] and is self-reported in the other three. [122], [128], [130] It should be noted that both these means of measurement are susceptible to potential social desirability bias and should be interpreted with this in mind. Additionally, there seem to be potential positive effects on re-hospitalization rates[31]; however, results are mixed as other researchers did not find evidence of a reduction in hospital admission rates, the time between hospitalizations, or time spent in a psychiatric hospital[131]. Regarding changes in recovery and symptom severity, some studies reported improvements in negative symptoms, positive symptoms [27], cognition, and global clinical symptoms. [132] These results were strengthened when the text-messaging intervention was coupled with a secondary intervention (e.g., telephone intervention or assertive community treatment). [120], [129] Other researchers did not find significant improvements in symptom severity[131]. Mixed outcomes are reported for social and community functioning. [121], [125], [133] Studies report mixed findings regarding service engagement. One study reported improved therapeutic alliance with their mobile clinician compared to in-person, and participant feedback results reflect a sense of support among users when receiving daily messages.[126], [134]

Internet-Based Interventions

Eleven of the included papers described independent internet-based interventions (i.e., not paired with other technology). Of these, one was a cross-sectional study,[135] five were pilot trials, [136], [137], [138], [139], [140] two were RCT protocols, [141], [142] two were RCTs, [143], [144] and one was a secondary analysis. [145] The sample size of included studies examining internet-based interventions ranged from 10-300, with approximately 50% being over 100 (M= 97). The length of the intervention ranged from two to 26 months (M = 9, mode = 2, 18). Of the internet-based interventions included treatment targets included recovery, [137], [141] cognition, [138], [140] working memory, [139] symptom severity [143], [144] and illness self-management.[135] Most studies investigating internet-based interventions reported to be based on an evidence-based framework, including CHIME, [137] cognitive remediation, [138], [139], [140] CBT, [144] peer support, [143] and mixed approaches. [141] Like smartphone interventions, internet-based interventions aim to extend access to specialized clinical resources beyond in-person care through the delivery of written, video, or audio modules containing psychoeducation, skills and other resources consistent with the evidence-based approach being utilized.

Feasibility. Studies examining the feasibility of internet-based interventions (n=6) included varied measures of feasibility and engagement. Study attrition was reported between 64-100%. [136], [138], [140], [142] Given the range of interventions delivered, intervention engagement was measured differently in each study; one reported the number of logins (e.g., mean = 39.2 over the intervention),[136] one reported the mean time spent on the website per week (e.g., 3hrs/week),[138] another reported percent of participants completing at least 80% of modules according to a predetermined meaningful completion rate (e.g., 70% of participants completed 80% of modules),[140] and one reported the percent of participants that used the website (e.g., 41% of participants used the website). [135] Two studies found that participant factors impacted engagement, such that younger age, [135], [138] higher education, [135] being employed, [135] and lower cognitive symptoms [138] led to better engagement.

One study specifically reported on integrating a website into regular therapy sessions and found that the website was used in 95% of therapy sessions. [142] Qualitative feedback related to the use in sessions included that the website helped facilitate conversation and reflection in their sessions and was a key tool for engagement, leading to increased perceived recovery. [142] However, only 60% of participants reported use outside of sessions. [142] Another study presented findings related to a self-guided website [145] and found that the self-guided nature to some was motivating and cultivated a sense of autonomy in recovery, whereas others found the self-guided nature overwhelming, which interrupted engagement. Positive aspects reported related to the self-guided website were having at-demand resources more so than any clinician-driven service, having the means to distract from distress in a meaningful, positive way, and having the ability to interact with peers and psychoeducation was a normalizing experience. [145]

Efficacy. There were three included studies that reported primary outcomes pertaining to the efficacy of internet-based interventions. [139], [143], [144] Each of these interventions focussed on different evidence-based approaches. One study examined the impact of online peer support (i.e., comparing anonymous listserv group email communication or communication with peers via online bulletin board compared to TAU) on subjective recovery, quality of life, empowerment, and social support. [143] No significant group differences were found with regard to online peer support and the control group for either the listserv or bulletin board communication types. [143] Another investigated remote cognitive remediation (i.e., online computerized tasks, psychoeducation, and strategy development paired with weekly clinician calls) targeting working memory. [139] Compared to TAU, remote cognitive remediation was associated with improved working and episodic memory, with medium effect sizes reported.

[139] Lastly, another study looked at the effects of self-guided CBT for psychosis on various psychotic symptoms compared to a waitlist condition. [144] Individuals receiving self-guided CBT for psychosis demonstrated greater improvements in symptoms overall and self-reported hallucinations compared to the waitlist condition, with a small to medium effect size reported. [144] However, did not find significant differences in other positive psychotic symptoms. [144]

Discussion

The primary aim of this review was to provide a high-level overview of the use of personal technologies in research on digital mental health interventions for individuals with SSDs. Publication trends show rapid growth in the area over the past 5-7 years, highlighting increasing interest in this area[10], [11], [12]. The lower number of publications reported for 2021-2023 is likely partly attributable to a combination of the large number of protocols published in 2020, as many of these trials may still be underway, and research challenges related to the pandemic. Personal technologies leveraged most often included the use of smartphone applications or an application in combination with other technology, such as a clinician web portal.

Our review confirms that various technologies have already garnered acceptance among individuals with SSDs, as evidenced by consistently high ratings of acceptability, useability, and satisfaction. Some studies even report that augmenting care with technology improved engagement in traditional in-person/remote care.[73], [126], [134] Participants typically report that these technologies facilitate self-reflection and understanding, better communication with their clinical teams, improved access to evidence-based resources, and support in times of need. Findings related to feasibility presented in this review are similar to findings reported elsewhere for groups with serious mental illness. [146]

Despite high levels of acceptance and interest, sustained engagement in technological interventions is an ongoing concern [147] and is not well understood. Measures of engagement are highly inconsistent across studies, including module completion, response rates, skills and homework completion, number of posts, etc., making it almost impossible to understand a cohesive story regarding engagement with digital tools in groups with SSDs. While simple metrics like screen clicks or the number of days/hours used are commonly reported, this metric lacks an understanding of clinically meaningful engagement. [148] Beyond access metrics, there is no consistent measure of technology use. The challenge of heterogeneity in engagement metrics is already well-known [149], but a lack of progress in agreement around these common metrics hinders future advances in the field. [150] Further, likely in part owing to a lack of definition in this area, means of addressing technology disengagement are also poorly understood. A review examining the use of persuasive system design (PSD; design features designed to address/enhance engagement) in technologies designed for use in depression and anxiety reported that PSD efforts did not systematically lead to improved engagement but are associated with improved efficacy. [151]

Moreover, some ongoing challenges may impact the feasibility of using such technologies in practice, including understanding the link between privacy protections embedded in these technologies and meaningful engagement. Privacy concerns are seldom outlined in the included publications, which may result from the dearth of available guidelines, policies, and reporting standards. Privacy concerns are often cited by healthcare providers as a key barrier to the use of technology in practice[152], and as such, to encourage technological adoption, more data on privacy features needs to be made available. There is also a dearth of information regarding patient safety and urgent/crisis resources and support. In the current review, the majority (60%) of included studies did not touch on safety at all, which is well above the proportions reported across the field of digital mental health (35%). [153] The most common safety indicators reported in the current review and reported across the field [153] were serious and other adverse events, which are often mandatory reporting standards for ethics boards and do not provide nuanced information regarding technology use and patient wellbeing.

Further, there are promising early results regarding efficacy, but overall findings are mixed. Pilot studies tend to show more optimistic outcomes across a range of mental health outcomes; however, once studies reach the RCT phase, findings become more mixed. Similar observations have been made in other areas of serious mental illness, such as bipolar disorder. [154] Evidence for the efficacy of digital mental health interventions is stronger in broader diagnostic domains such as depression and anxiety. [155] Considering methods, the findings of this review are consistent with general clinical methods commentary, noting that pilots tend to show better outcomes [156] and are focused on the feasibility and perceived usefulness of the intervention. This observation about pilot studies likely occurs as a function of their design (i.e., no control and/or small sample), as well as the setting in which research is conducted. In the present review, participants were recruited from treatment facilities and, therefore, had already received and likely were actively receiving other forms of treatment during the trials. Moreover, even if control groups are used, pilot studies contain smaller sample sizes, which have sampling bias implications and create conditions where they may receive greater research support than larger RCTs. The pragmatic implications of formal digital health RCTs are, however, not without their limitations. While RCTs provide an unbiased estimate of effectiveness in the sample, they often fail to provide an accurate real-world picture of intervention usefulness.[157] This highlights the benefits of consideration for both study designs, as well as the need for more implementation-focused trial designs.

In the included RCTs, it does not appear that study procedures such as blinding, type of technology, or sample size systematically impact outcomes, as no obvious patterns have emerged between study type/methodology. Still, with few studies featuring an active control group, any assessment of efficacy is still preliminary. Future studies should consider the active intervention when planning a control group and the purpose of the technology (e.g., if testing an evidence-based treatment that is typically delivered in person and not included in TAU, then TAU would not be an active control group, an in-person service delivering the evidence-based treatment would better represent an active control). Yet, there are some included interventions that have garnered significant support and exhibit positive early results. [55], [60], [89], [99], [101], [141]

Of note, all included studies utilized samples of individuals currently in treatment and thus were all offered adjunctly to traditional clinician-delivered care. However, few studies describe how the technology was blended or integrated into the care structure. As such, the field provides little direction on the role of technology and its integration into existing care models. Further, there were few clinical integration/effectiveness studies, underscoring the next frontier for this research in SSDs. Understanding how external-to-technology factors, including primary treatment methods, may impact engagement, efficacy and effectiveness. For example, the included studies that describe the role of technology within the clinical context describe technology-forward (i.e., self-guided, clinician-supported) and clinician-forward (i.e., clinician-delivered, technology-supported) interventions. Clinician-forward interventions, in our small sample of studies that describe clinical integration, seem to demonstrate better engagement [112] and better outcomes [89], [99], [112] than technology-forward interventions, depending on the target and treatment approach. [29]

Other reviews report mixed findings in relation to blended (technology-supported) approaches. One review and meta-analysis of digital mental health interventions across disorders suggests that technology-supported interventions outperform (g =.16, p= <.0001) traditional TAU (solely clinician-delivered). [158] However, this review did not report on the more nuanced technological differences that we highlight here regarding whether the intervention was delivered by the technology (i.e., technology-forward) or supported clinician-delivered care (i.e., clinician-forward). Another review and meta-analysis suggested that technology engagement was associated with efficacy regardless of intervention type (i.e., guided or unguided) [159], suggesting that engagement may be the underlying mechanism for effectiveness in these trials rather than the level of clinician involvement. Thus, more research is needed to define the role of technology within clinical spaces to understand the implementation and best practices related to technology-assisted care.

Future research in this promising area should focus on the identified key gaps to move the field toward implementation readiness. Firstly, studies should clarify the technology's intended role, intervention targets, and functionality. This is important for understanding implementation into existing clinical structures and interpreting study outcomes. Second, given the significant barriers of safety and privacy to clinical adoption, a more detailed exploration of safety and privacy indices is critical. Last, a better understanding of barriers to participating in and disengagement from digital interventions is crucial for understanding its usefulness and scope in clinical settings.

Limitations. There are several limitations to this review. First, as a scoping review, we could not provide a detailed review of each study but rather a high-level examination of the findings in the field to date. Thus, data has been synthesized and presented in accordance with outlined scoping review guidelines, and, as such, the methodological quality of each study was not rigorously reviewed. Second, we limited our search to using personal technologies to deliver or support specialized care for individuals with SSDs. Other technologies are being used in SSD treatment that this review did not include, such as virtual reality, avatar therapy, cognitive remediation, brain stimulation, and more. Third, we restricted this review to outcomes directly related to general recovery (i.e., core symptoms and functioning) and treatment engagement and did not focus on specific domains like cognitive deficits. Fourth, other interventions exist for comorbid conditions such as substance use and smoking cessation[160], physical activity[161], and resources for family and social supports[162]. Lastly, we only included technologies that were used to deliver interventions; we did not include studies that were used to improve the understanding of SSDs, such as observational methods like technology-assisted ecological momentary assessment or health services-based interventions like those that are embedded in electronic medical records for purposes such as medication algorithms, symptom-monitoring or other purposes. Future reviews may consider focusing on these additional areas of digital mental health to understand how other technologies may support the recovery of individuals with SSD diagnoses.

Conclusion

Overall, using personal technologies to deliver specialized care requires more careful consideration before advocating for broad implementation, highlighting the same challenges as other psychotherapeutic intervention research. Namely, the prolonged time between investigation and implementation is due to varied findings and a lack of cohesive targets and direction. Despite these challenges, as evidenced by this review, there is great promise for leveraging personal technology in mental healthcare to help provide pieces of the holistic care necessary for recovery in SSDs. Multifaceted mental health conditions such as SSDs are highly heterogeneous and may require multifaceted and flexible interventions. Though the exact nature of meaningful technological support is still being discovered, the studies in this review overwhelmingly demonstrate how flexibly personal technologies can support recovery from medication adherence to potentially delivering complex psychosocial interventions like CBT. Further, studies clearly demonstrate the feasibility of personal technologies to extend access to specialized information beyond traditional care and into everyday life. Thus, these technologies are well-suited to be integrated into existing specialty care structures for individuals with SSD diagnoses.

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7500(22)00031-0.

Supplementary Files

Figures

Describes the review process that determined the included and excluded studies. The abbreviation “SSDs” refers to schizophrenia spectrum disorders.

Figure 1: PRISMA Breakdown of Search Results

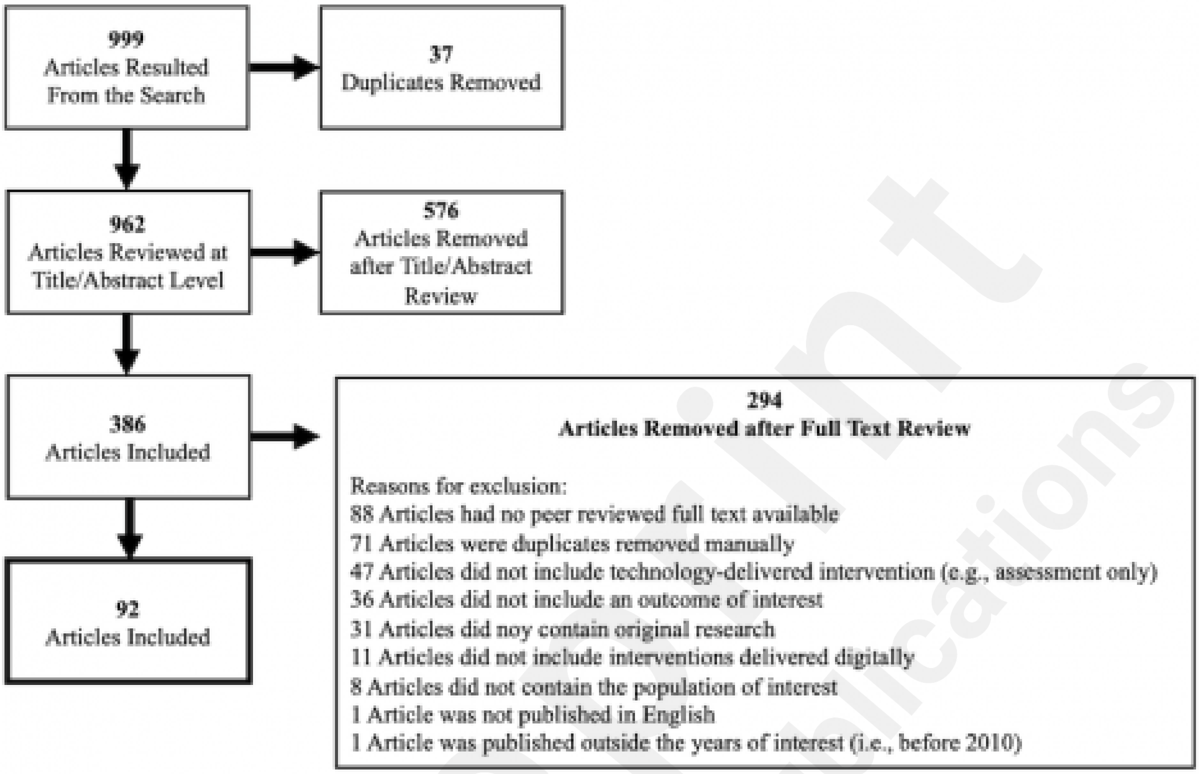
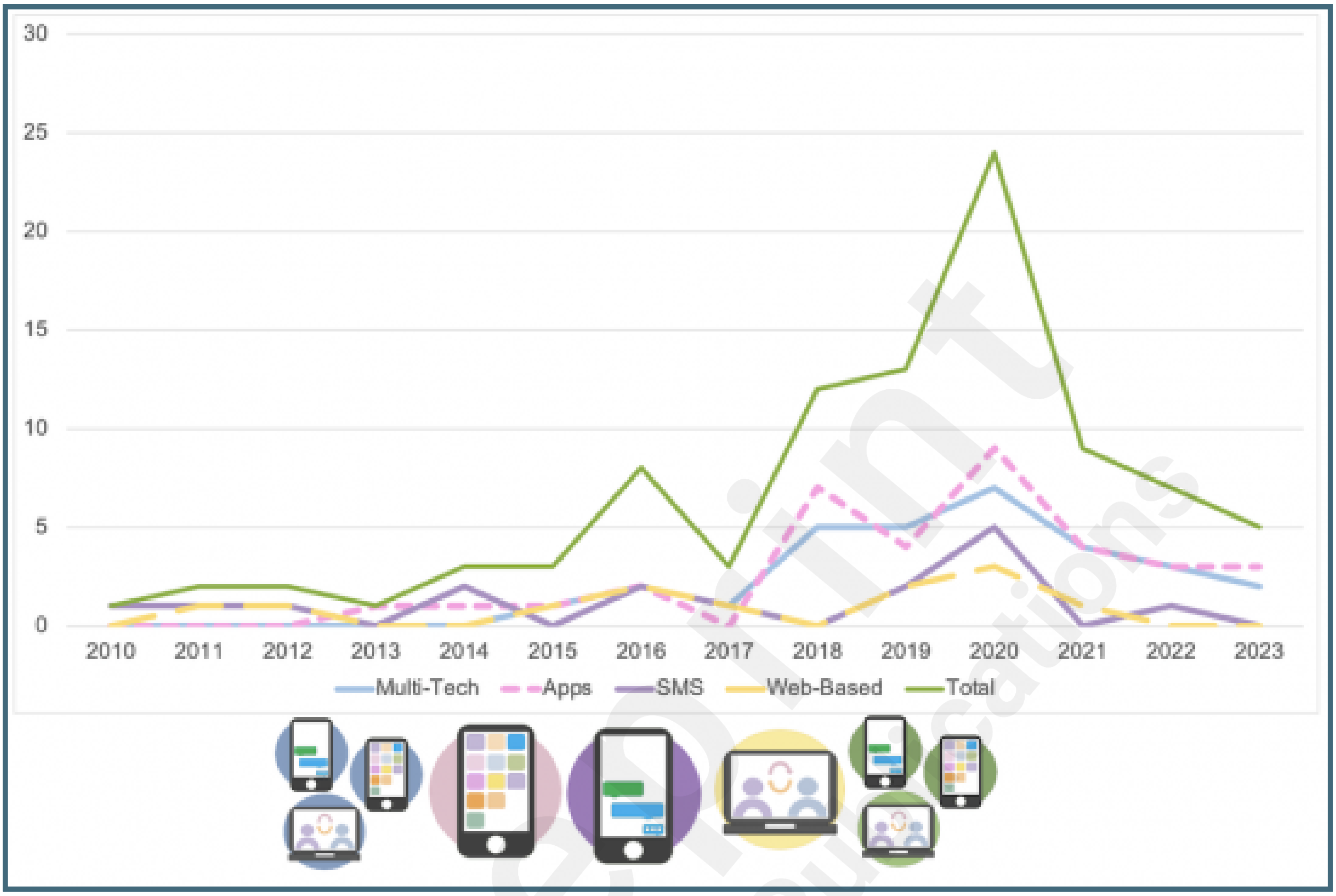
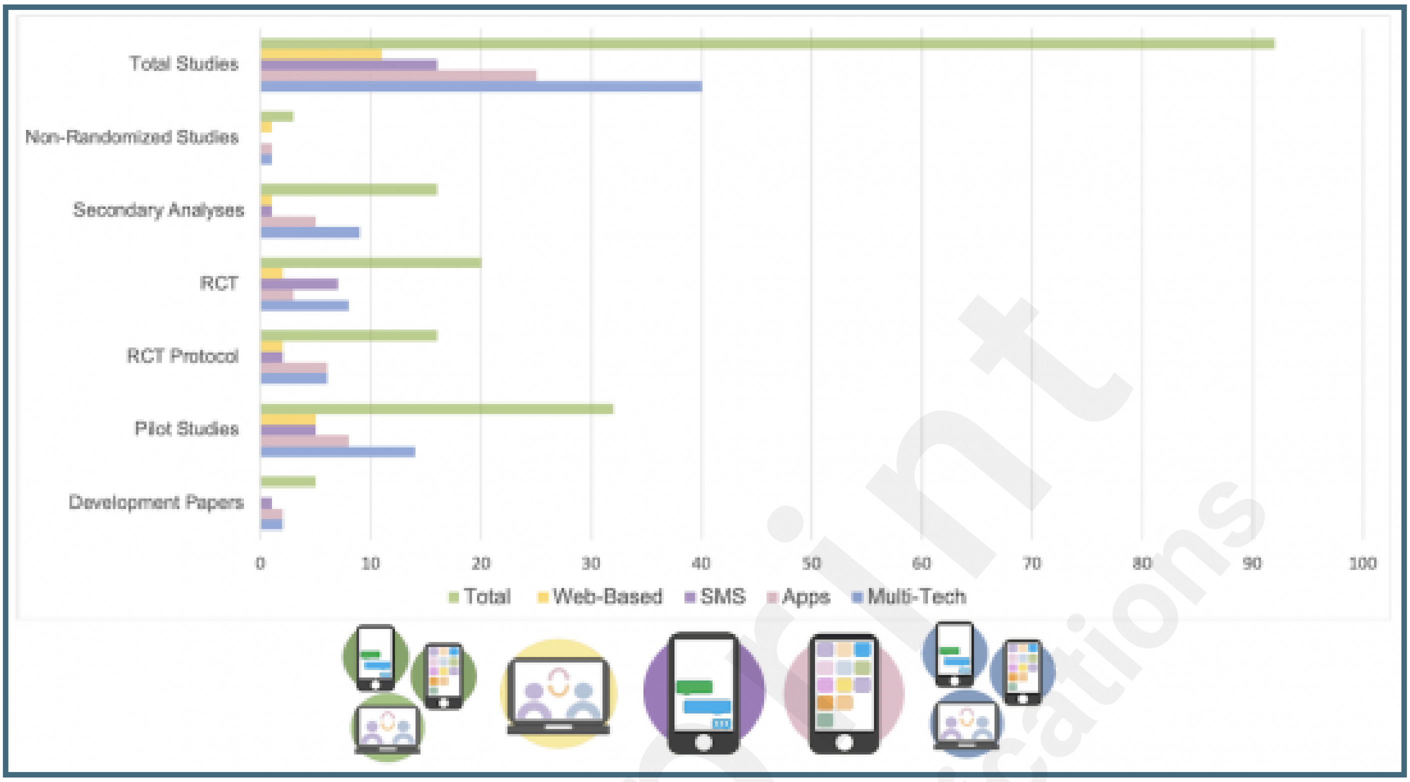


Figure 1. Describes the review process that determined the included and excluded studies. The abbreviation “SSDs” refers to schizophrenia spectrum disorders.

Number of publications over time by technological modality.



Stage of research of publications by technological modality.



Multimedia Appendixes

Supplemental table of included studies divided by technology type (n=92).
URL: http://asset.jmir.pub/assets/06a1115d88e578e154ff7aef30d4a42c.docx

CONSORT (or other) checklists

PRISMA-ScR checklist.
URL: http://asset.jmir.pub/assets/d0d81b651efdc78d57853e3548500fe3.pdf