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The use and effectiveness of telehealth to support the management of severe mental

illness: A systematic review

Abstract

Background: It is important that people with SMI receive early interventions to prevent mental health deterioration or relapse. Telecommunications and other technologies are increasingly used to assist healthcare delivery ('telehealth'), providing service users with immediate real-time information to improve the management of chronic health conditions. Telehealth has been found to be successful in improving management and symptoms across a number of health conditions, whilst also being acceptable to users. Initial findings suggest technology could improve quality of life in people with SMI.

Objectives: This systematic review aimed to identify the variety of uses and efficacy of telehealth technology for SMI.

Methods: We systematically searched electronic databases from inception to March 2016 (MEDLINE, EMBASE, PsycINFO, Cochrane Central Register of Controlled Trials, AMED, Health Technology Assessment, CINAHL plus and NHS EED) for randomised controlled trials (RCTs) evaluating telehealth for adults with SMI, published in English. Additional literature was identified by searching reference lists of key articles. The articles meeting the inclusion criteria were systematically reviewed and assessed for quality and risk of bias.

Results: The search identified 31 eligible articles, describing 29 trials. The included studies evaluated the use of computers to deliver cognitive rehabilitation (15 trials), patient education (3 trials), online self-management interventions (2 trials), and to support consultations (1 trial). Virtual reality (VR) was used to simulate work and social situations (2 trials) and to deliver cognitive training (1 trial). Telephones were used to prompt medication use (3 trials) and report SMI symptoms to healthcare teams (1 trial). Remote sensors were used to monitor medication use (1 trial). Telephone support was found effective for improving medication adherence and reducing symptom severity and inpatient days. Computer assisted cognitive rehabilitation was effective in improving cognitive function. The impact of telehealth on other outcomes was inconsistent. Few studies evaluated the

use of remote medication telemonitoring, VR, online self-management and computer-mediated consultations, suggesting these are novel technologies for managing SMI, although all were found effective for improving psychosocial and behavioural outcomes. The results of this review should be taken in the context of varied quality in study design, with only five studies demonstrating a low risk of bias.

Conclusions: A growing variety of telehealth technologies are used to support SMI. Specific types of technology have been found to be effective for some outcomes, for example telephone prompts for medication adherence, while other types of telehealth had no benefit over traditional methods and were less acceptable to patients. Few studies found benefits for telehealth on quality of life, except for novel technologies with a limited number of trials. Further research is warranted to establish the full potential benefits of telehealth for improving quality of life in SMI, acceptability from the service user perspective, and cost-effectiveness.

Introduction

Telecommunications and other technologies are increasingly being used to assist in healthcare delivery and are collectively known as "telehealth". Telehealth is broadly defined as the use of applications in healthcare including telephones, mobile phones, computers, the internet and audio and video processing to provide service users with immediate real-time information aimed at enhancing the management of their condition or its symptoms [1-3]. Telehealth has been found to be effective for managing a range of long-term conditions, including respiratory and cardiac diseases and diabetes [4-7]. Benefits include reductions in health service use [4-7], including hospitalization and emergency department visits, and improving clinical outcomes [4;7], for example glycemic control in people with diabetes [4]. Some initial evidence also suggests that technology is found to be acceptable by users to support health management, particularly in terms of convenience [8]. While studies measuring the acceptability of using technology to support healthcare are still emerging, a review by Or & Karsh [9] identified specific factors that predict acceptability of telehealth for long-term conditions, including younger age, higher levels of education, prior experience, perceived usefulness and ease of use, and satisfaction [9].

Severe mental illness (SMI) is commonly defined by persistent and extensive functional disability [10] and includes psychotic disorder, schizophrenia, schizoaffective disorder, major depressive disorder and bipolar disorder. Previous systematic reviews have evaluated either the use of one specific type of telehealth, for example telephone prompts to promote appointment attendance [11; 12], or the use of telehealth more broadly in a specific mental illness. Some initial findings suggest technology-based prompts could improve quality of life and SMI symptoms in people with SMI, however the quality of the evidence has been found to be low [12]. Furthermore the review of telephone prompts was published in 2009 and given the rise in use of technology and updated review is due. Two reviews evaluated a range of applications for general mental health, including dementia, child psychiatry, suicide prevention, substance misuse and psychotic disorders [13;14] and

found evidence for benefits to mood, trauma-related symptoms and suicide attempts, and better medication adherence. However, there does not exist a review of the range of available telehealth technologies and their use to support people with SMI. Given the current multitude of available telehealth technologies and the rapid increase in their use, a further review is required to identify the range of uses for telehealth in the context of SMI and whether they lead to increased service user engagement and improved psychological and clinical outcomes across SMIs.

The aims of this review are to: 1. Identify and describe how telehealth interventions for people with SMI have been implemented to date and 2. To synthesise the evidence in relation to the effectiveness or efficacy of available interventions.

Methods

Study eligibility

Studies were selected for inclusion in the review if they met the following criteria:

1. **Types of participants**

Adults aged 18 years or over with SMI defined as psychotic disorder, schizophrenia, schizoaffective disorder, major depressive disorder and bipolar disorder as defined by Johnson [10], however diagnosed. If studies included service users with and without SMI only data that could be extracted for those with SMI were included. Studies for which it was unclear whether participants in a population of "young people" were aged 18 years or over were not included.

2. **Types of studies**

Randomised controlled trials (RCTs) available in English language.

3. **Types of interventions**

Interventions that used telehealth technology targeted to improve the management of SMI.

4. **Outcome measures**

Articles measuring the following outcome measures were considered for this review:

(1) General or disease specific psychological or psychosocial outcomes, including quality of life or mood, using generic or disease-specific validated tools.

(2) Clinical outcomes including reduction in psychotic symptoms, introduction of new antipsychotics, increased intensity of medication, hospital re-admission, mortality rates, progression of SMI.

(3) Attendance as an outpatient or in primary care.

(4) Adherence to treatment, including medication or recommended psychological support.

Studies were excluded if: SMI was caused by dementia or brain injury, they were not available in English, they investigated telecare or social care technology such as remote sensors for falls, the intervention focused on carers or healthcare professionals rather than service users, participants were not randomised, technology was not the primary focus of the intervention, participants had major depressive disorder (MDD) or other mood disorders without psychosis.

Search strategy

Electronic searches using the following databases were conducted from inception to March 2016: MEDLINE, EMBASE, PsycINFO, Cochrane Central Register of Controlled Trials, Allied and Complimentary Medicine Database (AMED), Health Technology Assessment (HTA), CINAHL plus with full text via EBSCOHost, NHS Economics Evaluations Database (NHS EED) by searching 'all fields' using the following search terms: TELEHEALTH, TELE*, TECHNOLOGY, E?HEALTH, M?HEALTH, ONLINE, WEB*, INTERNET, COMPUTER, MOBILE, APP, VIRTUAL CONSULTATION, PHONE, POCKET PC, IPHONE, SHORT MESSAGE SERVICE, SMS, TEXT MESSAG*, WIRELESS, SMARTPHONE, REAL-TIME, ELECTRONIC DIAR* *and* INTERVENTION, PROGRAM*, THERAPY, SUPPORT, EDUCATION, TRAINING *and* SEVERE MENTAL ILLNESS, MENTAL DISORDER, PSYCHOTIC DISORDER, MOOD, AFFECTIVE DISRODER, PERSONALITY DISORDER, BIPOLAR DISORDER, SCHZOPHRENIA, DEPRESSION, SCHIZOAFFECTIVE DISORDER *and* RANDOMI?ED, TRIAL, CLINICAL TRIAL, COMPARATIVE STUDY, SYSTEMATIC REVIEW, META-ANALYSIS, REVIEW, CROSSOVER PROCEDURE, DOUBLE BLIND*, SINGLE BLIND*.

The first author checked titles and all three authors reviewed abstracts to exclude any irrelevant articles. Full-texts of the remaining articles were obtained; all three authors screened these. Any disagreements were discussed within the research team to reach consensus.

References were searched for additional papers.

Data extraction and management

The first author extracted data using a standardised form developed by the Cochrane Collaboration [15], which included information on the following: study characteristics (including aim and design), participants (including population description, inclusion and exclusion criteria and baseline imbalances), features of the intervention and comparison groups (including description, timing and providers), outcome measures, statistical methods used in analysis, results, and conclusions.

Risk of bias

The Cochrane Collaboration's tool to assess risk of bias in RCTs [16] was used. The Cochrane risk of bias tool includes a list of potential sources of bias in clinical trials, in seven main areas: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias [16]. The rating scale for each area of bias ranges from 'low risk of bias' to 'high risk of bias', and an option of 'unclear risk of bias' for studies that do not provide enough detail to be able to make a clear judgement [16]. Two of the review authors (SW, KM) independently judged each article for risk of bias, discussing disagreements until a consensus was reached.

Results

Electronic searches identified 13,907 unique articles and reference searches of key articles identified a further 17 potentially eligible articles. Thirty-one articles were found to meet the inclusion criteria, which have been presented in a PRISMA [17] diagram (Figure 1). A meta-analysis was not performed due to the heterogeneity of the interventions, including their methods of delivery and the outcome measures of the included studies. The characteristics of the final 31 articles can be seen in Table 1.

Table 1. Participant characteristics of the included studies

First author, country of origin, year, design, length of follow-up	Population, setting, total number randomised	Participant demographics	Illness severity
Beebe, USA, 2008, RCT, 12 weeks	Adults with schizophrenia from a community mental health centre, 29; Telephone intervention problem solving (TIPS) = 15, TAU = 14.	Male (n, %) Intervention = 7 (54), TAU = 8 (67); Age (not separated by group) 52 years (range 25 to 69); Caucasian (n, %) TIPS = 8 (62), TAU = 8; African American (n, %) TIPS = 5 (38), TAU = 6 (50); Oral atypicals (n, %) TIPS = 10 (77), TAU = 9 (75), Depot typicals (n, %) TIPS = 4 (31), TAU = 1 (8), Antidepressants (n, %) TIPS = 7 (54), TAU = 4 (33), Antianxiety agents (n, %) TIPS = 3 (23), TAU = 5 (42), Antiparkinsonians (n, %) TIPS= 5 (38), TAU = 2 (17), Hypnotics (n, %) TIPS = 2 (15), TAU = 3 (25)	Not reported
Bellucci, USA, 2002, RCT, 8 weeks	Adults with schizoaffective disorder or schizophrenia, 34; CACR = 17, control = 17	Characteristics not separated by group. Age (mean) 42; Male (n, %) 16 (47.1%); An average of 3.1 psychiatric medications	SANS summary score: mean (SD) CACR = 13.7 (3.6) Control = 13.1 (3.8)
Benedict, USA, 1994, RCT, follow-up not reported	Adults with chronic schizophrenia from an outpatient day treatment centre, 38; CACR= 16, TAU = 17	Male (n) Experimental = 8, Control = 9; Age (mean, SD) Experimental = 38.1 (11.6), Control = 39.5 (11.1); White/black Experimental = 14/2, Control = 15/2; Days hospitalized (mean, SD) Experimental = 269.0 (211.8), Control = 173.8 (200.7); Chlorpromazine equivalents (mean, SD) Experimental = 279.7 (196.6), Control = 346.1 (544.1); Benzotropine equivalents (mean, SD) Experimental = 2.8 (2.2), Control = 3.1 (2.7)	SANS (mean, SD) Experimental = 11.7 (3.5), Control = 11.7 (3.9); SAPS (mean, SD) Experimental = 9.6 (2.9), Control = 8.4 (3.3)

Burda, USA, 1994, RCT, 8 weeks	Adult inpatients with schizophrenia or schizoaffective disorder in a medical centre, 69; CACR= 40, control = 29	Age (mean, SD) Experimental = 50 (12.51), control = 41.97 (8.16); Diagnosis (not separated by group): undifferentiated type schizophrenia (n=24), paranoid type schizophrenia (n=23), schizoaffective (n=22);	Not reported
Cavallaro, Italy, 2009, RCT, 12 weeks	Adults with schizophrenia at two psychiatric care centres, 100; CACR = 50, control = 50	Age (mean, SD) Experimental = 33.2 (9.5), Control = 34.2 (6.8); Illness duration in years (mean, SD) Experimental = 8.28 (6.7), Control = 8.08 (5.1)	PANSS-positive SRT+CRT = 10.8 (3.8) SRT+PBO = 10.05 (3.6); PANSS-negative SRT+CRT = 13.7 (4.5) SRT+PBO = 14.6 (4.3)
Chan, Hong Kong, 2010, RCT, 10 weeks	Older adults with chronic schizophrenia from a residential care setting, 29; VR = 14, Control = 15	Male (n, %) VR = 10 (83.3), Control = 8 (53.3); Age (mean, SD) VR = 66.4 (6.2), Control = 65.87 (5.54)	Not reported
D'Amato, France, 2011, RCT, 12 weeks	Adults inpatients with schizophrenia, 77; CACR = 39, control = 38	Male (n) CRT = 29, Non-CRT = 29; Age (mean, SD) CRT = 33.4 (6.9), Non-CRT = 32.2 (6.0)	PANSS CRT = 73.3 (11.6) Non-CRT = 75.7 (13.0)
Dickinson, USA, 2010, RCT, 12 weeks	Adults with schizophrenia or schizoaffective disorder attending a Veterans Integrated Services Network, and community psychiatry clinics, 67; CACR = 35, control = 32	All participants were diagnosed with schizophrenia or schizoaffective disorder using the Structured Clinical Interview for DSM-IV (SCID), information from the participants' mental health care providers, and medical records; Male n (%) Remediation = 23 (65.7), Control = 21 (75.0); Age (mean, SD) Remediation = 46.9 (6.6), Control = 48.5 (8.8); African American n (%) Remediation = 23 (65.7), Control = 15 (53.6); Receiving second-generation antipsychotic (versus low-dose first-generation antipsychotic or other) n (%) Remediation = 26 (74.3), Control = 19 (67.9)	SANS score (mean, SD) Remediation = 23.60 (8.32), Control = 27.11 (11.98)
Frangou, UK, 2005, RCT, 8 weeks	Adults with schizophrenia attending outpatient clinics, 108; @HOME = 36, TAU = 36, Pill counting group = 36	Male (n) Routine care = 13, Pill counting = 7, @HOME = 5; Age (mean, SD) Routine care = 47.2 (9.8), Pill counting = 49.6 (11.6), @HOME = 45.5 (9.6); Hospitalisations in previous 12 months (mean, SD) Routine care = 4.3 (5.9), Pill counting = 3.6 (2.7), @HOME = 2.8 (2.5)	PANSS (mean, SD) Routine care = 46.6 (15.9) Pill counting = 43.4 (15.5) @HOME = 43 (14.9)
Hansson, Multicentre (Spain, The Netherlands, UK, Sweden, Germany & Switzerland), 2008,	Adults with schizophrenia on caseloads of participating key workers, 507; DIALOG = 271, TAU	Female (%) Intervention = 32.5, TAU = 35.2; Age (mean, SD) Intervention = 42.5 (11.3), TAU = 41.8 (11.6); Duration of illness (yr) Intervention = 15.2 (9.9) TAU = 16.6 (10.5)	PANSS (mean, SD) Intervention = 62.2 (17.4) TAU = 64.8 (19.8)

RCT, 12 months	= 236		
Hermanutz, Germany, 1991, RCT, 4 weeks	Adults with schizophrenia on admission wards, 30; CACR = 10, control = 10, "0" group = 10	All participants were treated with major tranquilizers (average daily neuroleptic dose in chlorpromazine equivalents 150-750 mg); Age (mean, SD) Experimental = 31.5 (18-52), Control = 30 (22-60), "0" = 31.5 (22-54); Illness duration in years (range) Experimental = 6 weeks to 2.6 years, Control = 3 weeks to 10 years, "0" = 5 weeks to 6 years	Not reported
Hogarty, USA, 2004, RCT, 12 & 24 months	Adults with schizophrenia or schizoaffective disorder from a medical centre, 121; CACR = 67, Enriched supportive therapy (EST) group = 54	Characteristics not separated by group. Diagnosis (% of total sample) Paranoid schizophrenia = 56, Schizoaffective disorder = 30, Other schizophrenia = 14	Not reported
Jones, UK, 2001, RCT, 12 weeks	Adults with schizophrenia in community mental health services, 112; Computer only = 56, Nurse + computer = 28, Nurse only = 28	Characteristics not separated by group; Aged between 18 and 65 years; Male (%) 67	Not reported
Keefe, USA, 2012, RCT, 12 weeks	Adults with schizophrenia at one of nine sites of the Schizophrenia Trials Network, 53; CACR = 27, control = 26	Characteristics not separated by group; Age, mean (SD): 37 (10.27); Male /Female: 39/14; White/ Black/ Other: 30/18/5	CGI (mean, SD) Control = 3.62 (0.75) Treatment = 3.41 (0.84); PANSS (mean, SD) Control = 56.69 (15.35) Treatment = 55.70 (13.75)
Kuosmanen, Finland, 2009, RCT, follow-up not reported	Adults with schizophrenia on nine acute wards in two psychiatric hospitals, 311; IT education group = 100, Conventional education group = 106, TAU = 105	Female (%) IT = 39, Conventional education = 39, Standard care = 45; Age (mean, SD) IT = 37.3 (12.4), Conventional education = 39.1 (12.6), Standard care = 37.9 (12.8)	PANSS total score (mean, SD) IT = 70.9 (18.2) conventional = 70.1 (20.6) standard care 73.2 (23.4)
Kurtz, USA, 2007, RCT, 12 months	Adults with schizophrenia or schizoaffective disorder attending The Institute of Living and a	Male (%) CR = 60, CS = 74; Age (mean, SD) CR = 36.7 (12.2), CS = 32.9 (9.3); Duration of Illness in years (mean, SD) CR = 11.0 (10.4), CS = 9.8 (6.3); Treated with antipsychotic medicine (%) CR = 91, CS = 95	Not reported

	community centre, 42; CACR = 23, control = 19		
Lee, Korea, 2013, RCT, 12 weeks	Adults with schizophrenia referred to a psychiatric rehabilitation unit, 60; CACR = 30, control = 30	Male (n) CT = 16/14 UR = 17/13; Age (mean, SD) CT = 43.53 (4.87) UR = 43.46 (3.53); Duration of illness in years (mean, SD) CT = 17.75 (4.14) UR = 17.53 (3.03); Medication in chlorpromazine mg daily equivalents (mean, SD) CT = 316.58 (182.15) UR = 317.08 (182.23)	PANSS (mean, SD) Positive symptoms CT = 15.21 (3.65) UR = UR 15.20 (3.65); Negative symptoms CT = 15.43 (4.24) UR = 15.69 (4.69); General psychopathology CT = 33.29 (6.89) UR = 33.22 (6.78)
Madoff, USA, 1996, RCT, 1 week, 4 weeks & 12 weeks after discharge	Adult acute psychiatric inpatients, 42; Computer = 34, control = 21	Male (n, %) Computer = 17 (50), Control = 8 (38); Age (mean, SD) Computer = 35.6 (9.5), Control = 34.6 (9.6); White ethnic group (n, %) Computer = 22 (65), Control = 13 (65)	Not reported
Mak, Poland, 2013, RCT, 8 weeks	Adults with paranoid schizophrenia, 81; CACR = 41, control = 40	Male (n) CACR = 19, control = 18; Age (mean, SD) CACR = 34 (11.07), control = 39 (12.99); Illness duration (mean, SD) CACR = 9 (7.21), control = 11 (8.56); Olanzapine CACR = 18 Control = 16; Ziprasidone CACR = 5 Control = 12; Perazine CACR = 7 control = 9; Clozapinum CACR = 3 Control = 0; Quetiapinum CACR = 1 Control = 0; Amisulpridum CACR = 1 Control = 0; Risperidone CACR = 2 Control = 3; Zuclopenthixol CACR = 3 Control = 0	PANSS Positive scale (mean, SD) CACR = 9.10 (2.25) control = 14.45 (7.10); PANSS Negative scale CACR = 13.68 (5.99) control = 20.98 (7.07); General psychopathology scale CACR = 24.59 (7.14) control = 33.73 (9.22)
Montes, Spain, 2010, RCT, 16 weeks	Adults with schizophrenia treated at community mental health centres, 928; Intervention = 456, Control = 472	Male n (%) Intervention = 276 (65.1) Control = 288 (65.5); Age (mean, SD) Intervention = 40.7 (11.8) Control = 39.5 (11.5); Duration of illness in years (mean, SD) Intervention = 13.5 (9.7) Control = 12.7 (9.4); Treatment with atypical antipsychotics n (%) Intervention = 406 (96.0) Control = 425 (96.4); Schizophrenia subtype n (%) Paranoid Intervention = 309 (72.9) Control = 319 (72.7); Undifferentiated Intervention = 52 (12.3) Control = 51 (11.6); Disorganized Intervention = 18 (4.3) Control = 24 (5.5); Residual Intervention = 45 (10.6) Control = 45 (10.3)	CGI-SCH SI score (mean, SD) Positive symptoms Intervention = 2.7 (1.3) control = 2.7 (1.3); Negative symptoms Intervention = 3.3 (1.3) control = 3.2 (1.3); Global symptoms Intervention = 3.3 (1.2) control = 3.2 (1.2)

Park, Korea, 2011, RCT, 5 weeks	Adults inpatients with schizophrenia, 91; Social skills training- virtual reality (SST-VR) = 46, Social skills training-traditional role play (SST-TR) = 45	Female n (%) SST-VR = 17 (51.5), SST-TR = 13 (41.9); Age (mean, SD) SST-VR = 28.1 (7.7), SST-TR = 31.2 (7.7); Duration of illness in years (mean, SD) SST-VR = 6.0 (5.7) SST-TR = 5.9 (6.3); Medications n (%) Atypical antipsychotics SST-VR = 30 (90.9) SST-TR = 29 (93.5); Typical antipsychotics SST-VR = 6 (18.2) SST-TR = 5 16.5; Mood stabilizers SST-VR = 1 (3.0) SST-TR = 1 (3.2); Antidepressants SST-VR = 1 (3.0) SST-TR = 3 (9.7); Benzodiazepines SST-VR = 9 (27.3) SST-TR = 7 (22.6)	PANSS (mean, SD) total SST-VR = 73.3 (12.6) SST-TR = 71.4 (12.7); Positive symptoms SST-VR = 18.1 (5.3) SST-TR = 17.0 (5.1); Negative symptoms SST-VR = 18.9 (4.8) SST-TR = 18.4 (4.7); General symptoms SST-VR = 36.3 (8.6) SST-TR = 36.0 (8.9)
Priebe, centres in Spain, The Netherlands, UK, Sweden, Germany & Switzerland, 2007, RCT, 12 months	Adults with schizophrenia or related psychotic disorder treated in community psychiatric services, 507; DIALOG= 271, TAU = 236	Age in years, mean (s.d.) TAU = 41.8 (11.6), DAILOG = 42.5 (11.3); Female, n (%) TAU = 83 (35.2), DIALOG = 88 (32.5); Diagnosis n (%) undifferentiated schizophrenia TAU = 89 (37.7) DIALOG = 91 (33.6), Paranoid schizophrenia TAU = 63 (26.7) DIALOG = 89 (32.8), Catatonic schizophrenia TAU = 4 (1.7) DIALOG = 1 (0.4), Hebephrenic schizophrenia TAU = 10 (4.2) DIALOG = 7 (2.6), Schizoaffective manic TAU = 7 (3.0) DIALOG = 19 (7.0), Schizoaffective depression (moderate) TAU = 9 (3.8) DIALOG = 9 (3.3); Schizoaffective depression (severe) TAU = 2 (0.8) DIALOG = 3 (1.1); Schizoaffective bipolar disorder 9 (3.8) 15 (5.5); Delusional disorder TAU = 2 (0.8) DIALOG = 1 (0.4); Other non-organic psychotic disorders TAU = 41 (17.4) DIALOG = 36 (13.3); Length of illness, years, mean (s.d.) TAU = 15.2 (9.9) DIALOG = 16.6 (10.5)	PANSS sub-scale scores:mean (s.d.) Positive TAU = 14.6 (5.7) Intervention = 15.0 (5.8); Negative TAU = 15.7 (6.0) Intervention = 17.2 (6.9); General TAU = 31.8 (9.1) Intervention = 32.6 (10.1)
Proudfoot, Australia, 2012, RCT, 12 weeks & 6 months	Adults with bipolar disorder at the Black Dog Institute Mood Disorders Clinic, 419; Bipolar Education Program (BEP) = 139, BEP plus online support (BEP+IS) = 134, control = 134	Male n (%) BEP = 46 (33.1%), BEP + IS = 36 (26.9%), Control = 41 (30.6%); Age n (%) 18–29 BEP = 43 (30.9%) BEP + IS = 38 (28.4%) Control = 36 (26.9%), 30–39 BEP = 49 (35.3%) BEP + IS = 47 (35.1%) Control = 54 (40.9%), 40–49 BEP = 28 (20.1%) BEP + IS = 35 (26.1%) Control = 30 (22.4%), 50–59 BEP = 15 (10.8%) BEP + IS = 13 (9.7%) Control = 10 (7.5%), 60+ BEP = 4 (2.9%) BEP + IS = 1 (0.7%) Control = 4 (3%); Currently taking medication n (%) BEP = 114 (82.0%) BEP + IS = 115 (85.8%) Control = 114 (85.1%)	Not reported
Rass, USA, 2012, RCT, 5 weeks, 10 weeks & 20 weeks	Adults inpatients with schizophrenia or schizoaffective disorder, 48; CACR = 17, Active Control = 17, TAU = 10	Male (n) CR = 10, Active control = 11, TAU = 9; Age (mean, SD) CR = 37.2 (12.5), Active control = 45.4 (9.0), TAU = 43.9 (8.9); Illness duration (mean, SD) CR = 17.9 (11.6), Active control = 22.6 (12.1), TAU = 19.9 (9.3); Schizoaffective Disorder (n) CR = 9 Active	PANSS Positive (mean, SD) CR = 15.2 (5.6) Active control = 16.5 (6.2) TAU = 13.6 (3.8); PANSS Negative

		control = 11 TAU = 2	(mean, SD) CR = 12.4 (5.5) Active control = 13.2 (5.4) TAU = 15.0 (3.9); PANSS General (mean, SD) CR = 27.3 (7.9) Active control = 30.6 (8.2) TAU = 26.0 (3.8)
Sartory, Germany, 2004, RCT, 3 weeks	Adults inpatients with chronic schizophrenia, 42; CACR = 21, TAU = 21	Male (n) CR = 14, TAU = 14; Age (mean, SD) CR = 32.2 (8.5), TAU = 31.6 (8.9); Illness duration (mean years, SD) CR = 5.5 (4.8), TAU = 6.8 (5.5); Chlorpromazine equiv. (mg) CR = 550.92 (323.9) TAU = 584.8 (318.1)	No reported
Simon, USA, 2005, RCT, 12 months	Adults with bipolar spectrum disorder at four group-model behavioural health clinics, 441; Intervention = 212, TAU = 229	Female n (%) Intervention = 144 (68) Usual Care = 157 (69); Age (mean, SD) Intervention = 44.1 (13.4), Usual Care = 44.3 (12.9); Caucasion n (%) Intervention = 184 (87), Usual Care = 206 (90); Type 1 bipolar disorder n (%) Intervention = 165 (78) Usual Care = 171 (75)	Baseline mania PSR mean (SD) Intervention = 2.77 (1.72) Usual care = 2.78 (1.60); Current psychotic symptoms n (%) Intervention = 33 (16) Usual care = 30 (13)
Simon, USA, 2006, RCT, 24 months	Adults with bipolar spectrum disorder at four group-model behavioural health clinics, 441; Intervention = 212, TAU = 229	Female n (%) Intervention = 144 (68) Usual Care = 157 (69); Age (mean, SD) Intervention = 44.1 (13.4), Usual Care = 44.3 (12.9); Caucasion n (%) Intervention = 184 (87), Usual Care = 206 (90); Type 1 bipolar disorder n (%) Intervention = 165 (78) Usual Care = 171 (75)	Baseline mania PSR mean (SD) Intervention = 2.77 (1.72) Usual care = 2.78 (1.60); Current psychotic symptoms n (%) Intervention = 33 (16) Usual care = 30 (13)
Španiel, Czech Republic, 2012, RCT, 12 months	Adults with schizophrenia or schizoaffective disorder at 36 outpatient psychiatric centres, 158; Active group = 79, control = 79	Female (%) Active = 41.3 Control = 46.5; Age (mean, SD) Active = 32.4 (9.8) Control = 33.7 (10.4); Illness duration in months (mean, SD) Active = 101.4 (69.7) Control = 112.5 (91.2); Diagnosis schizophrenia/ schizoaffective n/n Active = 52/23 Control = 52/19	CGI-S score (mean, SD) Active = 2.3 (0.7) Control = 2.3 (0.7)

Todd, UK, 2014, RCT, 3 & 6 months	Adults with bipolar disorder in the community, 122; 'Living with Bipolar' Intervention (LWB) = 61, control = 61	Male n (%) LWB = 16 (26%) WLC =18 (30%); Age in years (mean, SD) LWB = 42 (10.35) WLC = 45 (11.97); White British LWB = 55 (90%) WLC = 54 (88%); Diagnosis: Bipolar I LWB = 47 (77%) WLC = 39 (64%), Bipolar II LWB = 11 (18%) WLC = 19 (31%), Rapid Cycling LWB = 3 (5%) WLC = 3 (5%)	Internal States Scale (ISS) scores (mean, SD): ISS Perceived Conflict LWB = 171.00 (102.92) WLC = 157.33 (102.43), ISS Wellbeing LWB = 100.44 (78.22) WLC = 106.86 (75.84), ISS Activation n LWB = 130.07 (123.00) WLC = 139.10 (127.33), ISS Depression LWB = 86.32 (61.57) WLC = 76.90 (52.35)
Tsang, Hong Kong, 2013, RCT, Not reported	Adult inpatients with schizophrenia attending a vocational rehabilitation program, 95; VR = 33, Therapist-administered training (TA) = 32, control = 30	Male (%) VR = 28 TA = 60 CG = 44; Age (mean, SD) VR = 39.60 (7.96) TA = 40.76 (9.19) CG = 41.56 (9.94); Illness duration in years (mean, SD) VR = 11.40 (7.08), TA = 16.0 (8.73), CG = 16.64 (9.40); Medication (%) Typical VR = 28% TA = 32% CG = 36%, Atypical VR = 72% TA = 68% CG = 64%	*Not reported*
Vita, Italy, 2011, RCT, 24 weeks	Adults with schizophrenia in 3 rehabilitative centres, 84; Integrated Psychological Therapy (IPT-cog) = 26, CACR = 30, Non-cognitive rehabilitation (REHAB) = 28	Female (n) IPT-cog = 5 CACR = 11 REHAB = 10; Age in years (mean, SD) IPT-cog = 37.15 (9.10), CACR = 36.87 (11.40), REHAB = 43.00 (7.76); Duration of illness in years (mean, SD) IPT-cog = 14.94 (9.76) CACR = 14.80 (9.78) REHAB = 17.93 (9.68); Chlorpromazine equivalents in mg (mean, SD) IPT-cog = 674.08 (417.97) CACR = 600.17 (362.59) REHAB = 714.00 (445.32)	CGI-S (mean, SD) IPT-cog = 5.0 (0.63) CACR = 4.67 (0.75) REHAB = 4.71 (0.93); PANSS (mean, SD) Positive IPT-cog = 19.0 (4.45) CACR = 18.97 (5.91) REHAB = 19.68 (6.67), Negative IPT-cog = 28.73 (6.65) CACR = 22.27 (7.95) REHAB = 21.18 (7.33)

The 31 articles reported 29 trials. A total of 17 trials focused on people with schizophrenia, 9 people

with schizophrenia or schizoaffective disorder and/or psychotic disorder and 3 bipolar disorder. A

range of telehealth devices were used with varying aims. Computers were used to improve cognitive

functioning and disease-specific knowledge, websites aimed to improve psychosocial functioning,

hand-held devices were used to improve communication with medical staff, telephones were used to improve medication adherence and disease-specific symptoms, virtual reality aimed to improve social and work-related functioning, and electronic medication dispensers aimed to improve adherence. The specific outcome measures included, medication adherence (4 studies), social functioning (including work behaviour) (5 studies), healthcare utilisation (4 studies), neurocognitive functioning (16 studies), knowledge about medication or SMI (2 studies), self-esteem (3 studies), self-efficacy (1 study), quality of life (4 studies), mood (4 studies), insight into condition (1 study), perceptions of deprivation of liberty (1 study), satisfaction with life or treatment (5 studies), and illness perceptions (1 study).

The 29 included trials recruited a total of 4,338 participants. Sample sizes ranged from 29 to 507. Details about each intervention can be seen in Table 2.

Table 2. Descriptions of the interventions included in the review

First author, country of origin, year, design, length of follow-up	Technology	Description of intervention and comparator
Beebe, USA, 2008, RCT, 12 weeks	Telephones	Participants received all usual care plus weekly telephone calls from a nurse over a period of 3 months. TAU consisted of the usual medications, physician visits, follow-up appointments, and care available at the community centre.
Bellucci, USA, 2002, RCT, 8 weeks	Computers	Participants received computer-based cognitive training from a psychology intern. Training sessions were administered in a private office in two half-hour sessions for 8 weeks. The waiting-list control group took part in standard therapeutic activities in the day treatment programme and received computer training at the end of the study
Benedict, USA, 1994, RCT, follow-up not reported	Computers	Participants received a mean of 14.4 (SD 1.09) 50-minute sessions of guided practice with six computer-based attention tasks administered by trained undergraduate research assistants. Three to five training sessions were scheduled per week. TAU participants received the same multidisciplinary, day-treatment program as experimental participants.
Burda, USA, 1994, RCT, 8 weeks	Computers	Participants received 24 half-hour sessions (or 12 h) of CACR training over 8 weeks. The TAU group did not use computers and participated in regular therapeutic activities on the ward.

Cavallaro, Italy, 2009, RCT, 12 weeks	Computers	Participants received neurocognitive exercises for 3 half-days a week for approx. 15 months. Sets of exercises were individually created for each participant on the basis of the quality of baseline neuropsychological assessment. The SRT+CRT condition consisted of three 1-h sessions a week for a period of 12 weeks, giving a total of 36 h. The control condition consisted of 1 h a week of computer-aided non-domain-specific activity and 2 extra h a week of standard rehabilitation programme (SRT).
Chan, Hong Kong, 2010, RCT, 10 weeks	Virtual reality	Participants received a series of simulated tasks within a VR environment through video contact twice a week. Ten sessions, each 15 min long, with increasing level of difficulty, was provided by an occupational therapist and consisted of two activities. Participants in the control group received TAU and the VR program 3 months later.
D'Amato, France, 2011, RCT, 12 weeks	Computers	The CACR group received, in addition to standard treatment, 14 individual 2 hour sessions of training in selecting, executing, and monitoring cognitive operations delivered over a 7-week period by a psychologist.
Dickinson, USA, 2010, RCT, 12 weeks	Computers	The CACR group received 36 sessions of cognitive remediation. Time in individual sessions included practice of cognitive exercises (roughly two-thirds of each session) alternated with trainer prompts, queries and feedback, and strategy review. Control group participants received the same amount of time on computers with the same trainers as the treatment group, but received gaming activities with low cognitive demand.
Frangou, UK, 2005, RCT, 8 weeks	Electronic medication dispenser	@HOME participants used a medication dispenser with a Medication Event Monitoring System (MEMSIV®). The bottle cap recorded when the bottle was opened and data were transmitted to the research and clinical teams via the @HOME platform. Alerts were issued if participants took less than 50% of their prescribed medication over 1 week. The Pill Counting group consisted of pharmacists counting the numbers of tablets returned at the hospital visit. TAU received standard care.
Hansson, Multicentre (Spain, The Netherlands, UK, Sweden, Germany & Switzerland), 2008, RCT, 12 months	Computers	Key workers in the intervention group discussed issues with their participants using a computer-mediated procedure every 2 months. TAU continued with standard treatment delivered by their key worker.

Hermanutz, Germany, 1991, RCT, 4 weeks	Computers	Participants undertook computer exercises in attention 15 times during 3-4 weeks. The control group were instructed by a therapist in small groups to read newspaper articles and answer questions about, and reproduce, their content. The "0" group did not receive any kind of psychological training
Hogarty, USA, 2004, RCT, 12 & 24 months	Computers	CACR consisted of combined 75 hours of progressive computer-assisted training in neurocognition and 1.5 hours per week of social cognitive group exercises (approx. 56 sessions). Small groups of 6 participants met 4 to 6 months after starting computer-assisted training. Participants were treated by 3 experienced psychologists. The therapy group received individual education delivered by two psychiatric nurses.
Jones, UK, 2001, RCT, 12 weeks	Computers	The computer only group were shown general information, personal information from their medical records and questionnaires. In community psychiatric nurse only, hour-long sessions covered the same content. The combination group received the community psychiatric nurse sessions, plus 24 sessions on the computer and a final session with the nurse. All groups received 5 sessions in total.
Keefe, USA, 2012, RCT, 12 weeks	Computers	The CACR group received the computerized Posit Science Brain Fitness auditory training program for 3–5 one-hour sessions weekly for 40 sessions or 12 weeks, whichever came first. Participants also attended structured 'bridging groups' every week. The control group played computer games for the same number of hours, received the same amount of contact with personnel, and attended Healthy Lifestyle Groups.
Kuosmanen, Finland, 2009, RCT, follow-up not reported	Computers	The IT education group received needs-based computerised education from a nurse consisting of 5 40-minute sessions delivered over one month. The conventional education group received 5 30-minute nurse-delivered education sessions with oral and written material in addition to standard care and were given leaflets. TAU received standard acute psychiatric care.
Kurtz, USA, 2007, RCT, 12 months	Computers	The CACR group received a 12-month, standardized course of cognitive remediation. The CS group received a 12-month course of tutorials in general computer literacy using Microsoft Office. Participants in both groups trained on computers side by side in rooms of 3–4 computers supervised and coached by both pre-doctoral, and doctoral level clinicians who offered positive reinforcement for progress on the respective training sequences.

Lee, Korea, 2013, RCT, 12 weeks	Computers	The Cog-trainer program included 20 one-hour sessions of neurocognitive exercises delivered by a therapist up to two times a week over 3 months. The therapist provided support for tasks the participant could not accomplish and ceased assistance in those areas where competence was achieved.
Madoff, USA, 1996, RCT, 1 week, 4 weeks & 12 weeks after discharge	Computers	All participants completed assessments of familiarity with medication, followed by 4 sessions of a computer-based interactive educational program to improve medication knowledge. The control group received a nurse tutorial covering the same material.
Mak, Poland, 2013, RCT, 8 weeks	Computers	The experimental group received 16 sessions (two per week) of CACR training. Sessions lasted about 40 minutes, 20 minutes for each procedure out of attention/ concentration and topological memory. The control group were not treated with RehaCom.
Montes, Spain, 2010, RCT, 16 weeks	Telephones	The IG received a standardized telephone call from a nurse at weeks 4, 8, and 12 consisting of a brief semi-structured assessment of treatment adherence and the Drug Attitude Inventory (DAI-10). The treating psychiatrist received a structured report of each contact and, if non-adherent, the participant was scheduled to visit the psychiatrist within the next 7 days. The control group received usual care (a visit from the psychiatrist after 4 months, without telephone calls).
Park, Korea, 2011, RCT, 5 weeks	Virtual reality	Both groups received 3 training sessions in conversation skills, assertiveness skills and emotional expression skills administered semi-weekly for 10 sessions. Each session included a therapist modeling followed by role-playing and then positive and corrective feedback. Each session included different scenes per participant. The VR group received a personal computer providing the virtual environment, a head mounted display, and a position tracker for following the head direction in real time.
Priebe, centres in Spain, The Netherlands, UK, Sweden, Germany & Switzerland, 2007, RCT, 12 months	Computers	DIALOG consisted of a computer-mediated procedure for clinicians to discuss 11 domains with their participants. Clinicians were instructed on how ratings should be used to facilitate a dialogue with participants, identifying changes since the last rating, explicit dissatisfaction with life domains or treatment aspects, or the participant wanted additional or different support. The control group continued with TAU.

Proudfoot, Australia, 2012, RCT, 12 weeks & 6 months	Computers	The BEP group received 'MoodSwings', an online self-help audio–visual program based on CBT modules. Participants completed 6 modules, taking 30–40 min to complete, over 3 months with a small group moderated discussion and 3 booster modules at 3, 6 and 12 months. The BEP+IS group received the online psychoeducation program supplemented by coaching and support from peers with bipolar disorder who had managed their condition for at least 2 years via email. The control group received simple facts about bipolar disorder delivered as brief online text.
Rass, USA, 2012, RCT, 5 weeks, 10 weeks & 20 weeks	Computers	The CACR group completed a cognitive training programme for 2 hours 2 days per week for 10 weeks. The active control group watched films, cartoons, or television shows using the same schedule. TAU participants came in only for assessments.
Sartory, Germany, 2004, RCT, 3 weeks	Computers	CACR involved a computerized training program consisting 30 computer tasks designed to train attention and concentration. The training, labelled "computer game sessions", was delivered 45 mins per day for 15 days in small groups of up to 6 with an attendant present at all times. TAU received standard care and later received CACR
Simon, USA, 2005, RCT, 12 months	Telephones	Participants received structured monthly telephone medication monitoring for 24 months and a structured group psychoeducational program provided by a nurse care manager. Telephone monitoring and care management were supported by a web-based computer application integrating contact tracking, structured assessment, pharmacotherapy recommendations, and feedback reports to care providers. The group psychoeducational program included 5 weekly group sessions (Phase 1) followed by twice-monthly sessions (Phase 2). TAU received no additional services.
Simon, USA, 2006, RCT, 24 months	Telephones	Participants received a collaborative treatment plan with the nurse care manager and monthly telephone call for 24 months to review SMI symptoms, medication use, and adverse effects. Nurse care managers sent structured feedback to mental health providers. Participants attended a group psychoeducational program including five weekly group sessions (Phase 1) followed by twice-monthly sessions for a total of up to 48 sessions (Phase 2). TAU received no additional services.
Španiel, Czech Republic, 2012, RCT, 12 months	Telephones	All participants received the Information Technology-Aided Program of Relapse Prevention in Schizophrenia (ITAREPS) consisting of automatic SMS

		requests once a week to participants' and their families' mobile phones to complete questionnaires about symptoms for 12 months. Participants sent their scores via SMS and if a total score exceeded a threshold, an automatically generated e-mail was sent to the treating psychiatrist. In the active group, ITAREPS reported the occurrence of prodromes to the investigators via emails. Control group did not receive the e-mail service
Todd, UK, 2014, RCT, 3 & 6 months	Computers	Participants received an online interactive self-management intervention based on CBT principles and psycho-education. Ten interactive modules were available; participants used it when they felt it appropriate. Generic email prompts were sent to participants every fortnight. Participants were also encouraged to make use of peer support. The WLC group received TAU.
Tsang, Hong Kong, 2013, RCT, Not reported	Virtual reality	All participants attended at least 3 hours of prevocational skills training in the OT Department in hospital in every working day during hospitalization. VR participants also attended vocational skills training in a virtual boutique scenario (VRVTS). In TA, participants attended prevocational skills training and therapist-administered vocational skills training program in a boutique. The training content of VR and TA were the same and all participants were required to attend 10 30-min sessions of training over 5 weeks.
Vita, Italy, 2011, RCT, 24 weeks	Computers	Participants received a group-based structured CBT program with neurocognitive and social cognitive remediation integrated into psychosocial rehabilitation over 5 modules. CACR consisted of the Cogpack programme. The comparison group participated in group psychosocial interventions, consisting of different types of activities (e.g. art therapy or physical training), administered for the same amount of time as the intervention.

Risk of bias

Results for the risk of bias assessment can be found in Multimedia Appendix 1: Risk of bias assessment. Of note, only five studies were rated as high quality. One study demonstrated a particularly high and at times unclear risk of bias, for the majority of sources of bias [49]. Several studies did not provide enough detail to be able to make a clear judgement that they had not introduced bias into their findings.

Intervention effectiveness

Results for each of the 31 studies can be found in Multimedia Appendix 2: Results of included studies. A description of the findings is presented in the following sections.

Cognitive outcomes

Twenty of the 31 articles reported the impact of telehealth for SMI on cognitive outcomes. Neurocognitive functioning was measured in 18 studies and encompassed memory, attention, executive functioning, and visual perception. Fifteen of these studies measured the impact of computer-assisted cognitive rehabilitation (CACR) on *neurocognitive functioning* [18-32], of which 11 found statistically significant improvements [20-24; 26; 28 -31; 33]. Two of the 18 studies evaluated the use of VR, for cognitive rehabilitation [33] and vocational rehabilitation [34] for adults with schizophrenia. VR was found to have a significant effect on cognitive functioning in both studies [33;34]. One study [35] evaluated the use of offline personalised computer-based health education, compared to nurse-delivered health education, and a combination of both interventions but found no significant differences from baseline to follow-up in any of the trial arms on measures of neurocognitive functioning or knowledge about schizophrenia [35; 36].

To summarise the findings for cognitive outcomes, 11 out of 15 studies found computer-assisted cognitive remediation (CACR) to be beneficial for cognitive outcomes, and virtual reality-based cognitive and vocational training was found to be effective for cognitive function, while computer-based patient education was found to have no benefit for cognitive outcomes over nurse-delivered education.

Psychosocial outcomes

Twenty-one of the 31 articles reported the impact of telehealth on psychosocial outcomes. These included *positive and negative symptoms* [28; 21; 22; 24; 27; 30; 36; 37; 38], *social adaptation* including social adjustment and cognition [21; 24; 27; 28; 31; 39- 41], *quality of life* [20; 21; 39; 40;

36; 38; 42], *mood* [31; 39; 36; 43; 44], *satisfaction with care* [42], *self-esteem* [18; 24; 39], *self-efficacy* [34], *illness perceptions* [39], *insight* [35], and *perceptions of deprivation of liberty* [45].

Positive and negative symptoms

Six studies evaluated the effectiveness of CACR on schizophrenia symptoms [18; 21; 22; 24; 27; 30], of which four did not find any effect but two [18] [27] found a beneficial effect on negative symptoms [18;27]. One study also measured positive symptoms and global symptoms, finding a beneficial effect on positive symptoms [27] but not global symptoms [27].

Telephone-based nurse support [36] reduced positive schizophrenia symptoms when compared to a control group, but no differences were observed for negative or global schizophrenia symptoms [36]. Telemonitoring [37] had a beneficial effect on positive and negative schizophrenia symptoms over standard care, although a non-technology "pill counting" group also led to improved symptoms.

Computer mediated structured consultations [38] did not have an impact on symptoms.

Social adaptation

The included trials measured several different aspects of social adaptation. These included social cognition, social adjustment, social professional and family functioning.

Eight of the 31 studies evaluated the impact of telehealth on social adaptation, encompassing social adjustment and social cognitions, of which three reported a benefit. Of five trials of CACR, two reported a beneficial effect, on the social and living conditions subscales of the Health of the Nation Outcome Scale (HoNOS; 46) [27], social adjustment (defined as role performance) and social cognition (defined as awareness of relationships), which were measured using a combination of existing outcome measures [28]. However, others found no effect of CACR on social autonomy [21], social professional and family functioning [31] or social cognition as measured by the Matrics Consensus Cognitive Battery (MCCB; 47) [24].

An online self-management intervention [40] improved social functioning but an online CBT-based intervention (alone or with peer support) [39] did not affect perceptions of stigmatisation. Using virtual reality to deliver social skills training [41] did not differ from social skills training with role-play on social problem-solving, social adjustment or stigma.

Quality of life

Seven articles reported the impact of telehealth for SMI on quality of life. Three studies found a significant benefit of telehealth for SMI. CACR had a significant effect on overall quality of life and a self-directedness subscale in one study [20], but not in another [21]. Computer mediated structured consultations ("DIALOG") improved quality of life at a 12 month follow-up [38]. Service users with a shorter duration of illness and a better 'perceived helping alliance' with key workers prior to receiving DIALOG improved more in subjective quality of life than standard care [42]. Hansson et al [42] also found that people with more severe negative schizophrenia symptoms prior to the intervention experienced a greater improvement in quality of life after receiving DIALOG. Online self-management [40] had a significant effect on both physical and psychological quality of life but nurse-based telephone support [36] was not effective.

Two studies measured *satisfaction with life*. There were no significant differences between 'Moodswings', 'Moodswings' plus online peer support, and a standard care control group, on satisfaction with life [39]. Similarly, there was no difference between an IT education group and standard care on satisfaction with life [45].

Mood

A nurse-delivered monthly telephone monitoring intervention [43;44] reduced depressive symptoms for bipolar disorder after 12 months, but this effect was not maintained at the two year follow-up. Furthermore, a significant reduction in mania was found at the two-year follow-up, but not at the initial 12-month assessment. No benefit was found for CACR [31], an online CBT-based intervention

[39], or a telephone-based nurse support intervention [36] over a no treatment control. Noteworthy is the control condition in Proudfoot et al's [39] study, which involved information about bipolar disorder being emailed to participants weekly.

Satisfaction with health care

One trial measured the effectiveness of telehealth on satisfaction with care. Computer-mediated consultations improved treatment satisfaction [42].

Self-esteem

Three studies measured the impact of telehealth for SMI on self-esteem. Self-esteem was not improved by CACR [18;24], or by an online CBT-based intervention [39].

Self-efficacy

The one study that measured self-efficacy, found no differences between VR vocational training, therapist-administered vocational training, and a non-training control group in terms of self-efficacy for performing work-related tasks [34].

None of the computer-based education trials found a significant impact on insight into schizophrenia [35], or perceived deprivation of liberty among adults with schizophrenia [45].

To summarise the findings for psychosocial outcomes, CACR was found to have no effect on schizophrenia symptoms in the majority of studies that measured this outcome, and had no effect on mood over standard care. Two out of three studies that measured the impact of CACR on psychosocial adjustment found an improvement. Telephone support was found to reduce the severity of positive symptoms and depressive symptoms in schizophrenia and remote telemonitoring was found to improve global schizophrenia symptoms over pill-counting alone. Computer-mediated structured consultations and online self-management for bipolar disorder were both found to lead to improvements in quality of life. While online patient education improved social functioning, it had

no effect on mood. VR had no benefits in improving nonverbal social skills over traditional face to face training.

Behavioural outcomes

Ten of the 31 studies measured the effectiveness of telehealth interventions on behavioural outcomes. Outcomes included *adherence to treatment* [36; 37; 48; 49], *healthcare utilisation*, including number of inpatient days and amount of antipsychotic medication taken [37; 43; 50; 40], *work habits* [22; 34], and *conversational skills*, including non-verbal skills [41]

Adherence to treatment

Of the four studies that measured *adherence to treatment*, significant improvements were found with nurse-based telephone support [48; 36] and telemonitoring [37], but not for computer-based medication education [49].

Healthcare utilisation

Of the four studies that evaluated the use of telehealth on *healthcare utilisation*, all found a significant positive effect. Remote medication monitoring [37] led to fewer medical and emergency visits than pill counting alone and standard care. Telemonitoring of symptoms [50] led to significantly fewer inpatient days when compared to a control group who received standard care. Simon et al [43] found better adherence to atypical antipsychotic use and increased attendance for medication management visits in service users who received nurse-based telephone support. Todd et al [40] reported that medication and service use reduced on average in the self-management website group and increased on average for the standard group, although statistical analysis of the difference is not reported.

Work habits

Of the two studies that measured *work habits*, which involved direct observation of work behaviour and an interview with the work supervisor, both found the telehealth intervention to be effective.

CACR [22] had a significant effect on work habits and VR [34] was as effective as therapist-delivered vocational training for work-related tasks, with a significant improvement seen in both groups.

Conversational skills

Park et al [41] found that enabling service users to practice their social skills using VR after receiving social skills training, had a significant effect on *conversational skills* and assertiveness in comparison to a face-to-face role playing group (without VR), although the role playing group showed greater improvement in nonverbal skills.

To summarise the findings for behavioural outcomes, telephone support and remote telemonitoring consistently led to improvements in medication adherence and reduced inpatient days, while computer-based education had no effect. Telemonitoring and online CBT-based self-management both led to reduced emergency healthcare visits. CACR and VR were both effective for improving work behaviour and VR improved assertiveness in social situations over traditional face to face training.

Acceptability

Of note, only one of the included studies formally measured whether participants found the intervention they received acceptable. Frangou et al [37] measured acceptability, ease of use within routine care, and perceived effectiveness qualitatively from the perspective of service users and their healthcare professionals. There was unanimous agreement among service users that the telemonitoring intervention helped them to manage their own condition, was easy to use and easy to incorporate into daily life, and caregivers shared these views [37]. While Park et al [41] did not report measuring 'acceptability', they did record 'interest in participation' using a two-item questionnaire, which evaluated participants' interest in the session they received and their expectations for the next session. The VR group scored higher on interest in participation than the traditional social skills training group [41], suggesting a preference for technology. Jones et al [35]

similarly did not refer to 'acceptability', but assessed participants' opinions about the computer-based education intervention combined with nurse-based education, versus computer-based or nurse-based education alone. Significantly more service users in the nurse-based education group perceived the information they received as definitely relevant to them compared to the computer-delivered education group and the combination group, despite the nurse-delivered intervention providing the same content as the computer system [35].

One indicator of acceptability may be significant drop-out rates from the intervention group. Most of the included studies did not present a substantial drop-out rate, although not all studies adequately reported reasons for drop-out. Of the studies reporting a substantial drop-out rate, Proudfoot et al [39] reported a higher dropout from the website condition (30%), compared to the website plus peer support condition (19%). Jones et al [35] reported substantial drop-outs from the computer-delivered education (41%) and nurse-delivered education conditions (46%), when compared to the combined condition (29%). Reasons for drop-out from the computer education group included refusal to continue taking part, the intervention being unsafe, and physical problems limiting the ability to continue with the intervention [35]. Rass et al [25] also reported a higher drop-out from a CACR group (19%) than either control condition (0%), including three participants who stopped attending the intervention and two who did not complete final follow-up assessments. In a longitudinal study assessing telephone monitoring plus a structured group psychoeducational programme, while the authors reported a high level of contact in the telephone element of the intervention (85% of participants completed 12 or more telephone contacts), group participation dropped substantially to 51% after 12 months [44], suggesting a group-based education intervention may be less acceptable than telephone monitoring in adults with bipolar disorder.

Discussion

Principal results

The aims of this review were 1. To identify which, and how, telehealth interventions have been trialled for people with SMI and 2. To synthesise the evidence in relation to the effectiveness or efficacy of these interventions.

This review identified 31 articles describing 29 trials, including a total of 4,338 participants with schizophrenia, schizoaffective disorder, psychotic disorder and bipolar disorder. The studies in the included articles evaluated the use of computers for cognitive rehabilitation, patient education, consultations with key workers and interactive online CBT-based self-management interventions; the use of VR to simulate work and social situations and to deliver cognitive training; the use of telephones to prompt medications use and to report SMI symptoms to healthcare teams; and the use of remote sensors to monitor medication use.

This review found evidence for using some types of technology to support the management of SMI, whilst finding that not all technology is effective, depending on the outcome of interest. Interventions containing telephone support from the medical team, including phone calls and SMS prompts about medication, were consistently found to be effective for improving medication adherence, whilst also reducing severity of mania symptoms and reducing inpatient days. CACR was found to be effective for improving cognitive outcomes in schizophrenia in most, but not all, studies. An online CBT-based self-management intervention for bipolar disorder was effective at improving quality of life and social functioning. The use of VR was found to be effective for improving work-related behaviour, conversational skills, assertiveness and cognitive functioning, although face to face social skills training was found to be more effective for improving nonverbal social skills than VR delivered training. Computers appeared not to have a superior benefit for delivering patient education over traditional nurse-delivered education, and in fact participants preferred the nurse-delivered method. This finding is perhaps reflective of the nature of interactions with healthcare

staff, which can provide a personal and individualised approach to supporting people with SMI, for example by offering opportunities like discussing diagnoses, and modelling nonverbal social cues. Hand-held devices to support healthcare consultations were found to be effective for improving quality of life and satisfaction with care, but not for improving positive or negative schizophrenia symptoms. Telemonitoring, which was found to be effective for improving medication adherence and also led to fewer medical and emergency visits, including inpatient days, whilst simultaneously improving schizophrenia symptoms.

Notably, five studies demonstrated a low risk of bias for six out of the seven sources of bias listed in the Cochrane risk of bias tool [42; 27; 38; 43; 40], and six studies demonstrated a low risk of bias for five out of the seven sources [48; 22; 36; 39; 44; 50]. One study demonstrated a particularly high and at times unclear risk of bias, for the majority of sources of bias [49]. Several studies did not provide enough detail to be able to make a clear judgement that they had not introduced bias into their findings, particularly in reference to whether participants were assigned to groups using an adequate randomisation method and whether allocation had been truly concealed. The findings of this review should therefore be viewed in light of the potential bias introduced into the findings of some of the studies included.

It is also worth noting the variety of comparison groups employed within the studies included in this review. In the majority of articles (n= 17), the authors reported that the comparison group received standard care, or treatment as usual. This may have differed between trials. For example in the context of inpatient care, this included medication and attendance at routine therapy groups [32] but in the context of community care, this might have included medication, physician visits and support available community centres [e.g. 48]. However for nine of the studies, the control group received a comparative intervention, consisting of healthcare professional-delivered education about their condition [28; 49] text-delivered education [39], therapist-delivered skills training or psychosocial interventions [34; 41; 27], or computer-delivered activity, such as computer games or education about their condition [20; 24; 35].

Comparison with prior work

This review supports the findings of previous reviews evaluating cognitive training in schizophrenia [52; 53], although evidence suggests that cognitive training is effective regardless of whether it is delivered via computer technologies or non-computerised psychological interventions [52]. Substantial variations in intensities and duration of the interventions that used software to support neurocognitive training may have impacted on the results of these studies. If training was particularly intensive, for example half a day or delivered over several months, it is possible this might have overburdened participants with SMI, leading to a lack of significant findings or reduced participants' attention abilities. A recent meta-analysis suggests that as little as 5 to 15 hours of cognitive remediation could be sufficient for improving cognitive outcomes in schizophrenia [53], suggesting that more intensive cognitive training may not be necessary and that future interventions should be designed with this in mind.

CACR was most commonly assessed offline using PCs and CD-ROM software, with little change in the software used over time. With the rise in more sophisticated technologies, including VR, which in this review was found to improve social and neurocognitive outcomes in SMI, perhaps we can expect to see VR interventions delivered more widely to support SMI outcomes in the coming years. VR has the potential to provide usable and safe, ecologically valid assistance in the management of SMI, as already found in general healthcare [54]. In particular, our findings support a recent systematic review of VR for SMI and was found to be more interesting training than control conditions [55].

We identified surprisingly few studies that had evaluated online interventions to support individuals with SMI. Educational websites were not found to be effective for improving knowledge about medication, adherence, self-esteem, insight into SMI or deprivation of liberty over traditional nurse-delivered education. However, when websites provided more interactive elements than traditional education, such as peer support or CBT-based self-management techniques, improvements in quality of life, mood, and social adaptation were seen. Further research on the psychosocial benefits

of web-based interventions for people with SMI is suggested, particularly given the small number of studies to date and the growing evidence for such interventions in common mental health disorders, including anxiety and depression [56; 57]. Web-based interventions will however need to take the specific needs of people with SMI into account to improve accessibility. For example, service users often report that common website design guidelines produce websites that are confusing for them to use, particularly in the presence of cognitive deficits [58].

The finding that telephones were effective for promoting adherence to medication use and attendance at healthcare appointments was consistent with a recent systematic review [59] of mobile phone-based technologies for supporting general healthcare, and another review for the use of remote technology in SMI [59].Further evidence suggests that the use of telephones has a beneficial impact on adherence over interventions that do not use technology, for example psychoeducation, for patients who are non-adherent due to forgetfulness [60]. While telephone-based interventions may not consistently improve clinical factors associated with SMI, the findings of the studies included in this review give early promise to the use of telephones in supporting adults with SMI to manage their medication. With advances in the function of telephones, including smartphone apps, this provides further opportunities for supporting people with SMI in the future. One might have expected more interventions, however, as Bakker et al [61] recently emphasised, mental health apps have not to date utilized the designs made available by physical health and social networking apps, nor have the hundreds of apps available been tested using formal experimental methods.

The present review also found that the use of telephones improved patients' attitudes towards using their treatment, as well as their quality of life. Leach and Christensen [62] suggest telephones are acceptable and cost-effective uses of technology to support healthcare due to their accessibility and convenience. A large scale survey of users of mental health services in the USA in 2013, found that 72% reported owning a mobile device, and both users and non-users expressed an interest in future

services being offered through mobile devices [63], suggesting that accessing a mobile device may not pose a barrier to people with SMI.

The positive findings for the use of telemonitoring to improve global schizophrenia symptoms, medication adherence and medical and emergency visits, are consistent with reviews that have found positive effects of telemonitoring for managing chronic health conditions, including heart failure [64] and respiratory conditions [65]. Furthermore, a recent review of the use of remote technology for SMI found this to be a feasible and acceptable method of healthcare delivery [66]. These are positive initial results for a form of telehealth that was found to be acceptable from both the service user and healthcare perspective and future research evaluating the use of telemonitoring for SMI could have implications for the delivery of future services for people with SMI.

The finding that computer-mediated consultations led to improvements in quality of life and reduced unmet need in service users with SMI is promising for a novel use of technology, where there is currently a limited evidence base. One recent qualitative study reports that healthcare professionals perceive tablet computers to fill a need between smartphones and desktop computers and have some value in supporting consultations with patients [67]. Tablet computers offered support in structuring consultations, ensuring patients' priorities were discussed [38] thus patients might feel their needs have been better dealt with.

Few studies evaluated the use of remote medication telemonitoring, computer-mediated consultations, or online self-management resources, suggesting these are novel technologies for managing SMI, although all were found to be effective for improving psychosocial and behavioural outcomes. We were surprised to find the limited use of these more advanced technologies in an SMI context, given the rise in their use to support broader healthcare in recent years. For example, online self-management programmes for diabetes [51]. We suggest that future research should seek to establish the full potential benefits of these novel uses of telehealth for improving the management of SMI.

Of note is the varied quality of the studies included in the review, with only five studies rated as high quality. This suggesting high levels of bias were potentially introduced into the results of these studies. Of particular note is the small sample size of the majority of articles in this review, with 19 out of the total 31 studies having samples of fewer than 100 participants. Furthermore the type of comparison or control group employed might have had an influence on the effect size of the intervention evaluated and noteworthy is the variety of comparison groups included in this review. The generalisability of the findings from many of these studies is therefore limited.

Limitations

To our knowledge this is the first systematic review of RCTs across a range of telehealth technology interventions delivered to people with SMI. The studies included in this review measured a plethora of outcomes using heterogeneous measures and a range of interventions, making meta-analysis of the results impossible. In addition, we excluded articles that had not been published in English. It is possible therefore that we excluded relevant foreign language articles from this review. One author performed the data extraction process and while this was not verified by a second author, all authors were involved in the screening process and two authors independently completed the risk of bias assessment, thus several stages of the review process were validated by more than one author.

Noteworthy is the lack of studies that formally evaluated the acceptability of telehealth interventions. Of those that did measure the opinions of their participants, telehealth was found to be acceptable particularly in comparison to more traditional face-to-face methods of the delivery. However, this may depend on whether a face-to-face element to the intervention is also offered, as it has been suggested that this may be preferable over unguided interventions [68]. If telehealth is to be developed to support the care of people with SMI, it is important that acceptability of the interventions is considered as part of the evaluation and formally measured. From a health commissioning perspective, it is also possible that telehealth delivery costs are higher than usual care [1]. Cost-effectiveness was not formally evaluated by the studies included in this review so it is

unclear if this is also the case with interventions in SMI. Future studies should evaluate the costs of using technology to support the management of SMI.

Conclusions

This systematic review has identified a range of ways in which telehealth has been used support the management of SMI and its symptoms. The studies found some strengths of cognitive remediation for schizophrenia, whether delivered by PC and CD-ROM or virtual reality. The use of telephone support from the medical team was consistently found to be effective for improving medication adherence and reducing severity of symptoms and inpatient days. Few studies evaluated the use of remote medication telemonitoring, VR, online self-management and hand-held devices, suggesting these are novel technologies for managing SMI, although all were found to be effective for improving some psychosocial and behavioural outcomes. Patient preferences should be assessed and accommodated, as some may prefer traditional methods of delivery with healthcare staff over computer-based methods. Given the poor quality of all but five of the included trials and that few studies have evaluated the acceptability and cost-effectiveness of using technology to support people with SMI, further studies are needed to establish the potential benefits in these areas.

Acknowledgements

Conflicts of interest

Abbreviations

BEP = Bipolar Education Program

CACR: Computer-assisted cognitive remediation

CBT = Cognitive behavioural therapy

CG = Conventional group

CGI = Clinical Global Impression Scale

EST = Enriched supportive therapy

IPT = Integrated psychological therapy

LWB = Living with Bipolar Disorder

OT = Occupational therapy

PANSS = The Positive and Negative Syndrome Scale

RCT: Randomised controlled trial

SANS = Scale for the Assessment of Negative Symptoms

SD = Standard deviation

SMI: Severe mental illness

SST-TR = Social skills training with traditional role playing

TA = Therapist-administered

TAU: Treatment as usual

VR: Virtual reality

WHOQoL: World Health Organisation Quality of Life Assessment

WLC = Waiting list control

1. Henderson, C, Knapp, M, Fernández, JL, Beecham, J, Hirani, SP, Cartwright, M, & Doll, H Cost effectiveness of telehealth for patients with long term conditions (Whole Systems Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial. BMJ; 2013; 346: f1035.

2. Nickelson, DW Telehealth and the evolving health care system: strategic opportunities for professional psychology. Research and Practice; 1998; 29(6): 527-535

3. VandenBos, GR & Williams, S The internet versus the telephone: what is telehealth anyway? Professional Psychology: Research and Practice; 2000; 31(5): 490-2

4. Polisena, J, Tran, K, Cimon, K, Hutton, B, McGill, S & Palmer, K Home telehealth for diabetes management: a systematic review and meta-analysis. Diabetes Obes Metab; 2009; 11:913-30.

5. Polisena, J, Tran, K., Cimon, K , Hutton, B, McGill, S, Palmer, K, & Scott, R E Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. Journal of telemedicine and telecare; 2010; 16(3), 120-127.

6. Paré, G, Jaana, M, & Sicotte, C Systematic review of home telemonitoring for chronic diseases: the evidence base. Journal of the American Medical Informatics Association; 2007; 14(3), 269-277.

7. Barlow, J, Singh, D, Bayer, S, & Curry, R A systematic review of the benefits of home telecare for frail elderly people and those with long-term conditions. Journal of telemedicine and telecare; 2007; 13(4), 172-179

8. Hommel, K A, Hente, E, Herzer, M, Ingerski, L M, & Denson, L A Telehealth behavioral treatment for medication nonadherence: a pilot and feasibility study. European journal of gastroenterology & hepatology;2013; 25(4): 469.

9. Or, C K, & Karsh, B T A systematic review of patient acceptance of consumer health information technology. Journal of the American Medical Informatics Association;2009 16(4): 550-560.

10. Johnson, D. L. (1997). Overview of severe mental illness. Clinical Psychology Review, 17(3), 247-257.

11. Reda, S, Rowett, M & Makhoul, S Prompts to encourage appointment attendance for people with serious mental illness (Review). The Cochrane Library; 2001: Issue 2

12. Kauppi, K, Välimäki, M, Hätönen, H M, Kuosmanen, L M, Warwick-Smith, K, & Adams, C E Information and communication technology based prompting for treatment compliance for people with serious mental illness. The Cochrane Library; 2014

13. Hailey, D, Roine, R, & Ohinmaa, A The effectiveness of telemental health applications: a review. The Canadian Journal of Psychiatry;2008 53(11): 769-778.

14. van der Krieke, L, Wunderink, L, Emerencia, A C, de Jonge, P, & Sytema, S E–mental health self-management for psychotic disorders: State of the art and future perspectives. Psychiatric services;2014 65(1): 33-49.

15. The Cochrane Collaboration. Data collection form for intervention reviews: RCTs only. Accessed from: http://training.cochrane.org/resource/data-collection-forms-intervention-reviews. Cochrane Library; 2014

16. Higgins, J P T, Altman, DG, Gotzsche, P C, Juni, P, Moher, D, Oxman, A D, Savovic, J, Schulz, K F, Weeks, L & Sterne, J A C The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ; 2011; 343:1-9

17. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS medicine, 6(7), e1000097.

18. Bellucci, D M, Glaberman, K, & Haslam, N Computer-assisted cognitive rehabilitation reduces negative symptoms in the severely mentally ill. Schizophrenia research; 2003 59(2): 225-232

19. Burda, P C, Starkey, T W, Dominguez, F, & Vera, V Computer-assisted cognitive rehabilitation of chronic psychiatric inpatients Computers in Human Behavior; 1994 10(3): 359-368

20. Cavallaro, R, Anselmetti, S, Poletti, S, Bechi, M, Ermoli, E, Cocchi, F, .. & Smeraldi, E Computer-aided neurocognitive remediation as an enhancing strategy for schizophrenia rehabilitation Psychiatry research; 2009; 169(3), 191-196

21. d'Amato, T, Bation, R, Cochet, A, Jalenques, I, Galland, F, Giraud-Baro, E, .. & Brunelin, J A randomized, controlled trial of computer-assisted cognitive remediation for schizophrenia. schizophrenia Research; 2011; 125(2), 284-290

22. Lee, W K Effectiveness of computerized cognitive rehabilitation training on symptomatological, neuropsychological and work function in patients with schizophrenia. Asia-Pacific Psychiatry; 2013 5(2): 90-100.

23. Mak, M, Samochowiec, J, Tybura, P, Bienkowski, P, Karakiewicz, B, Zaremba-Pechmann, L, & Mroczek, B The efficacy of cognitive rehabilitation with RehaCom programme in schizophrenia patients. The role of selected genetic polymorphisms in successful cognitive rehabilitation. Annals of Agricultural and Environmental Medicine; 2013 20(1): 77-81

24. Keefe, R S, Vinogradov, S, Medalia, A, Buckley, P F, Caroff, S N, D'Souza, D C, .. & Marder, S M Feasibility and pilot efficacy results from the multisite Cognitive Remediation in the Schizophrenia Trials Network (CRSTN) randomized controlled trial. The Journal of clinical psychiatry; 2012 73(7): 1016-1022.

25. Rass, O, Forsyth, J K, Bolbecker, A R, Hetrick, W P, Breier, A, Lysaker, P H, & O'Donnell, B F Computer-assisted cognitive remediation for schizophrenia: a randomized single-blind pilot study. schizophrenia Research; 2012 139(1): 92-98.

26. Sartory, G, Zorn, C, Groetzinger, G, & Windgassen, K Computerized cognitive remediation improves verbal learning and processing speed in schizophrenia research; 2005 75(2): 219-223.

27. Vita, A, De Peri, L, Barlati, S, Cacciani, P, Deste, G, Poli, R, .. & Sacchetti, E Effectiveness of different modalities of cognitive remediation on symptomatological, neuropsychological, and functional outcome domains in schizophrenia: a prospective study in a real-world setting. Schizophrenia Research; 2011 133(1): 223-231.

28. Hogarty, G E, Flesher, S, Ulrich, R, Carter, M, Greenwald, D, Pogue-Geile, M, .. & Parepally, H Cognitive enhancement therapy for schizophrenia: effects of a 2-year randomized trial on cognition and behavior. Archives of general psychiatry; 2004 61(9): 866-876

29. Kurtz, M, Seltzer, J C, Shagan, D S, Thime, W R, & Wexler, B E Computer-assisted cognitive remediation in schizophrenia: what is the active ingredient? Schizophrenia research; 2007 89(1): 251-260.

30. Dickinson, D, Tenhula, W, Morris, S, Brown, C, Peer, J, Spencer, K, .. & Bellack, AS A randomized, controlled trial of computer-assisted cognitive remediation for schizophrenia. American Journal of Psychiatry; 2010 167(2): 170-180

31. Hermanutz, M, & Gestrich, J Computer-assisted attention training in schizophrenics European Archives of Psychiatry and Clinical Neuroscience; 1991 240(4-5): 282-287

32. Benedict, R H, Harris, A E, Markow, T, McCormick, J A, Nuechterlein, K H, & Asarnow, R F Effects of attention training on information processing in schizophrenia. Schizophrenia Bulletin; 1994 20(3): 537-546

33. Chan, C L, Ngai, E K, Leung, P K, & Wong, S Effect of the adapted virtual reality cognitive training program among Chinese older adults with chronic schizophrenia: a pilot study. International journal of geriatric psychiatry; 2010 25(6): 643-649

34. Tsang, M, & Man, D W A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation. Schizophrenia research; 2013 144(1): 51-62.

35. Jones, R B, Atkinson, J M, Coia, D A, Paterson, L, Morton, A R, McKenna, K, .. & Gilmour, W H Randomised trial of personalised computer based information for patients with schizophrenia. BMJ; 2001 322(7290): 835-840

36. Montes, J M, Maurino, J, Diez, T, & Saiz-Ruiz, J Telephone-based nursing strategy to improve adherence to antipsychotic treatment in schizophrenia: A controlled trial International journal of psychiatry in clinical practice; 2010 14(4): 274-281.

37. Frangou, S, Sachpazidis, I, Stassinakis, A, & Sakas, G Telemonitoring of medication adherence in patients with schizophrenia Telemedicine Journal & E-Health; 2005 11(6): 675-683

38. Priebe, S, McCabe, R, Bullenkamp, J, Hansson, L, Lauber, C, Martinez-Leal, R, .. & Van den Brink, R Structured patient–clinician communication and 1-year outcome in community mental healthcare. The British Journal of Psychiatry; 2007 191(5): 420-426.

39. Proudfoot, J, Parker, G, Manicavasagar, V, Hadzi-Pavlovic, D, Whitton, A, Nicholas, J, .. & Burckhardt, R Effects of adjunctive peer support on perceptions of illness control and understanding in an online psychoeducation program for bipolar disorder: a randomised controlled trial. Journal of affective disorders; 2012 142(1): 98-105.

40. Todd, N J, Jones, S H, Hart, A, & Lobban, FA A web-based self-management intervention for bipolar disorder 'living with bipolar': a feasibility randomised controlled trial. Journal of affective disorders; 2014 169: 21-29.

41. Park, K M, Ku, J, Choi, S H, Jang, H J, Park, J Y, Kim, S I, & Kim, J J A virtual reality application in role-plays of social skills training for schizophrenia: a randomized, controlled trial. Psychiatry research; 2011 189(2):166-172.

42. Hansson, L, Svensson, B, Björkman, T, Bullenkamp, J, Lauber, C, Martinez-Leal, R, .. & Van Den Brink, R What works for whom in a computer-mediated communication intervention in community

psychiatry? Moderators of outcome in a cluster randomized trial. Acta Psychiatrica Scandinavica; 2008 118(5): 404-409

43. Simon, G E, Ludman, E J, UnÜtzer, J, Bauer, M S, Operskalski, B, & Rutter, C Randomized trial of a population-based care program for people with bipolar disorder. Psychological medicine; 2005 35(01): 13-24.

44. Simon, G E, Ludman, E J, Bauer, M S, Unützer, J, & Operskalski, B Long-term effectiveness and cost of a systematic care program for bipolar disorder. Archives of general psychiatry; 2006 63(5): 500-508.

45. Kuosmanen, L, Välimäki, M, Joffe, G, Pitkänen, A, Hätönen, H, Patel, A, & Knapp, M The effectiveness of technology-based patient education on self-reported deprivation of liberty among people with severe mental illness: a randomized controlled trial. Nordic journal of psychiatry; 2009 63(5): 383-389.

46. Wing, J.K., Beevor, A.S., Curtis, R.H., Park, S.B., Hadden, S., Burns, A., 1998. Health of the Nation Outcome Scales (HoNOS). Research and development. Br. J. Psychiatry 172, 11–18.

47. Nuechterlein KH, Green MF, Kern RS, et al. The MATRICS consensus cognitive battery: Part 1. Test selection, reliability, and validity. Am J Psychiatry. 2008; 165:203–213.

48. Beebe, L H, Smith, K, Crye, C, Addonizio, C, Strunk, D J, Martin, W, & Poche, J Telenursing intervention increases psychiatric medication adherence in schizophrenia outpatients. Journal of the American Psychiatric Nurses Association; 2008 14(3): 217-224

49. Madoff, S A, Pristach, C A, Smith, C M, & Pristach, E A Computerized medication instruction for psychiatric inpatients admitted for acute care. MD computing: computers in medical practice; 1995 13(5): 427-31.

50. Španiel, F, F, Hrdlicka, J, Novak, T, Kozeny, J, Hoeschl, C, Mohr, P, & Motlova, L B Effectiveness of the information technology-aided program of relapse prevention in schizophrenia (ITAREPS): a randomized, controlled, double-blind study. Journal of Psychiatric Practice; 2012 18(4):269-280.

51. Pal, K., Eastwood, S. V., Michie, S., Farmer, A. J., Barnard, M. L., Peacock, R., ... & Murray, E. (2010). Computer-based diabetes self-management interventions for adults with type 2 diabetes mellitus. Cochrane Database Syst Rev, 3.

52. Twamley, EW, Jeste, DV, & Bellack, AS A review of cognitive training in schizophrenia. Schizophrenia bulletin;2003 29(2): 359.

53. McGurk, SR, Twamley, E W, Sitzer, D I, McHugo, G J, & Mueser, K T A meta-analysis of cognitive remediation in schizophrenia. American Journal of Psychiatry;2007 164(12): 1791-1802.

54. Schultheis, MT, & Rizzo, AA The application of virtual reality technology in rehabilitation. Rehabilitation psychology;2001 46(3): 296.

55. Välimäki, M, Hätönen, H M, Lahti, M E, Kurki, M, Hottinen, A, Metsäranta, K, Riihimäki, T & Adams, C E Virtual reality for treatment compliance for people with serious mental illness. The Cochrane Library; 2014

56. Grist, R, & Cavanagh, K Computerised cognitive behavioural therapy for common mental health disorders, what works, for whom under what circumstances? A systematic review and meta-analysis. Journal of Contemporary Psychotherapy; 2013 43(4):243-251

57. Richards, D, & Richardson, T Computer-based psychological treatments for depression: a systematic review and meta-analysis. Clinical psychology review;2012 32(4): 329-342.

58. Rotondi, AJ, Sinkule, J, Haas, GL, Spring, MB, Litschge, CM, Newhill, CE, .. & Anderson, CM Designing websites for persons with cognitive deficits: Design and usability of a psychoeducational intervention for persons with severe mental illness. Psychological Services;2007 4(3): 202.

59. Free, C, Phillips, G, Watson, L, Galli, L, Felix, L, Edwards, P, .. & Haines, A The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis. PLoS medicine;2013 10(1): e1001363.

60. Naslund, J A, Marsch, LA, McHugo, GJ, & Bartels, SJ Emerging mHealth and eHealth interventions for serious mental illness: a review of the literature. Journal of mental health; 2015 24(5): 321-332.

61. Bakker, D., Kazantzis, N., Rickwood, D., & Rickard, N. (2016). Mental health smartphone apps: review and evidence-based recommendations for future developments. *JMIR mental health*, *3*(1).

62. Leach, LS, & Christensen, H A systematic review of telephone-based interventions for mental disorders. Journal of Telemedicine and Telecare; 2006 12(3): 122-129.

63. Ben-Zeev, D, Davis, KE, Kaiser, S, Krzsos, I, & Drake, RE Mobile technologies among people with serious mental illness: opportunities for future services. Administration and Policy in Mental Health and Mental Health Services Research;2013 40(4): 340-343.

64. Chaudhry, SI, Mattera, JA, Curtis, JP, Spertus, JA, Herrin, J, Lin, Z, .. & Krumholz, HM Telemonitoring in patients with heart failure. New England Journal of Medicine;2010 363(24): 2301-2309.

65. Jaana, M, Paré, G, & Sicotte, C Home telemonitoring for respiratory conditions: a systematic review. The American journal of managed care;2009 15(5): 313-320.

66. El-Mallakh, P, & Findlay, J Strategies to improve medication adherence in patients with schizophrenia: the role of support services. Neuropsychiatric disease and treatment; 2015 11: 1077.

67. Anderson, C, Henner, T, & Burkey, J Tablet computers in support of rural and frontier clinical practice. International journal of medical informatics;2013 82(11): 1046-1058.

68. Apolinário-Hagen, J, Kemper, J, & Stürmer, C Public acceptability of E-mental health treatment services for psychological problems: A scoping review. JMIR mental health;2017 4(2).