1   **Title:** *Digital health interventions for children and young people with mental health*

2   *problems: a systematic and meta-review*

3   **Abbreviated title**: DHIs for children and young people's mental health

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15   <u>Word count</u>: 12,433

16   **ABSTRACT**

17   **Background:** Digital health interventions (DHIs), including computer-assisted therapy,

18   smartphone apps and wearable technologies, are heralded as having enormous potential

19   to improve uptake and accessibility, efficiency, clinical effectiveness and personalisation

20   of mental health interventions. It is generally assumed that DHIs will be preferred by

21   children and young people (CYP) given their ubiquitous digital activity. However, it remains

22   uncertain whether: DHIs for CYP are clinically and cost-effective, CYP prefer DHIs to

23   traditional services, DHIs widen access and how they should be evaluated and adopted by

24   mental health services. This review evaluates the evidence-base for DHIs and considers

25   the key research questions and approaches to evaluation and implementation.

26   **Methods:** We conducted a meta-review of scoping, narrative, systematic or meta-

27   analytical reviews investigating the effectiveness of DHIs for mental health problems in

28   CYP. We also updated a systematic review of RCTs of DHIs for CYP published in the last

29   three years.

30   **Results:** 21 reviews were included in the meta-review. The findings provide some support

31   for the clinical benefit of DHIs, particularly computerised CBT (cCBT), for depression and

32   anxiety in adolescents and young adults. The systematic review identified 30 new RCTs

33   evaluating DHIs for ADHD, autism, anxiety, depression, psychosis, eating disorders and

34   PTSD. The benefits of DHIs in managing ADHD, autism, psychosis and eating disorders

35   are uncertain, and evidence is lacking regarding the cost-effectiveness of DHIs.

36   **Conclusions:** Key methodological limitations make it difficult to draw definitive

37   conclusions from existing clinical trials of DHIs. Issues include variable uptake and

38   engagement with DHIs, lack of an agreed typology/taxonomy for DHIs, small sample sizes,

39   lack of blinded outcome assessment, combining different comparators, short-term follow-

40   up and poor specification of the level of human support. Research and practice

41   recommendations are presented that address the key research questions and

42   methodological issues for the evaluation and clinical implementation of DHIs for CYP.

43   **Keywords:** digital health, mental health, eHealth, methodology, randomised controlled

44   trials, prevention

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46

INTRODUCTION

The past decade has seen a significant increase in the prevalence of mental health problems in children and young people (CYP) (Collishaw, 2015), with the worldwide prevalence rate of mental disorders in CYP now estimated to be 13.4% (Polanczyk, Salum, Sugaya, Caye & Rohde, 2015). With increasing demand on child and adolescent mental health services (CAMHS), the access to evidence-based psychological treatments is severely limited by the supply of trained mental health practitioners, and it is estimated that 75% of CYP with mental health problems in the U.K. receive no treatment at all (Davies, 2014).

Digital technology and digital health interventions (DHIs) have been heralded as offering enormous potential as scalable tools to improve outcomes, to widen access and meet the increasing demand on mental health services. Suggested benefits of DHIs include improved uptake and accessibility, efficiency, clinical effectiveness and personalisation of mental health interventions. Given the strength of these claims with respect to health service policy and implementation, it is important that they are tested empirically.

It is commonly assumed that because young people are ubiquitous consumers and users of digital technology for social and recreational purposes, they will be equally enthusiastic recipients of DHIs (Johnson, Fuchs, Horvath & Scal, 2015). These assumptions may often drive digital health service transformation but are rarely tested. The ability of digital technology to deliver automated and self-directed interventions is frequently argued as a way to improve access, ease pressures on face-to-face (FtF) services, and avoid the reported stigma associated with physical visits to mental health services (Hollis et al., 2015).

The range and scope of DHIs and digitally-delivered healthcare services have evolved rapidly since Eysenbach's (2001) initial description of internet-enabled or computer-enabled interventions. These early DHIs in the mental health field typically contained static content with limited interactivity and were 'fixed' in terms of access (e.g. via a PC or

74   laptop, requiring a wired internet connection), meaning that users needed to be in a

75   specific location to access the intervention. Examples of these DHIs include computerised

76   cognitive behavioural therapy (cCBT) (see Table 1. for a glossary of digital health

77   terminology) which typically mimics FtF-delivered CBT sessions by providing a series of

78   discrete modules that users complete sequentially over a specific time period. Recent

79   advances in computerised technologies and programming has led to the possibility of cCBT

80   interventions becoming more interactive and adaptable for young people though use of

81   gamification and 'serious games' (Fleming et al., 2014). DHIs also include

82   telecommunications processes (e.g. text messaging, emailing, video conferencing) to

83   support remote synchronous and asynchronous delivery of therapy (Boogerd, Arts,

84   Engelen & van de Belt, 2015; Naslund, Marsch, McHugo & Bartels, 2015; Zulman et al.,

85   2015). These approaches are often referred to as 'tele-health', 'tele-medicine' or 'tele-

86   psychiatry' and fall within the broad description of 'eHealth' (see Table 1.).

87   Over the last decade, the increased popularity and availability of mobile digital

88   technologies, such as smartphones and wearable technologies, has led to the development

89   and evaluation of mobile DHIs, also known as 'mHealth' (see Table 1.). mHealth DHIs

90   include smartphone applications ('apps'), remote monitoring and tracking devices, and

91   wearable computers (e.g. smartwatches, virtual reality headsets).Remote active and

92   passive monitoring of parameters, such as mood, activity and sleep, are now being

93   integrated with therapeutic interventions. Hence, the distinction between mHealth digital

94   monitoring and interventions is likely to become increasingly blurred.

95   DHIs vary widely with respect to design, mode of delivery and the mechanisms through

96   which they aim to change mental health and wellbeing. Typically, DHIs include content

97   (e.g. educational text, pictures and videos) and/or processes (e.g. games, mood trackers)

98   that relate to the mental health problem being targeted. They can be accessed through

99   different hardware (e.g. laptops, mobile phones, smartphones, wearables) and involve

100 varied levels of interactivity. For example, *MoodGym* (a free publically-available cCBT

101 course) is accessed online through a web browser and consists of five modules relating to

102 understanding and managing depression and anxiety. Originally launched in 2001,

103 *MoodGym*'s content is delivered through an eLearning format consisting of text, images,

104 animations, and interactive activities and quizzes (Christensen, Griffiths & Korten, 2002).

105 An example of a more recently developed DHI, *FindMe* (a publically-available app) is a

106 game designed for children with autism to practice social skills, which can run on a tablet

107 computer regardless of internet connectivity (Fletcher-Watson et al., 2015).

108   [Table 1 approximately here]

109 The number of DHIs aimed at CYP's mental health is growing rapidly (particularly mHealth

110 apps) and outstrips the capacity of traditional randomised controlled trials (RCTs) to

111 generate evidence of effectiveness. In 2015, mental health apps made up almost a third

112 of disease-specific apps in app marketplaces (IMS Institute for Healthcare Informatics,

113 2015). As RCTs typically take five to seven years from initiation to reporting, this time

114 frame is too slow to keep pace with the growth of DHIs. Given the continuing process of

115 improvement and iterations in digital technology platforms and interfaces, it is likely that

116 a DHI may be obsolete by the time a RCT is completed (Schueller, Muñoz & Mohr, 2013).

117 One possible solution to rationalising the requirement for RCTs for all DHIs is to apply the

118 concept of 'substantial equivalence' as used for medical device and pharmaceutical

119 regulation by the US FDA and similar regulatory bodies. Essentially, if a pivotal trial exists,

120 DHIs meeting criteria for 'substantial equivalence' would not require further RCT evidence.

121 For example, if a pivotal RCT (or meta-analysis) demonstrated effectiveness of a cCBT DHI

122 for depression in CYP, then each subsequent version/iteration of a cCBT DHI for depression

123 would not be required to demonstrate further RCT efficacy and safety evidence – but rather

124 substantial equivalence to existing 'predicate' interventions (FDA U.S. Food & Drug

125 Administration, 2014). If substantial equivalence was established, then the relevant data

126 to collect would then focus on usage, adherence, demographic access parameters, and

127 user preferences (Murray et al., in press).

128

129   Reviews of previous research have highlighted the disappointingly poor quality of RCTs of

130   DHIs. In particular, there are major difficulties combining and comparing trials in

131   systematic reviews and meta-analyses without clear specification of the DHI, including the

132   theoretical underpinning of the intervention, mode of digital delivery, level of therapist

133   input, and selection of intervention comparator. There have been attempts to standardise

134   and improve reporting of trials in the field with an eHealth version of the Consolidated

135   Standards of Reporting Trials statement ('CONSORT eHealth') (Eysenbach & CONSORT

136   eHealth Group, 2011). However, the uptake and impact of this and other reporting

137   standards on the design and conduct of RCTs of DHIs remains to be established.

138   In addition to establishing the evidence-base for the clinical and cost-effectiveness of DHIs,

139   we need better evidence on usability, acceptability and adherence with DHIs (i.e. do CYP

140   actually want to use DHIs for mental health problems?), whether DHIs actually widen

141   access, and how they should best be integrated into mental health services.

142   In this review we address the broad question of whether the promise and potential of DHIs

143   has been realised. Firstly, we review the evidence for the clinical and cost-effectiveness of

144   DHIs for mental health problems in CYP by conducting a synthesis of previous reviews and

145   an updated systematic review of RCTs of DHIs in CYP (NCCMH, 2014; Pennant et al.,

146   2015). Secondly, we identify and discuss the key research questions, methodological and

147   clinical issues related to the future development, evaluation and implementation of DHIs.

148   **METHODS**

149   **Meta-Review**

150   **Inclusion criteria**

151   We included scoping reviews, narrative reviews, systematic reviews, and meta-analyses

152   that focused on the evaluation of DHIs for improving mental health outcomes in CYP.

153   Reviews of interventions (e.g. CBT, self-help) that were adapted for digital delivery (e.g.

154   cCBT as an adaptation of FtF CBT) were included if they reported analyses relating to the

155   digital version of the intervention and included ≥2 studies. Reviews that reported results

156   for adults were included if they separately reported analyses/findings for CYP, and included

157   >2 studies of DHIs in CYP. Included reviews had to be peer-reviewed and in English.

158   **Search strategy**

159   Two authors (BD and CF) devised the search strategy by collating MeSH terms and

160   keywords reflecting: a) CYP (e.g. child, adolescent, young person); b) mental health

161   disorders; c) DHIs (e.g. internet interventions, apps, eHealth); and d) the sub-types of

162   review included in the meta-review. The search was run on eleven online databases (Allied

163   and Complementary Medicine, Ovid, MEDLINE, PsychINFO, PsychARTICLES, Embase,

164   PubMed, ASSIA, Cochrane Library, CINAHL, and Web of Science), and a limited keyword

165   search was also performed on the JMIR Publications database. The search was performed

166   between 16th-19th November 2015, with a cut-off publication date of November 1st 2015.

167   Reference lists of included reviews were hand-searched for additional publications. Each

168   review's eligibility was assessed by BD through screening citation titles, with uncertainties

169   discussed with CF and full-texts accessed if necessary. The full search terms and process

170   are available in Appendix 1.

171   **Data extraction and synthesis**

172   Data extraction was conducted by BD using a template to collate the review's methodology

173   (e.g. aim of review, date of search), focus (e.g. type of intervention, age-group, and type

174   of mental health problem), search findings (e.g. number of papers, information about

175   interventions in review), and synthesis of the findings (e.g. descriptive or quantitative

176   synthesis). The data were checked by CF for accuracy. The heterogeneity of the included

177   reviews precluded a meta-analysis of the extracted data, and our findings are presented

178   as a systematic narrative review.

179   The AMSTAR tool was used to assess the methodological quality of systematic reviews and

180   meta-analyses included in the meta-review (Shea et al., 2007). This tool is an 11-item

181   checklist of questions to appraise review quality: a 'yes' response is given a score of one,

182   with 'no', 'can't answer' and 'not applicable' responses given scores of zero. This results in

183   scores that range from 0-to-11, with three categories of methodological quality: 0-4

184   indicate 'low' quality, 5-8 'moderate' quality, and 9-11 'high' quality. Following guidance

185   from a previous meta-review (Joyce et al., 2015), an alternate categorisation system was

186   used for systematic reviews without a meta-analysis: 0-3 indicated 'low' quality, 4-7

187   'moderate', and 8-9 as 'high' quality. Each included review was assessed independently

188   by BD and CF, with any disagreements discussed to reach consensus.

189   **Systematic review**

190   **Search strategy**

191   Our review updated a previous systematic review, using the same inclusion/exclusion

192   criteria, search protocol and methodology as NCCMH (2014) and Pennant et al (2015)

193   (NCCMH, 2014). To be included in the review, participants had to be aged <25 years.

194   Studies that included participants aged ≥18 yrs were included if either a) the sample's

195   mean age was ≤18 years, or b) all participants were aged ≤25 years. Additional keywords

196   were added to the search to include recent technological developments in eHealth (e.g.

197   apps, ecological momentary assessment, virtual reality and wearable devices). The

198   updated search identified papers published from June 2013 to December 31st 2015. The

199   full search protocol and terms are available in Appendices 2 and 3.

200   **Study selection and data extraction**

201   Citations from the search were screened for eligibility by CF and categorised as either

202   'eligible' or 'potentially eligible'. All 'potentially eligible' citations were read in full by CF

203   and BD to identify whether they met full inclusion criteria, with any uncertainties

204   discussed. Data extraction for eligible studies was conducted by CF and BD using a

205   template. This included information about study design (e.g. number of trial arms), the

206   target condition, main intervention evaluated (e.g. theoretical approach, type of

207   technology used to deliver intervention, location of delivery, level of human/therapist

208   support), inclusion/exclusion criteria, type of comparator, sample size, number of

209   participants in each trial arm, participant characteristics (e.g. age, gender, baseline

210   symptomology), primary and secondary outcome measures, fidelity and adherence

211   measures, key findings, and reporting of adverse events.

212   **RESULTS**

213   **Findings from search: Meta review**

214   A total of 1678 citations were identified through the search. After screening each citation's

215   title, 105 were identified as potentially eligible and the abstract read. The full texts of 37

216   articles were reviewed and 21 selected for inclusion. Figure 1 depicts the search process.

217   [Figure 1 approximately here]

218   The 21 reviews consisted of two scoping reviews (Boydell et al., 2014; Seko, Kidd, Wiljer

219   & McKenzie, 2014), 12 systematic reviews (Ali, Farrer, Gulliver & Griffiths, 2015; Calear &

220   Christensen, 2010; Clarke, Kuosmanen & Barry, 2015; Farrer et al., 2013; Fleming, et al.,

221   2014; Hailey, Roine & Ohinmaa, 2008; Reyes-Portillo et al., 2014; Rice et al., 2014;

222   Richardson, Stallard & Velleman, 2010; Rickwood & Bradford, 2012; Schlegl, Burger,

223   Schmidt, Herbst & Voderholzer, 2015; Siemer, Fogel & Van Voorhees, 2011), two meta-

224   analyses (Ebert et al., 2015; Podina, Mogoase, David, Szentagotai & Dobrean, 2015), and

225   five combined systematic reviews and meta-analyses (Davies, Morriss & Glazebrook,

226   2014; Newton & Ciliska, 2006; Pennant, et al., 2015; Rooksby, Elouafkaoui, Humphris,

227   Clarkson & Freeman, 2015; Ye et al., 2014).

228   The 21 reviews contained a total of 190 papers focused on the evaluation of approx. 147

229   unique DHIs. Appendix 4 cross-tabulates the DHIs in the 21 reviews. The majority of the

230   reviews were focused on the clinical effectiveness of DHIs, in particular cCBT (including

231   electronically-delivered CBT and internet-delivered CBT; see Table 1.), for anxiety and

232   depression. The reviews are summarised in Table 2.

233   **Methodological quality of included reviews**

234   Two included reviews used a scoping methodology and so were not included in the AMSTAR

235   rating (Boydell, et al., 2014; Seko, et al., 2014). Using the AMSTAR checklist, the majority

236   of systematic reviews (N=9) and all reviews with meta-analyses (N=9) were rated as

237   having 'moderate' methodological quality. Of the remaining systematic reviews, two were

238   rated 'low' and one as being 'high' quality. Nine reviews explicitly stated that they included

239   grey and unpublished literature in their review (Ali, et al., 2015; Calear & Christensen,

240   2010; Clarke, et al., 2015; Farrer, et al., 2013; Newton & Ciliska, 2006; Podina, et al.,

241   2015; Richardson, et al., 2010; Rickwood & Bradford, 2012; Ye, et al., 2014). Five reviews

242   commented on the proportion of included studies that used intention-to-treat (ITT)

243   analyses (Ali, et al., 2015; Davies, et al., 2014; Ebert, et al., 2015; Farrer, et al., 2013;

244   Rooksby, et al., 2015). In the two meta-analyses of cCBT for anxiety and/or depression,

245   inspections and analyses of funnel plots suggested some possible publication bias (Arnold

246   et al., 2013; Ebert, et al., 2015; Podina, et al., 2015), while Davies et al's (2014) review

247   of computer and web-based interventions did not appear to find unusual symmetry in

248   funnel plots. Using the trim-and-fill procedures, Podina et al. (2015) found no evidence of

249   publication bias in six studies with cCBT-waitlist comparisons, but one study (out of four)

250   using a cCBT versus FtF CBT comparison design showed a higher-than-expected effect size

251   that did not significantly change the meta-analytic findings. Using the same procedure,

252   Ebert et al (2015) found that adjusting for missing studies did not result in significant

253   changes upon meta-analysis findings.

254   **Findings from search: Systematic review**

255   Our updated search identified 5291 citations, reduced to 3748 after removing duplicates.

256   120 were identified as potentially eligible and their full-texts read. Thirty-one publications

257   met inclusion criteria: two were from the same trial, resulting in 30 unique RCTs. These

258   trials evaluated DHIs aimed at improving outcomes in attention deficit/hyperactivity

259   disorder (ADHD) (N=10), autism spectrum disorders (ASD) (N=3), psychosis (N=1),

260   anxiety (N=4), depression (N=6), anxiety and depression (N=3), eating disorders (N=2),

261   and post-traumatic stress disorder (PTSD) and depression (N=1). Figure 2 illustrates this

262   process. A total of 5273 participants (M=175.7, Mdn=89) were randomised across the 30

263   studies. Table 3 provides a summary of included studies, including the numbers of

264   dropouts in each study. Unless otherwise stated, study results are from ITT analyses.

265   [Figure 2 approximately here]

266   [Table 2 approximately here]

267   [Table 3 approximately here]

268

269   **Clinical outcomes**

270   **Anxiety and depression**

271   **Meta-review findings**

272   Twelve reviews focused on anxiety and/or depression, predominantly with modularised

273   cCBT interventions compared to either inactive (e.g. waitlist, no treatment) or active non-

274   therapeutic (e.g. attention) controls.

275   Six reviews included meta-analyses of anxiety and/or depression outcomes (Davies, et al.,

276   2014; Ebert, et al., 2015; Pennant, et al., 2015; Podina, et al., 2015; Ye, et al., 2014),

277   predominantly comparing the experimental intervention to 'non-active' or 'non-

278   therapeutic' controls (e.g. waitlist, placebo). Meta-analyses found support for the

279   effectiveness of cCBT in CYP with small-to-moderate effects (g=.16 to .62) on depression

280   outcomes, and moderate-to-large effects (g=.53 to 1.41) for cCBT targeting anxiety.

281   Heterogeneity varied considerably across analyses (I^2 range: 0% to 92.6%). One review

282   found cCBT interventions were effective for anxiety outcomes in adolescents and young

283   adults (age 12-25 years) but not in children (age 5-11 years) (Pennant, et al., 2015).

284   Analyses comparing cCBT to an active comparator failed to show superiority of DHIs for

285   anxiety and depression outcomes (Davies, et al., 2014; Ye, et al., 2014), while Pennant

286   et al.'s (2015) analysis of two trials supported superiority of FtF CBT over cCBT. Through

287   the use of an evidence-base level criteria tool to classify interventions into different

288   categories of efficacy, Reyes-Portillo et al. (2014) suggests the evidence for effectiveness

289   is strongest for *BRAVE-Online* and categorises it as a 'probably efficacious' DHI.

290   Two reviews that compared non-cCBT DHIs (e.g. problem-solving therapy, cognitive bias

291   modification) for anxiety and/or depression found that these interventions had mixed or

292   uncertain effects (Pennant, et al., 2015; Reyes-Portillo, et al., 2014), with meta-analyses

293   failing to demonstrate superiority of non-cCBT DHIs (Pennant, et al., 2015).

294   In looking at whether parents were involved in the DHI delivery, Podina et al. (2015)

295   comment that as the majority (five out of six) of studies using a cCBT-waitlist comparison

296   involved a degree of parental support, it would suggest that parents are needed in order

297   for the intervention to produce positive outcomes. In their meta-analysis of cCBT for

298   depression and anxiety in CYP, Ebert et al. (2015) classified interventions by their level of

299   parental involvement: parents were involved in six (out of 13) studies. Parental

300   involvement was not found to be associated with effect sizes (g=0.64, compared to g=0.83

301   in studies with no parental involvement), suggesting that parental support may not be

302   needed to see positive results. Parental involvement may be particularly needed with

303   younger CYP to support engagement (i.e. starting and working with the intervention)

304   (Pennant, et al., 2015).

305   Three reviews reported results separately for different age groups or reported on age as

306   a moderating variable. The effects of DHIs on anxiety and depression outcomes were

307   greater in adolescents and young adults than in children (Ebert, et al., 2015; Pennant, et

308   al., 2015; Podina, et al., 2015). A meta-analysis combining both anxiety and depression

309   outcomes Ebert et al. (2015) found a larger effect size (g=0.95) with adolescents (aged

310   ≥13 years), compared with children (aged ≤12 years, g=0.51) and studies combining

311   adolescents and children (g=0.48). Pennant et al. (2015) found effects for anxiety cCBT

312   interventions to be greater for young people aged 18–25 years than young people aged

313   12-17 yrs. However, the 18 to 25 year olds also had higher baseline anxiety scores which

314   may account for larger effects.

315

Systematic review findings

Almost half of the 30 RCTs evaluated DHIs for depression (N=6), anxiety (N=4), or both depression and anxiety (N=4).

i.   Depression

Six RCTs evaluated DHIs for depression (Kramer, Conijn, Oijevaar & Riper, 2014; Lillevoll, Vangberg, Griffiths, Waterloo & Eisemann, 2014; Saulsberry et al., 2013; Smith et al., 2015; Stasiak, Hatcher, Frampton & Merry Sally, 2014; Yang, Ding, Dai, Peng & Zhang John, 2014). Three DHIs used cCBT (*MoodGym*, *StressBusters*, and *The Journey*) (Lillevoll, et al., 2014; Smith, et al., 2015; Stasiak, et al., 2014); one DHI (*Project CATCH-IT*) incorporated behavioural activation, CBT, interpersonal psychotherapy, and community resiliency concept model (Saulsberry, et al., 2013); one DHI delivered one-to-one chatroom-based Solution-Focused Brief Therapy (SFBT) (*PratenOnline)* (Kramer, et al., 2014); and one DHI used computer-based attention bias modification (ABM) training (Yang, et al., 2014). 1345 participants were included in the six depression trials, with sample sizes ranging from 34 to 775 (M=224, Mdn=98). Studies targeted adolescents and young adults, ranging from 12 to 22 years old (M=17.6, Mdn=17.3). At post-intervention assessment, attrition ranged from 0% (Yang, et al., 2014) to 42.2% (Kramer, et al., 2014) (M=16%, Mdn=11.5%). Lillevoll et al. (2014) found substantial non-participation from the *MoodGYM* intervention, with only 8.5% (45/527) participants logging on*,* and few proceeding beyond the first part of the programme. Unlike the other included RCTs, Lillevoll et al. (2014) had a naturalistic design that did not control or monitor the location where the intervention was accessed. Although participants were randomised to receive one of three types of email-reminder (plus a waitlist control group), it was their own choice to create a *MoodGYM* user account to access and use the online intervention.

Five trials recruited participants with elevated depression scores (Kramer, et al., 2014; Smith, et al., 2015; Stasiak, et al., 2014; Yang, et al., 2014) or persistent subthreshold

342   depression (Saulsberry, et al., 2013). One trial was a population-based intervention,

343   where elevated baseline depressive symptoms were not an inclusion criterion (Lillevoll, et

344   al., 2014). Severe depressive symptomology, or a diagnosis of major depression, were

345   exclusion criteria for five studies. Two of the studies involved interventions accessed at

346   school (Smith, et al., 2015; Stasiak, et al., 2014); three evaluated interventions accessed

347   at a time and location chosen by the young person (Kramer, et al., 2014; Lillevoll, et al.,

348   2014; Saulsberry, et al., 2013); and one was accessed in a laboratory setting (Yang, et

349   al., 2014).

350   The level of human and technical support provided to participants varied greatly between

351   DHIs. The RCT of *MoodGym* involved three trial arms: one condition received no prompts

352   (i.e. completely unguided), while the other two arms received automated emails which

353   were either tailored or untailored to participants' baseline data (Lillevoll, et al., 2014).

354   *Project CATCH-IT* was delivered in conjunction with a one-off FtF meeting with a primary

355   care physician (Saulsberry, et al., 2013). Adolescents received *The Journey* cCBT

356   intervention within school time with "minimal oversight from school counsellors" (Stasiak,

357   et al., 2014). *PratenOnline* provided online chat-based SFBT that involved secure, one-to-

358   one, synchronous remote live therapy (Kramer, et al., 2014). Two studies did not specify

359   support provided with the DHIs (Smith, et al., 2015; Yang, et al., 2014).

360   These recent studies were associated with greater pre-post improvements in depression

361   outcomes, compared to: waitlist control (Kramer, et al., 2014; Smith, et al., 2015); no

362   intervention (Yang, et al., 2014); a computer-delivered psychoeducational program

363   (Stasiak, et al., 2014); a placebo version of ABM training (Yang, et al., 2014); and a group

364   who received the same *Project CATCH-IT* DHI but with briefer FtF advice from practitioners

365   (Saulsberry, et al., 2013). Additionally, *Project CATCH-IT* reduced hopelessness and self-

366   harming thoughts (Saulsberry, et al., 2013), while computer-based ABM training had no

367   effects on ruminations (Yang, et al., 2014). As a result of low-take up of *MoodGym*, Lillevoll

368   et al. (2014) performed 'users vs. non-users' analyses but failed to find any significant

369   intervention effects for depressive symptoms and did not perform ITT analysis.

370   Four trials reported post-intervention follow up data extending from 3 to 12 months

371   (Kramer, et al., 2014; Saulsberry, et al., 2013; Smith, et al., 2015; Yang, et al., 2014).

372   Over a quarter (28.2%) of young people receiving *PratenOnline* maintained clinically-

373   significant change at 4.5 month follow-up, compared to waitlist controls (11.4%) (Kramer,

374   et al., 2014). Improvements found at 6-weeks post-intervention were sustained and

375   increased in both intervention groups at one year follow-up for *Project CATCH-IT*

376   (Saulsberry, et al., 2013). Adolescents who used *StressBusters* self-reported

377   improvements in depression and anxiety from post-intervention to 3-month follow-up, but

378   not at 6-month follow-up (Smith, et al., 2015). This study did not perform ITT analysis.

379   For university students participating in lab-based ABM training, post-intervention

380   reductions in depressive symptomology were maintained at 3 and 7-month follow-up, but

381   there were no between-group differences at 7-month follow-up (Yang, et al., 2014).

382   ***ii.   Anxiety***

383   Four RCTs evaluated DHIs for anxiety (Shechner et al., 2014; Sportel, Hullu, Jong & Nauta,

384   2013; Storch et al., 2015; Vigerland et al., 2016). Two RCTs compared cCBT to treatment-

385   as-usual (TAU) (any psychotherapy and/or medication; Storch, et al., 2015) or waitlist

386   (Vigerland, et al., 2016); one compared ABM training plus CBT, to attention placebo plus

387   CBT, and FtF CBT alone (Shechner, et al., 2014); and one compared cognitive bias

388   modification (CBM) training to in-class group CBT and no-treatment control (Sportel, et

389   al., 2013). Participants in all four of the RCTs were recruited on the basis of having a

390   diagnosis of an anxiety disorder (Shechner, et al., 2014; Storch, et al., 2015; Vigerland,

391   et al., 2016), or meeting the threshold for high-levels of social anxiety and/or test anxiety

392   (Sportel, et al., 2013). A total of 496 participants were included, with sample size ranging

393   from 63 to 240 (M=124, Mdn=96.5). Studies included both children and adolescents

394   (range 6 to 18 years), with a mean age range of 9.8 to 14 years (M=11.3 yrs, Mdn=10.7

395   yrs). Attrition at follow-up ranged from 15.3% to 51.1%. Participants completed the

396   intervention at a variety of locations: home (Sportel, et al., 2013; Vigerland, et al., 2016),

397   a community health centre (Storch, et al., 2015) or hospital (Shechner, et al., 2014).

398   cCBT was associated with significant improvements in anxiety post-intervention and at

399   follow-up, compared to waitlist (Vigerland, et al., 2016) and TAU groups (Storch, et al.,

400   2015; Vigerland, et al., 2016). However, Vigerland et al. (2016) did not perform ITT

401   analysis. The augmentation of FtF CBT with computer-based ABM training significantly

402   decreased the frequency of parent and child-rated anxiety symptoms compared to FtF CBT

403   alone (Shechner, et al., 2014). A home-based trial of online CBM training found a

404   significant reduction in social phobia and anxiety scores for both online intervention and

405   group CBT arms compared to no treatment, with post-treatment effects at 6 month follow-

406   up largest for the group CBT intervention (Sportel, et al., 2013).

407   ***iii.   Anxiety and Depression***

408   Four studies evaluated DHIs targeting both anxiety and depression: three evaluated a

409   cCBT intervention (Melnyk et al., 2015; Sethi, 2013; Wong, Kady, Mewton, Sunderland &

410   Andrews, 2014); the other evaluated a multi-theoretical intervention incorporating

411   motivational-enhancement, cognitive behavioural strategies and behavioural principles

412   (Ruggiero et al., 2015). A total of 2173 participants were recruited to these trials; age

413   range 12-25 years, (M=17.9, Mdn=18.5). Participants were recruited with mild-to-

414   moderate anxiety symptoms and/or depression symptoms (Sethi, 2013), or because they

415   lived in an area which had experienced a significant natural disaster (Ruggiero, et al.,

416   2015). Participants completed the intervention in school (Wong, et al., 2014), or in a

417   community centre or on university campus (Sethi, 2013). The other two interventions

418   were delivered online without specifying a location (Melnyk, et al., 2015; Ruggiero, et al.,

419   2015).

420   The findings for the three cCBT interventions were mixed. In a four-arm trial, Sethi (2013)

421   found the three experimental groups (*MoodGym*-only, FtF CBT-only, and combination of

422   *MoodGym* and FtF CBT) reported improvements in depression and anxiety symptoms, but

423   the group who received *MoodGym* combined with FtF CBT reported the greatest reduction

424   in anxiety symptoms. Melnyk et al. (2015) found that the intervention significantly reduced

425   anxiety but only for those with elevated levels at baseline. However, this study did not

426 perform ITT analysis. In the trial of *ThisWayUp* (Wong, et al., 2014*)*, participants who

427 received the depression-focussed modules had reduced anxiety and depression scores,

428 while those who received the anxiety-focussed modules only improved with anxiety

429 symptoms. *ThisWayUp* involves FtF group discussions and worksheets to consolidate

430 learning, and so constitutes a 'blended' online and FtF intervention. Evaluation of *COPE*

431 (*Creating Opportunities for Personal Empowerment*) found no post-intervention

432 differences for anxiety and depression symptoms between the intervention and no-access

433 control (Melnyk, et al., 2015). Finally, a multi-theoretical online intervention (*Bounce Back*

434 *Now*) for adolescents affected by natural disaster resulted in improvements in PTSD and

435 depressive symptoms at 12-month follow up (Ruggiero, et al., 2015).

436 *Summary: DHIs for anxiety and depression*

437 Depression and anxiety were the most common clinical targets for DHIs in both the meta-

438 review and systematic-review. DHIs most frequently cited were *MoodGym*, *BRAVE-Online,*

439 *Project CATCH-IT*, *Master Your Mood Online (Grip Op Je Dip)* and *MobileType*. Except for

440 *MobileType*, these DHIs all provide web-delivered module-based cCBT. While these

441 modularised cCBT DHIs follow the traditional 'sessional' approach to CBT therapy, they are

442 somewhat limited in that they require a sit-down approach to treatment and fail to fully

443 exploit the ubiquitous nature of modern digital technologies. For example, mobile

444 technology (e.g. smartphones, wearables) can accommodate different styles of delivery,

445 learning and collection of patient-centred outcomes, such as ecological momentary

446 sampling and instant access to crisis management strategies. *MobileType* is a mobile

447 phone-delivered intervention which uses a momentary sampling approach to remotely

448 assess participants' mood, stress, current activity and alcohol and cannabis use within

449 their natural environment (Kauer, Reid, Sanci & Patton, 2009). While mood monitoring is

450 not therapeutic in its own right, these extra activities could potentially improve the

451 personalisation of the intervention and support adherence. Increasingly, remote active and

452 passive monitoring of mood are being integrated with therapeutic interventions. Hence,

453 the distinction between mHealth digital monitoring and interventions is likely to become

454 increasingly blurred.

455 Overall, the strongest evidence of clinical effectiveness comes from DHIs using a cCBT

456 approach, with weaker evidence for the effectiveness of non-CBT DHIs. The largest effects

457 for DHIs are reported in RCTs with: a) non-active comparators (e.g. waitlist control) vs.

458 active comparators (TAU or attention control), b) interventions targeting older adolescents

459 and young adults vs. children, and c) facilitated therapist-guided support vs. self-guided

460 intervention. Most trials recruited participants with mild to moderate clinical symptoms

461 and excluded young people with severe depression or high suicidal risk. Uptake and

462 adherence was particularly poor for self-guided interventions such as *MoodGYM* that

463 included automated prompts but no human support. No studies provided data on cost-

464 effectiveness of DHIs.

465 **Eating disorders**

466 **Meta review findings**

467 Two reviews evaluated DHIs for treating and preventing eating disorders (EDs) (Newton

468 & Ciliska, 2006; Schlegl, et al., 2015). Newton and Ciliska (2006)reported findings from

469 five   trials   of   *Student   Bodies,*   an   online   self-guided   intervention   including

470 psychoeducational, social learning theory and cognitive behavioural approaches. Four

471 trials were conducted with American undergraduate university students with a mean age

472 range of 19.3 - 20 years; the other trial was a quasi-experimental study with high school

473 students (M=15 years). Meta-analysis found no significant benefit of *Student Bodies* at

474 post-intervention, or at follow-up, for ED-related attitudes, behaviours, or body

475 satisfaction. In a systematic review of technological interventions for EDs, Schlegel et al.

476 (2015) report findings from three studies with adolescents: two cCBT programmes with

477 weekly therapist email support (*SALUD BN* and *Overcoming Bulimia Online*) were effective

478 in reducing binging, vomiting and ED psychopathology at post-intervention and follow-up.

479 The additional intervention (*My Body, My Life*), which was facilitated by weekly online

480   group sessions with a therapist, showed moderate pre-post improvements in perceived

481   body image. Two other reviews report findings from DHIs for EDs (Ali, et al., 2015; Siemer,

482   et al., 2011). Ali et al. (2015) suggested the inclusion of peer support in *Student Bodies*

483   had little effect on ED-related attitudes.

Systematic Review

485   Findings from the updated review found low quality evidence of equivalence between the

486   *Student Bodies* intervention and waitlist control for ED symptomology (e.g. binging,

487   purging, restrictive eating) and weight concerns (NCCMH, 2014). We identified two further

488   RCTs of *Student Bodies* in female university students (N=216, aged 18-25 years) who

489   were either at high-risk or met criteria for subclinical EDs. Saekow et al. (2015) found no

490   differences (ITT analysis) between intervention and waitlist control for ED symptomology,

491   weight concern and psychosocial functioning, although significant improvements in these

492   measures were found with a non-ITT analysis of those who completed the entire

493   intervention. Kass et al. (2014) found participants using *Student Bodies* with access to the

494   online discussion group had significantly lower weight concern scores than those without

495   the group discussion feature, but no differences were found for ED symptomology.

ADHD

497   None of the 20 included reviews assessed the effectiveness of DHIs for ADHD in CYP. We

498   identified 10 RCTs for the updated systematic review that evaluated computer-based

499   cognitive training interventions aimed at improving ADHD-related symptoms and

500   behaviours. Interventions included: electroencephalogram (EEG) based neurofeedback

501   training (NFT) (N=2) (Arnold, et al., 2013; Dongen-Boomsma, Vollebregt, Slaats-Willemse

502   & Buitelaar, 2013); NFT augmenting TAU (N=2) (Bink, van Nieuwenhuizen, Popma,

503   Bongers & van Boxtel, 2015; Bink, Van Nieuwenhuizen, Popma, Bongers & Van Boxtel,

504   2014; Steiner, Frenette, Rene, Brennan & Perrin, 2014); NFT with medication (N=1) (Li,

505   Yang, Zhuo & Wang, 2013); working memory training (WMT) (N=3) (Chacko et al., 2014;

506   Dongen-Boomsma, Vollebregt, Buitelaar & Slaats-Willemse, 2014; Egeland, Aarlien &

507   Saunes, 2013); executive functioning training (EFT) (N=1) (Dovis, Oord, Wiers & Prins,

508   2015); or treatment delivered via videoconferencing (N=1) (Myers, Vander Stoep, Zhou,

509   McCarty & Katon, 2015). All studies involved participants with ADHD (N=9) or who met

510   criteria for possible ADHD (Myers, et al., 2015). Comparators included; placebo (N=7),

511   TAU (N=1), a partially active intervention (N=1), waitlist control and TAU (N=1), placebo

512   and medication (N=1), and a cognitive training program (N=1). All placebo conditions

513   involved a program that was identical to the experimental intervention but non-adaptive

514   (e.g. it did not increase in difficulty as performance improved). All trials included as a

515   primary outcome measure parent and/or parent, caregiver or teacher-rated ADHD

516   symptoms.

517   The majority of trials recruited children (M=9.98 yrs, Mdn=9.82), with seven including

518   only children aged ≤12 years. 861 participants were randomised, with sample sizes

519   ranging from 39 to 223 (M= 86, Mdn 80). Reported attrition was small across all studies.

520   Three studies delivered the intervention at home (Chacko, et al., 2014; Dongen-Boomsma,

521   et al., 2014; Dovis, et al., 2015), one in a clinic (Dongen-Boomsma, et al., 2013) and two

522   in school (Egeland, et al., 2013; Steiner, et al., 2014). Excluding the RCT evaluating a

523   videoconferencing service (Myers, et al., 2015), seven studies included in-person or

524   telephone-based support from a training aide (e.g. parent, guardian, teacher; N=2) or a

525   professional (e.g. certified coach, therapist, research assistant; N=5). The other two trials

526   failed to report whether support was provided (Arnold, et al., 2013; Li, et al., 2013).

527   EEG-based neurofeedback training (NFT) aims to improve ADHD symptoms through

528   training designed to suppress EEG theta wave activity and increase beta wave activity. All

529   four RCTs of NFT report mixed findings for effectiveness. Two studies found that both the

530   NFT and attention placebo groups reported pre-post improvements in parent and/or

531   investigator and/or teacher-rated ADHD symptoms, but there were no differences between

532   the two groups (Arnold, et al., 2013; Dongen-Boomsma, et al., 2013) and the study by

533   Arnold et al. (2013) did not perform ITT analysis. CYP who received NFT in addition to

534   methylphenidate medication showed significant improvements in parent-rated ADHD

535   symptoms and social functioning, compared to a control group who received attention

536   placebo plus methylphenidate medication (Li, et al., 2013). However, this study did not

537   perform ITT analysis. Finally in comparison to children who received a cognitive training

538   intervention, children who received the NFT intervention reported better parent-reported

539   executive functioning, behaviour regulation and metacognition outcomes, and teacher-

540   reported attention and inattention outcomes (Stangier, 2016).

541   Working memory training (WMT) and executive functioning training (EFT) aim to improve

542   specific or wider deficits in cognitive functioning and attentional skills (Melby-Lervåg &

543   Hulme, 2012). The three RCTs of WMT report contrasting results. Chacko et al. (2014)

544   found that WMT participants showed greater improvements in verbal and nonverbal

545   memory compared to attention placebo, with both groups reporting pre-post

546   improvements in parent-reported ADHD symptoms, but no differences between the two

547   groups. Egeland et al. (2013) reported no changes over time or between the WMT and

548   waitlist groups in parent and teacher-rated ADHD symptoms, but the WMT group did report

549   improved mathematics and reading skills. Egeland et al. (2013), however, did not perform

550   ITT analysis. Finally, Dongen-Boomsma et al (2014) found the WMT group showed

551   significantly greater improvements than attention placebo in one verbal working memory

552   task, and while both groups reported improvements over time in parent and teacher-rated

553   ADHD symptoms, there were no statistically significant differences between the groups.

554   However, again, this study did not perform ITT analysis. An intervention targeting multiple

555   aspects of executive functioning found ADHD symptoms improved over time regardless of

556   the intervention received (Dovis, et al., 2015). A trial of a videoconferencing telehealth

557   service for remote treatment of ADHD showed that both the videoconferencing and control

558   service improved teacher and caregiver-rated ADHD symptoms, with greater improvement

559   in the intervention group (Myers, et al., 2015).

560   *Summary: DHIs for ADHD*
561   Computerised cognitive 'brain training' programmes for ADHD include WMT, EFT and EEG

562   NFT. To date, the results of trials have been inconsistent, with no overall differences

563   reported between DHIs and active placebo interventions. The negative NFT findings

564   align with recent meta-analyses suggesting that NFT cannot be currently recommended

565   as treatment for ADHD (Cortese et al., 2016). In previous reviews, the largest effects for

566   non-pharmacological interventions on ADHD symptoms were found for outcomes

567   reported by parents who may be 'unblinded' to intervention allocation where there are

568   non-active comparators. Similarly, in our review treatment effects of DHIs are

569   attenuated or non-significant for ADHD outcomes reported by independent observers

570   (e.g. teachers), who are more likely to be 'blinded' to intervention allocation (Cortese et

571   al., 2015). Given that face to face non-pharmacological interventions for ADHD have not

572   demonstrated efficacy, it is perhaps not surprising that digital versions would also not be

573   effective. In summary, the results of the updated systematic review suggest that DHIs

574   (including WMT, EFT and EEG NFT) cannot be recommended for the treatment of ADHD.

575   **Autism Spectrum Disorders (ASD)**

576   Only one review identified a study of a DHI for CYP with ASD (Jang et al. 2012, cited in

577   Boydell et al., 2014): their evaluation of an eLearning training intervention for family

578   members of children with ASD found those who received the intervention reported

579   greater improvements in skills and knowledge relating to applied behaviour analysis.

580   We identified three RCTs of DHIs for CYP targeting ASD symptoms/ impairments: a mobile

581   phone 'app' for practising and improving communication skills (*FindMe*) (FindMe; Fletcher-

582   Watson et al., 2013); an interactive software program to improve recognition of emotion

583   in facial and vocal expressions (*MindReading*) (MindReading; Thomeer et al., 2015) and a

584   computer-based program to improve working memory (WM) and cognitive flexibility (CF)

585   (*Braingame Brian*) (Vries, Prins, Schmand & Geurts, 2015)(N=218, M age 7.8 yrs).

586   Findings from these studies are mixed. Fletcher-Watson et al. (2015) reported no

587   differences between experimental (*FindMe*) and waitlist and TAU combined groups for ASD

588   symptoms at post-intervention and follow-up, although parents gave positive feedback

589   about their child's enjoyment of the intervention. Compared to waitlist control, those who

590   used the *MindReading* program showed significant improvements with a large effect size

591   in social functioning, face and voice recognition at post-treatment and at 5-week follow-

592   up (Thomeer, et al., 2015). However, this study did not perform ITT analysis. All

593   participants using *Braingame Brian* improved in WM, CF, attention, social functioning,

594   quality of life and ADHD-related behaviour (Vries, et al., 2015).

595   *Summary: DHIs for ASD*

596   DHIs for CYP with ASD are designed primarily for pre-adolescent children and often

597   incorporate computer game-based formats aimed at training and improving core deficits

598   in social understanding, empathy, and emotional recognition. While these games appear

599   popular (particularly with parents) the results of trials have failed to show consistent

600   benefits that transfer outside the specific context of the game to affect core ASD

601   symptoms and deficits. Less attention has been given to DHIs which target associated

602   symptoms and behaviours in ASD such as anxiety and challenging behaviour. Given that

603   these symptoms may be more amenable to intervention than core deficits of ASD, and

604   trials are emerging show that these interventions work FtF, digital adaptations would be

605   welcome.

606   **Psychosis**

607   None of the 21 included reviews assessed the clinical effectiveness of DHIs for psychosis

608   in CYP. Our systematic review identified one study of *Captain's Log*, a computer-assisted

609   cognitive remediation (CACR) program for adolescents with, or at risk of, psychosis

610   (Urben, Pihet, Jaugey, Halfon & Holzer, 2012). This intervention aims to train attention,

611   concentration, memory, and visuo-spatial and visuo-motor skills. Post-intervention, both

612   experimental and placebo control groups reported a significant improvement in attention,

613   memory processing, general psychopathology and social functioning, with the intervention

614   group reporting significantly greater improvement in visuospatial abilities compared to

615   control (Holzer et al., 2014). However, there were no differences in WM, executive

616   functioning, psychotic symptoms and psychosocial functioning at 9-week and 6-month

617   follow up.

618   **Tele-psychiatry**

619   **Meta review findings**

620   Two reviews examined the effects of tele-psychiatry or tele-medicine for CYP (Boydell, et

621   al., 2014; Hailey, et al., 2008) with telecommunication technology (e.g. telephone,

622   videoconferencing) used to either deliver mental health treatment or to remotely diagnose

623   mental health disorders. Descriptive reviews suggest that delivering remote services via

624   telephone and video-conferencing is acceptable to healthcare practitioners, CYP, and their

625   families. However, studies to date have failed to report the impact on service access for

626   'hard to reach' groups, treatment adherence and clinical effectiveness, suggesting an

627   important gap in the research literature.

628   **Systematic review findings**

629   Myers et al. (2015) evaluated a videoconferencing intervention delivering six sessions of

630   pharmacotherapy and in-person caregiver behaviour training for children with ADHD. Both

631   the videoconferencing group and control group (who received only one videoconferencing

632   consultation) reported improvements in teacher and caregiver-rated ADHD symptoms,

633   with the intervention group (who received more clinical contact) reporting significantly

634   greater improvement. Unlike DHIs designed as interventions for specific conditions, tele-

635   psychiatry/tele-medicine refers to a generic telecommunications platform used to deliver

636   remote assessment, monitoring and treatment by healthcare professionals across a range

637   of conditions and interventions. Overall, remote videoconferencing appears acceptable to

638   those recruited into studies. However, there is a notable lack of evidence of cost-

639   effectiveness and whether this technology increases access to services for previously

640   excluded groups.

641   **Experience of using DHIs: Eliciting views of young people and parents**

642   We identified nine studies that explicitly sought participants' feedback about their

643   experience and satisfaction with the DHI, either through administering a quantitative

644   survey and/or a qualitative approach. Feedback about satisfaction was gained from the

645   CYP participants (Melnyk, et al., 2015; Saekow, et al., 2015; Stasiak, et al., 2014), the

646   CYP participant and their parents (Arnold, et al., 2013; Storch, et al., 2015; Thomeer, et

647   al., 2015; Vigerland, et al., 2016), or from the CYP's parents only (Fletcher-Watson, et al.,

648   2015; Steiner, et al., 2014). CYP and parents reported moderate-to-high satisfaction with

649   the DHIs (Arnold, et al., 2013; Stasiak, et al., 2014; Storch, et al., 2015; Thomeer, et al.,

650   2015; Vigerland, et al., 2016), with qualitative feedback being generally positive about

651   the DHI and its potential to help with mental health and wellbeing, and also provided

652   suggestions for future improvements in designing DHIs (Fletcher-Watson, et al., 2015;

653   Melnyk, et al., 2015; Saekow, et al., 2015; Stasiak, et al., 2014).

654   **Adherence to DHIs and association with outcome**

655   None of the studies in the meta-review addressed issues around dose response, such as

656   how much of the intervention is needed to produce beneficial outcomes. Given the current

657   challenges of the field (e.g. difficulties with establishing a DHI taxonomy), it is still difficult

658   to know exactly what amounts to an appropriate (or 'minimum effective') dose of an

659   intervention.

660   Similarly only four (out of 30) papers in the updated systematic review provided

661   information about the minimum effective 'dosage' of their DHI or levels of adherence. In

662   one trial of WMT for ADHD, a 'complier' meant the participant completed ≥20 training

663   sessions (out of a possible 25 sessions) (Dongen-Boomsma, et al., 2014), while in a trial

664   of EFT for ADHD "compliers" were defined as those who completed all 25 training sessions

665   (Dovis, et al., 2015). Lillevoll et al. (2014) categorised level of adherence of *MoodGym*

666   into three categories: non-participation, one module only, and two or more modules.

667   Finally in the evaluation of a web-based intervention for disaster-affected adolescents and

668   their families, Ruggiero et al. (2015) defined a "completer" as a participant (adolescent or

669   parent) who completed ≥1 intervention module.

670   Furthermore, seven studies reported associations between adherence/dosage and

671   outcomes. Four of these reported no associations between adherence or level of

672   intervention completion and outcome (Ruggiero, et al., 2015; Saekow, et al., 2015;

673   Steiner, et al., 2014; Vigerland, et al., 2016). In one trial of WMT for ADHD, participants

674   who did not complete WMT were more likely to score higher on inattentive and

675   hyperactive/impulsive measures (Dongen-Boomsma, et al., 2014), while spending longer

676   amounts of time engaging with a CACR program for psychosis was associated with greater

677   gains in attention (Holzer, et al., 2014). Finally, findings from the evaluation of the *FindMe*

678   app for children with ASD found no associations between time spent engaging with the

679   app and autism-related behaviours, but a negative correlation between game play, visual

680   perception and motor scores was found upon removal of an outlier (Fletcher-Watson, et

681   al., 2015).

682

683   **DISCUSSION**

684   Our review of the effectiveness of DHIs has focused on evidence from RCTs, with the

685   majority conducted on cCBT targeting depression and anxiety in adolescents and young

686   adults, with far less research focused on other clinical areas and therapeutic approaches

687   or mobile enabled (mHealth) technologies.

688   Overall, there is some support for the role of cCBT in improving symptoms of depression

689   and anxiety in CYP. There is also evidence from 'head to head' trials that therapist-guided

690   (remote) cCBT is as effective as FtF CBT (Sethi, 2013). However, existing trials have

691   focused on older adolescents with mild/moderate symptomatology and, as a result, it is

692   still not clear whether DHIs are useful for CYP who present with more severe

693   symptomatology typically found presenting to mental health services. Trials with active

694   comparators show less benefit of DHIs than those with non-active controls. There is some

695   evidence that human support, be that in the form of a therapist's guidance or researcher

696   contact, may be beneficial in terms of adherence and effectiveness. DHIs for ADHD, ASD,

697   eating disorders, psychosis and PTSD show uncertain benefits. Importantly, there is a

698   notable lack of evidence concerning the cost-effectiveness of DHIs.

699   Overall, the heterogeneity of DHIs and poor quality of many studies make it difficult to

700   draw definitive conclusions about the effectiveness of DHIs and the role they should play

701   in mental health services for CYP. Our review highlights a number of important research

702   questions and methodological issues that need to be considered for the field to move

703   forward.

704   **Research Priorities and Methodological Issues**
705   **Obtaining evidence of cost-effectiveness**
706   There is a remarkable lack of data on the cost-effectiveness of DHIs in CYP. This is

707   surprising given the promise that DHIs can increase health service efficiency through the

708   ability to deliver effective interventions at scale with minimal incremental costs. Several

709   of the reviews in our meta-review mention the limited information about cost-effectiveness

710   or even how DHI costs compare to usual mental health care and treatment. Many DHI

711   trials include some level of human support, but the costs of this compared to usual

712   treatment is not known. Boydell et al. (2014) note that the widely held assumption that

713   DHIs are more affordable and associated with lower costs, more ease of administration,

714   and reduced therapist time has not been substantiated to date. There are several factors

715   that influence the calculation of costs in delivering DHIs, such as where the DHI is delivered

716   (e.g. 'internally' within mental health services) (Palmqvist, Carlbring & Andersson, 2007),

717   the associated level of support given to users, and who 'owns' the DHI. For example, some

718   internet-delivered DHIs are commercialised and have to be bought in by individuals or

719   health service providers, while others are free to use and are publically available (e.g.

720   *MoodGym*) (Gilbody et al., 2015). We emphasise the need to consider sustainability and

721   cost-effectiveness from the beginning of DHI development. The development phase for a

722   DHI should include consideration of the long term costs of maintenance and updating, how

723   these costs could be met, and who will take responsibility for them.

724   **The role of human support in DHIs**
725   A critical research question in the design, evaluation and implementation of DHIs relates

726   to the use of human support and how this affects engagement with the intervention and

727   clinical outcomes. Across trials of DHIs the level of human support or facilitation is poorly

728 specified, which obscures the effect of human support on engagement/adherence and

729 outcomes. Between different DHIs, the level of human support varies in terms of who is

730 providing it (e.g. a trained layperson, parent, teacher or clinician), the degree of support

731 provided (e.g. unguided, semi-guided, fully guided), its purpose (e.g. to provide

732 encouragement, to check for technical issues, or augment therapy) and the uniqueness of

733 the support (e.g. tailored support for one user or automated support to all users). These

734 factors will all influence CYP's motivation and continued engagement with the intervention,

735 and providing some sort of human or therapist support, even at a minimal level, has been

736 previously identified as a significant moderating factor influencing therapeutic outcomes

737 and engagement (Rickwood & Bradford, 2012). This is important for policy because DHIs

738 are often promoted, incorrectly in our view, as a low cost alternative to FtF services due

739 to their automated delivery with very low or zero incremental costs.

740 Six adult-only studies found a positive relationship between adherence and receiving

741 support during online interventions, with qualitative findings suggesting that participants

742 were less likely to adhere if they had limited human contact (Beatty & Binnion, 2016).

743 Findings from 25 RCTs of mostly adult samples evaluating cCBT for depression show larger

744 intervention effects as the degree of human contact increased: no therapist contact,

745 d=.21; contact before treatment only, d=.44; contact during the treatment only, d=.58;

746 and contact before and during treatment, d=.76 (Johansson & Andersson, 2012).

747 However, meta-analyses of cCBT with CYP report mixed impact of support upon depression

748 and anxiety outcomes (Farrer, et al., 2013; Pennant, et al., 2015; Podina, et al., 2015).

749 Larger effect sizes were found for studies involving 'minimal' therapist input, compared to

750 studies with 'significant' input in cCBT for anxiety (Podina, et al., 2015). Ebert et al. (2015)

751 found a larger effect size in cCBT studies that had no parent involvement (g=.83)

752 compared to those with parent involvement (g=.64). In evaluating various technologies

753 upon mental health outcomes in university students, Farrer et al. (2013) found no

754 association between outcomes and amount of human contact provided to participants.

755 Hence, an important research question concerns the impact of human support on both

756   adherence and outcome for DHIs in CYP and whether the effects differ (and if so, why)

757   from the consistent findings reported in adults.

758   Young people have expressed a need for some level of support in receiving DHIs or to use

759   it in conjunction with FtF therapy (Cheek et al., 2014; Mitchell & Gordon, 2007; Pretorius,

760   Rowlands, Ringwood & Schmidt, 2010). Support may not have to be a 'real' person, but

761   could be automated through the DHI itself. When asked about their 'ideal app' for

762   managing their condition, young people and adults with ADHD highlighted the need for a

763   virtual 'coach' or 'mentor' to provide support and encouragement (Simons et al., 2016).

764   Developments in virtual reality, artificial intelligence and machine learning are creating

765   'virtual human' agents that, in the next generation of DHIs, could act as automated,

766   interactive coaches to support personalised delivery of DHIs (Valstar et al., 2014).

767   **Choosing appropriate comparators**

768   The range of comparators used across trials of DHIs range from active digital and non-

769   digital (e.g. attention control and FtF CBT) comparator interventions vs. non-active

770   controls (e.g. waitlist). In general, effects are largest when DHIs are compared to non-

771   active controls, and differences are smallest when there is an active comparator.

772   The selection of a suitable comparator is determined by the research question addressed.

773   In pragmatic trials that aim to determine the effectiveness of a new DHI compared to

774   current best practice, the comparator is typically TAU. However, in trials of DHIs, the

775   participants in the TAU group may have access to a range of other digital interventions

776   that may be hard to prevent or track (e.g. online psychoeducational material), but risks

777   undermining the results of the trial. In contrast, 'active' comparators control for non-

778   specific effects of the intervention package such as human support, attention and on-line

779   usage. It is critical to understand if human support is important only for increasing

780   engagement and adherence or is an active component in therapeutic change. If the latter

781   is true, then an 'active' control with human support may obscure the true effect to the

782   DHI.

783   **Identifying active components of DHIs**

784   Understanding which components of a DHI actually have the predicted impact on the

785   outcome, and whether and how components interact, is critical to DHI development and

786   evaluation. Most DHIs are highly complex, containing multiple components, so the

787   development process needs to include a period of optimisation. This entails evaluating

788   the performance of individual components of the intervention, and how they interact with

789   one another. One efficient method is the Multiphase Optimisation Strategy (MOST)

790   (Collins, Nahum-Shani & Almirall, 2014), which involves establishing a set of components

791   that are candidates for inclusion, specifying an optimization criterion for the entire

792   intervention, and then collecting experimental data to identify the subset of components

793   that meet the criterion. Here the term 'component' is broadly defined, and may refer to

794   aspects of the content of the intervention, including any human input; factors affecting

795   engagement, adherence to, fidelity of, or scalability of the intervention including the type

796   of technical platform and presentation features such as gamification; variables and

797   decision rules used to tailor intervention strategy, content, or intensity to individuals; or

798   any other aspect of an intervention that can profitably be separated out for examination

799   (Murray, et al., in press).

800   The experimental approaches that can be used for optimization include full or fractional

801   factorial experiments (Collins, Dziak & Li, 2009), the sequential multiple-assignment

802   randomized trial (SMART) (Almirall, Nahum-Shani, Sherwood & Murphy, 2014), and

803   system identification techniques (Rivera, Pew & Collins, 2007). The factorial experimental

804   design can be a useful and economical approach for examining the effects of individual

805   intervention components, and is the only experimental design that enables full

806   examination of all interactions.

807   **Towards a taxonomy of DHIs**

808   It is clear that the content of DHIs, their underpinning theory of change and their mode of

809   delivery will affect the impact of a DHI, yet in most studies these components are not

810   specified or analysed separately. This makes it difficult to judge whether a positive (or

811   negative) outcome of a trial is the result of: the intervention content and theory of the

812   change, the digital delivery platform or an interaction between the two.

813   Lack of clarity and precision in the terminology used to describe components of DHIs make

814   it difficult to group interventions and identify active components; a situation that is likely

815   to become even more complex as technology develops. An agreed working taxonomy of

816   digital mental health interventions, similar to that developed for behaviour change

817   interventions (the Behaviour Change Technique/BCT Taxonomy Project) (Abraham &

818   Michie, 2008), is required to enable interventions to be appropriately categorised and

819   analysed. In addition, adherence to the CONSORT eHealth guidelines (Eysenbach &

820   CONSORT eHealth Group, 2011) would make it easier to take these factors into

821   consideration when comparing individual studies.

822   DHIs that use psychotherapeutic theory as their theoretical basis (e.g. CBT) often do not

823   describe which features of the theory are being employed in the intervention. In a recent

824   review of CBT and behavioural activation (BA) apps for depression (Huguet et al., 2016)

825   produced a checklist of the 'core ingredients' involved in CBT and BA approaches (e.g.

826   challenging negative thoughts in CBT; activity scheduling of pleasant and avoidance

827   behaviours in BA), which enabled them to identify the 'ingredients' available in apps.

828   Similarly, digital interventions with gaming features (often called 'serious games') use

829   specific gaming elements in their delivery, such as having a storyline and setting rules,

830   goals, and objectives (Fleming, et al., 2014). It may be useful to apply a similar BCT

831   Taxonomy approach to DHIs so that clinicians and the public can clearly see how these

832   interventions aim to produce therapeutic change and researchers can judge their

833   effectiveness.

834   Related to this issue is the large number of different digital interventions being studied, all

835   of which differ to a greater or lesser degree according to their purpose, content, theory of

836   change, presentation interface and mode of delivery. As a result, it is difficult for DHIs to

837   undergo the incremental innovation seen in other areas of healthcare. An agreed taxonomy

838   for specifying the components of DHIs is required for replication of trial results, comparison

839   between DHI, synthesising data across trials in systematic reviews and meta-analyses.

840   **Tailoring and personalisation of DHIs**

841   In health behaviour change interventions, 'tailoring' typically refers to how targeted the

842   health messages being sent to users are. For example, 'generic' communication reflects

843   messages that are not individualised to the recipient's specific needs, but this may be

844   'personalised' by adding a user characteristic to the message (e.g. the user's name).

845   'Targeted' communication is used to provide messages to a specific group, such as those

846   of a specific age or who screen for a specific risk of developing a health problem (Musiat,

847   Hoffmann & Schmidt, 2012; Noar, Benac & Harris, 2007). Our review found similar

848   approaches for mental health DHIs. For example, some received 'personalised' feedback

849   in the form of information based on an assessment or data that was entered into the

850   intervention, which can vary in its degree of personalisation (Barak & Grohol, 2011;

851   Musiat, et al., 2012). Tailoring may also mean that an intervention has different user

852   'pathways' depending on, for example, the user's baseline symptoms (e.g. Chiauzzi,

853   Brevard, Thum, Decembrele & Lord, 2008), or allows users to choose the modules or

854   content that is most relevant to their presenting problem (e.g. Andersson, Estling,

855   Jakobsson, Cuijpers & Carlbring, 2011).

856   Research has shown that users want this type of tailoring or personalisation. Adults with

857   experience of using computerised therapies reported a desire for DHIs to be responsive to

858   the 'self' (e.g. sensitive to their clinical needs, feelings and personal preferences) (Knowles

859   et al., 2014). The research team responsible for the *SPARX* DHI also provides examples

860   of good practice in this area. In focus groups with rural Australian adolescents (Cheek, et

861   al., 2014), 'personalisation' of SPARX was a key theme that emerged. This reflected two

862   separate aspects valued by adolescents. The first centres on their personal choice to use

863   the intervention (e.g. where and when to use it) and who to share their feelings and the

864   intervention with (e.g. with a counsellor or adult). The second centres on the

865   personalisation of the intervention, which focused mainly on the ability of the user to

866   choose the gender of the 'guide' avatar, which they reported led to improved relatability.

867   This aspect was also highlighted and praised by sexual minority youth, who felt that

868   allowing them to personalise the avatar's gender and appearance reflected their real-world

869   experience of challenging gender expectations (Lucassen et al., 2013). Furthermore, the

870   research team have analysed qualitative data from five studies of SPARX to understand

871   how users' perceptions and elements of the intervention map onto the autonomy,

872   competence and relatedness aspects of self-determination theory, which in turn have been

873   theorised as key factors influencing engagement and adherence to computerised

874   interventions (Cheek et al., 2015).

875   Although the research on tailoring and personalisation for DHIs and the benefits that may

876   result from this is limited at present, it does suggest that the ability of a young person to

877   personalise relatively small features (e.g. the gender and appearance of a 'guide') may

878   have an impact on how users view and relate to a DHI. Further research is required to

879   explore how DHIs should be tailored and how this influences uptake, adherence,

880   satisfaction and outcomes.

881   **Privacy and security issues**

882   Privacy and security are important concerns when handling and managing health-related

883   data (Hollis, et al., 2015), as users may be concerned about where their information goes,

884   how it is stored, and who it is shared with. For example, when installing a new app on a

885   smartphone, the user will be asked for permission to access or read specific phone

886   functions, and some users may be concerned about why an app has to access such

887   information. When using internet-enabled technologies, adolescents and young people

888   have expressed concerns about data protection and security, and the information they

889   chose to share with the technology (Ring, 2014). In seeking user opinions about

890   developing an online mental health clinic, university students stated that data security in

891   online peer-to-peer interactions was paramount, and anonymity may help in maintaining

892   trust and privacy of access (Farrer, Gulliver, Chan, Bennett & Griffiths, 2015). Users have

893   to make the decision to trust apps based on the information provided to them, and so

894   transparency is needed to help users understand how ethically their data is managed and

895   stored (Huckvale, Prieto, Tilney, Benghozi & Car, 2015). Understandably these concerns

896   are also applicable to other non-app DHIs, and research is needed to gather CYPs'

897   opinions, concerns and requirements regarding data security and privacy of DHIs.

898   **Do children and young people prefer digital health interventions?**

899   Bradford and Rickwood (2014) found no evidence to confirm the assumption that young

900   people in Australia prefer digital or internet-delivered help over FtF or phone-based

901   services. While young people expressed some positive attitudes towards DHIs, overall they

902   had a strong preference for FtF help (59%), with only 16% expressing a preference for

903   online treatment (lower than the number of CYP who reported that they would not seek

904   help at all). CYP reported that the perceived benefits of FtF help (e.g. more personal, can

905   see who they are talking to, customised feedback) are valued as important when receiving

906   mental health treatment. Furthermore, in a study of young people attending a UK CAMHS

907   clinic (Stallard, Velleman & Richardson, 2010) found that half were not interested in cCBT,

908   preferring to talk to someone FtF. These somewhat discouraging findings suggest that the

909   common assumption that DHIs are the preferred form of intervention and service contact

910   for CYP may be unfounded, or at least over simplified and would benefit from further

911   exploration using qualitative research methods.

912   Qualitative research to date has shown that CYP have a number of concerns about DHIs

913   that could prevent uptake and adherence. Some of these issues are applicable to mental

914   health services in general and are concerned with stigma, embarrassment and shame

915   (Clement et al., 2015). Other factors are specifically related to accessing digital

916   interventions, and include: reduced motivation to engage in cCBT without reinforcement;

917   inadequate access to information about DHIs and their effectiveness; lack of technological

918   access; the belief that DHIs may be impersonal with limited interaction; lack of tailoring

919   to their specific presenting problems; and acceptability of DHIs for CYP at different ages

920   and developmental stages (Fleming, Dixon, Frampton & Merry, 2012; Lal et al., 2015;

921   Lucassen et al., 2015; Mitchell & Gordon, 2007; Pretorius, et al., 2010; Richards &

922   Timulak, 2013)

923   Despite identifying their limitations, CYP also report perceived benefits to using DHIs.

924   Research with young people both with and without experience of using DHIs, has identified

925   positive attributes of DHIs including; privacy and anonymity, flexibility, reduced pressure

926   and ability to complete interventions on their own terms, facilitating self-management,

927   and being experienced as less 'intense' than counselling (Bradley, Robinson & Brannen,

928   2012; Fleming, Lucassen, Stasiak, Shepherd & Merry, 2015; Mitchell & Gordon, 2007;

929   Pretorius, et al., 2010; Richards & Timulak, 2013; Simons, et al., 2016). Young people

930   value information, accessibility, self-reliance and control when accessing mental health

931   services (Plaistow et al., 2014). DHIs are usually considered 'more accessible', and online

932   resources are considered a way of enabling young people to have control, privacy and

933   independence when accessing mental health resources (Cheek, et al., 2014).

934   While these qualitative findings are encouraging and useful, further qualitative research is

935   required to investigates CYP's perceptions of specific DHIs including the way in which they

936   have been implemented (e.g. within a research framework, services, or 'in the wild'), their

937   perceived mechanisms of change (positive and negative) and recommendations for

938   improved engagement and effectiveness.

939   **How do Healthcare Professionals view the role of DHIs?**

940   The majority of research investigating the views of mental health professionals' (MHPs)

941   has focused on cCBT. There is a consensus among MHPs that FtF therapy is superior to

942   cCBT, despite the evidence (reported in this review and others) that cCBT can be as

943   effective as FtF therapy for depression and anxiety in CYP, at least in the short term and

944   for mild-to-moderate symptoms. The consequence of this is that MHPs tend to believe that

945   DHIs should not be widely and freely available online, and should not be delivered without

946   professional support (Fleming & Merry, 2013; Stallard, Richardson & Velleman, 2010;

947   Vigerland, et al., 2016). This view is consistent with the adult cCBT literature (Perle et al.,

948   2013) and evidence that MHPs believe DHIs are best offered as an adjunct FtF therapy

949   (Donovan, Poole, Boyes, Redgate & March, 2015; Perle, et al., 2013; Simons, et al., 2016;

950   Sinclair, Holloway, Riley & Auret, 2013; Stallard, Richardson, et al., 2010; Vigerland, et

951   al., 2016). There is also some empirical support for this approach suggesting that a

952   combination of cCBT and FtF CBT may be superior to either delivered alone (Sethi, 2013).

953   Interestingly, this view contrasts with the design of most clinical trials which typically

954   evaluate DHIs in isolation from other services and interventions. MHPs have expressed

955   concerns about DHIs in terms of a lack of therapeutic alliance and professional support,

956   lack of tailoring to individual needs, lack of formulation taking into account CYP's family

957   and school context, and difficulties in assessing progress due to a lack of clinical review

958   (Simons, et al., 2016; Stallard, Richardson, et al., 2010; Vigerland, et al., 2016).

959   MHPs' perceive the main benefits of DHIs as offering increased availability and access to

960   psychological help 'anytime, anywhere', digital technology being an appealing medium for

961   CYP (particularly those who struggle to talk about their feelings), the benefits

962   accompanying self-help such as increased self-confidence and self-awareness, and

963   reduced stigma (Simons, et al., 2016; Stallard, Richardson, et al., 2010; Vigerland, et al.,

964   2016).

965   **Do DHIs widen access to mental health services for CYP?**

966   In considering the potential for DHIs to widen access to services, it is also important to

967   consider CYP's attitudes towards DHIs. In receiving mental health services and making

968   decisions about treatment, CYP have stated a need for accessibility, self-reliance and

969   control (Plaistow, et al., 2014), and adolescents have stated that cCBT allowed for more

970   control (Fleming, et al., 2015). DHIs are usually considered more accessible through their

971   virtue of being accessed remotely via technology, at a time and place of the young person's

972   choosing and online resources are considered a medium that allows young people to have

973   control, privacy, and independence (Cheek, et al., 2014).

974   At present, there is a lack of data on whether DHIs can close the gap between supply and

975   demand for mental health interventions in CYP and crucially, whether they reach

976   populations currently underserved by traditional face to face services. There is a pressing

977 need to understand more about the individual characteristics of children and young people

978 who benefit most from DHIs as well as those characteristics that suggest DHIs would be

979 unhelpful or contra-indicated. Research is also needed to understand where best DHIs are

980 placed in existing care pathways. For example, should self-guided cCBT for depression be

981 offered routinely before face to face therapy, or alternatively in parallel with face to face

982 therapy to augment adherence and effectiveness? Similarly, should young people be

983 signposted to specific DHIs only after online or FtF assessment? High quality health

984 services research is needed to answer these questions.

985 **SUMMARY**

986 In recent years there has been a rapid growth in the development and evaluation of DHIs

987 for mental health problems in CYP. While the evidence we reviewed provides some support

988 for cCBT as a treatment intervention approach for mild to moderate depression and

989 anxiety, the benefits remain uncertain for other clinical areas. There is also insufficient

990 research investigating the 'active' and critical components of these interventions. We

991 recommend that future research should focus on identifying these 'active ingredients', i.e.

992 the individual components or specific mechanisms of change in cCBT and other DHIs that

993 are most effective for improving uptake, adherence and clinical outcomes in CYP.

994 A notable finding of our meta-review was that the research in this area (190 individual

995 papers) described 147 unique DHIs. Hence, a major challenge for the field is to develop

996 an agreed taxonomy to assist the identification of common active components of different

997 interventions. We would argue that a more efficient and theoretically sound approach

998 would be to develop DHIs through a process of optimisation by incorporating and testing

999 existing evidence-based components which act as 'core' building blocks for new DHIs.

1000 The majority of DHIs have been designed to help CYP at risk for developing, or with a

1001 diagnosis of, an anxiety disorder (including generalised anxiety, social anxiety, and specific

1002 phobia) and/or depression. Our review also identified a small number of trials of DHIs for

1003 ADHD, ED and ASD. However, areas such as psychosis, PTSD (and other specific anxiety

1004   disorders) are under-researched, while conditions such as Tourette Syndrome, conduct

1005   disorder, substance misuse and emerging personality disorder (or interpersonal problems)

1006   have been completely overlooked thus far. DHIs for ADHD have focussed predominantly

1007   on 'brain training' approaches using computerised WMT and CF training and EEG NFT.

1008   Future research should explore how these approaches transfer onto real-world outcomes,

1009   and if benefits are sustained and generalised outside the context of the specific

1010   computerised training tasks. Furthermore, there is a need for more non-pharmacological

1011   approaches that harness mobile (mHealth) DHIs, including wearable technologies, to treat

1012   and manage ADHD (Tarver, Daley, Lockwood & Sayal, 2014). More research is required

1013   on the role of factors such as reminders and human facilitation to understand whether it

1014   is possible to identify an 'optimum level' or whether it is preferable and feasible for each

1015   individual to design their own.

1016   Human facilitation/support is an important factor in influencing uptake, engagement and

1017   outcomes of DHIs. It appears that 'blended' DHIs that include human facilitation/support

1018   may achieve greater engagement, treatment adherence and improved retention in

1019   intervention trials. However, we are unable to draw any firm conclusions about what form,

1020   and how much human support, is most effective for CYP as a whole, let alone more specific

1021   user groups. It is important to note that the type and level of human support provided to

1022   encourage retention in trials is not necessarily practicable or transferable to routine clinical

1023   settings; therefore, it is unlikely that retention rates (and outcomes) reported in trials can

1024   be achieved if DHIs are implemented as unguided/unsupported interventions outside trial

1025   settings. Our results suggest that the level of support provided within trials for children is

1026   more substantial, particularly for ASD and ADHD. Furthermore, the characteristics of DHIs

1027   that support engagement at different ages requires further research. It is likely that DHIs

1028   for children need to incorporate more interactive, game-like elements so that the

1029   development of skills and progression through the intervention becomes self-reinforcing.

1030   Findings from the meta-review suggest that for cCBT, greater benefits are found in older

1031   CYP. The limited effectiveness of DHIs for mood disorders in younger children may result

1032   from insufficient adaptation of interventions to children's cognitive and developmental

1033   needs (Adelman et al. 2014).

1034   Research investigating the use and effectiveness of mHealth smartphone/tablet apps was

1035   mostly absent from our review. This area of healthcare delivery is growing for adult

1036   populations (East & Havard, 2015; Mani, Kavanagh, Hides & Stoyanov, 2015; Nicholas,

1037   Larsen, Proudfoot & Christensen, 2015). There are several commercially available

1038   Mindfulness interventions in a mobile application format that could have trans-diagnostic

1039   benefits for mental health (Mani, et al., 2015), but these have not been evaluated with

1040   CYP. Mobile apps may also be conceptualised as add-ons to online interventions, for

1041   example to make material available to users whilst on the go. Apps may also provide a

1042   means of supplementing therapy (both FtF and online) by allowing, for example, remote

1043   monitoring of symptoms (Simons, et al., 2016). Second generation DHIs also incorporate

1044   wearable devices (e.g. activity monitors), which have been more widely explored in the

1045   health psychology and behaviour change field for CYP (Turner, Spruijt-Metz, Wen & Hingle,

1046   2015). The rise in research on mental health-related apps and the potential behaviour

1047   change arising from wearables suggests a more holistic approach to digital interventions

1048   is on the horizon, with a blurring of boundaries between digital assessment, monitoring

1049   and interventions. However, this will also add to the complexity of assessing efficacy and

1050   determining the active components of an intervention. Virtual reality interventions were

1051   also absent from our review results. In adults, virtual reality interventions for mental

1052   health have predominantly focused on enhancing existing interventions such as exposure

1053   therapy for specific phobias (Pan, Gillies, Barker, Clark & Slater, 2012) or PTSD (Gerardi,

1054   Cukor, Difede, Rizzo & Rothbaum, 2010). However, new research is expanding into areas

1055   such as depression (Falconer et al., 2016), psychosis (Leff, Williams, Huckvale, Arbuthnot

1056   & Leff, 2013) and EDs (Marco, Perpiñá & Botella, 2013).

1057   **CONCLUSIONS**

1058   DHIs offer huge potential for widening access, increasing efficiency and improving

1059   healthcare outcomes. However, existing research indicates that benefits have yet to be

1060   fully realised and effectiveness of these approaches remains uncertain. For the field to

1061   realise the full potential of DHIs, it is necessary to simultaneously harness the latest

1062   technological innovations while maintaining a robust evidence base of clinical and cost-

1063   effectiveness. Meeting this challenge requires a novel integration of innovative approaches

1064   and research methods drawn from disparate disciplines and academic traditions. To date,

1065   the methods for developing and evaluating DHIs have borrowed largely from approaches

1066   used with psychological and pharmacological interventions. However, the development

1067   and evaluation of DHIs requires different approaches with integration and inter-disciplinary

1068   collaboration between methodologies and approaches drawn from engineering, computer

1069   science, human factors, human computer interaction, psychology and mental health

1070   services research.

1071   From a clinical perspective, we recommend that an integrated approach should be

1072   developed that takes into account the views of CYP, the opinions of MHPs (gatekeepers of

1073   DHIs), and seeks to blend DHIs with FtF therapy. MHPs emphasise the importance of DHI's

1074   being adjuncts to traditional FtF therapies. Consideration needs to be given to the possible

1075   adverse effects of CYP using DHIs outside mental health services on publically available

1076   apps. Adverse effects may result from an ineffective or unsuitable intervention, inaccurate

1077   health information, leaking of personal information, lack of support, lack of motivation or

1078   an exacerbation of symptoms. Consequences of a negative experience of DHIs for CYP

1079   such as a lack of faith in efficacy or specific feelings of helplessness, hopelessness and low

1080   self-worth may reduce future help seeking behaviour in CYP, which is a particular concern

1081   given the recurrent nature of mental health problems (Watsford & Rickwood, 2014). An

1082   additional safeguard for the use of DHIs would be to explicitly highlight the potential

1083   negative effects of DHIs. Many interventions do advise users to seek professional help if

1084   symptoms deteriorate or do not improve, but we would argue that this does not go far

1085   enough.

1086   Future generations of DHIs will also offer seamless integration of real-time passive and

1087   active monitoring with personalised therapeutic interventions. In this way, the huge

1088   potential of digital technology (real-time connectivity of data, ubiquitous reach,

1089   personalisation and convenience) can be best harnessed to improve the effectiveness and

1090   reach of evidence-based psychological therapies for CYP.

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1591   **Table 1**. Glossary of common terms and abbreviations used in the field of digital

1592   healthcare (Alkhaldi et al., 2015; Andersson, 2016; Barak, Klein & Proudfoot, 2009;

1593   Källander et al., 2013; Podina, et al., 2015; World Health Organisation, 2011)

Term	Definition
Digital health intervention (DHI)	Interventions that provide information, support and therapy (emotional, decisional, behavioural, and neurocognitive) for physical and/or mental health problems via a technological or digital platform (e.g. website, computer, mobile phone application (app), SMS, email, video-conferencing, wearable device).
eHealth	Electronic Health: Internet-based healthcare delivery, or anything health-related that uses information and communications technology (ICT), incorporating computers or internet in its delivery.
Internet, online or web-based interventions	Usually refers to a program or service delivered through the internet (e.g. a website), designed to create a positive change in behaviour or health status with varying levels of support (e.g. completely unguided, human-supported) given to user.
Computer-based or computer-delivered interventions	Similar to internet-based interventions, but usually refers to a program delivered via a computer: the intervention may be via the internet or an offline program (e.g. CD-ROM, or installed software). Includes psychoeducation and psychotherapy packages, 'serious' games and neurocognitive 'brain training' interventions.

Computer, internet-based, or mobile based CBT	The delivery of Cognitive Behavioural Therapy (CBT) via computer (cCBT), internet (iCBT) or mobile devices or applications (mCBT). Collectively may be referred to as electronically-delivered CBT (eCBT).
mHealth	Mobile-delivered Health: A branch of eHealth focusing on delivering healthcare-related information, interventions and monitoring through portable electronic/mobile devices and technologies, such as smartphones, tablets, and wearable devices. Examples of mHealth for mental health include smartphone applications ('apps'), text/SMS-delivered interventions, and patient monitoring devices.
Telehealth, telepsychiatry, and telemedicine	Delivery of health services and treatment via telecommunications technology (e.g. video-conferencing, SMS email). Includes online counselling and online therapy that may be synchronous (e.g. real-time video-conferencing) or asynchronous (e.g. email or SMS).

1594

Table 2. Summary of the 21 reviews included in the meta-review.

Review authors / year	Type of review	Design of studies in review	Mental health condition(s)	Population and age groups	Digital health interventions	No. of studies in review (date range of search)	AMSTAR score (rating)*
Ali et al. (2015)	Systematic review	RCTs; RTs; Pre-Post comparisons	Any mental health condition	Whole review was CAYP: mean age of sample between 12-25 years Adolescents: 12-17 years Young adults: 18-25 years	Online text-based peer-to-peer support networks and communication (e.g. forums, online support groups, virtual reality chat)	6 (up to June 2014)	7
Boydell et al. (2014)	Scoping review	No restrictions on study design	Any mental health condition	Whole review was CAYP: from 0 - 24 years	Technology-based interventions: including video-conferencing, internet-based interventions, email, telephone, mobile apps and interventions.	126 (up to December 31 2012)	n/a
Calear & Christensen (2010)	Systematic review	No restrictions on study design	Anxiety Depression	Whole review was CAYP: from 5-19 years Children: 5-12 years Adolescents: 13-19 years	Internet-delivered interventions	8 (up to June 2009)	4

Clarke et al. (2015)	Systematic review	RCTs; Experimental or quasi-experimental designs; Pre-Post comparisons	Any mental health condition	Whole review was CAYP: 12-25 years	Internet-delivered interventions	28 (From 2000 to June 11 2013)	7
Davies et al. (2014)	Systematic review and meta-analysis	RCTs	Anxiety Depression Stress Psychological distress	University students only: no min-max age range	Internet-delivered interventions Offline computer-based interventions	17 (up to June 2013)	8
Ebert et al. (2015)	Meta-analysis	RCTs (with non-active control condition only)	Anxiety Depression	Whole review was CAYP: up to 25 years old Children:<13 years old Adolescents: >13 years old	Computer-based, internet-delivered, or mobile-based CBT interventions	13 (up to December 4 2013)	8
Farrer et al. (2013)	Systematic review	RCTs; RTs	Any mental health condition	University students only: aged between 18-25 years, or mean age of sample within this age range	Technology-based intervention: accessed via device (e.g. computer, smartphone) or process (e.g. email, internet)	28 (up to May 2012)	8
Fleming et al. (2014)	Systematic review	No restrictions on study design	Depression	Review was with all populations, but all included studies were with CAYP	Online, digital, or computerised interventions which utilised elements of gaming ("serious games")	9 (2000-up to 21 June 2014)	4

Hailey et al. (2008)	Systematic review	Controlled studies	Any mental health condition	Review was with all populations: separate reporting of CAYP studies	Communications technology (e.g. internet, telephone, video-conferencing)	4 CAYP-only studies (up to June 2006)	5
Newton & Ciliska (2006)	Systematic review and meta-analysis	RCTs	Eating disorders	Review was with all populations: all included studies were with CAYP	Internet-based interventions	5 (1985 - 2004)	7
Pennant et al. (2015)	Systematic review and meta-analysis	RCTs	Anxiety Depression	Whole review was CAYP Children: 5-11 years Young people: 12-25 years	Computerised psychological therapies (e.g. internet-based interventions, CD-ROM, software, smartphone apps)	27 (up to June 2013)	7
Podina et al. (2015)	Meta-analysis	RCTs	Anxiety	Whole review was CAYP: from 5 - 18 years	Computer-based, or internet-delivered, or mobile-based, or virtual reality CBT interventions	8 (up to September 2015)	7
Reyes-Portillo et al. (2014)	Systematic review	No restrictions on study design	Anxiety Depression Suicide prevention	Whole review was CAYP: from 5-25 years Children: 5-12 yrs Adolescents: 13-17 years Emerging adults: 18-25 years	Internet-delivered interventions Mobile-based interventions	25 (January 2000 - December 2013)	6

Rice et al. (2014)	Systematic review	This review had two sections: 1) RCTs 2) any design describing associations between social networking use and depression	Depression	Whole review was CAYP: from 12-25 years	This review had two sections: 1) internet-delivered preventative interventions 2) internet-delivered interventions with social networking functions	1) 15 (up to June 2013) 2) 22 (up to June 2013)	4
Richardson et al. (2010)	Systematic review	No restrictions on study design	Anxiety Depression	Whole review was CAYP: 7 - 25 years	Computerised CBT (cCBT) or internet-delivered CBT (iCBT) interventions	10 (from 1980-2008)	5
Rickwood & Bradford (2012)	Systematic review	RCTs; Quasi-experimental designs; Pre-Post comparisons; Case studies; Longitudinal designs	Anxiety	Whole review was CAYP: 6 - 25 years	Review was of 'self-help interventions: majority of studies (5 out of 6) were computer-based or internet-delivered interventions	5 digital intervention studies (1970 to October 2011)	5
Rooksby et al. (2015)	Systematic review and meta-analysis	No restrictions on study design	Anxiety	Whole review was CAYP: children aged <12	cCBT or iCBT	6 (1950 - August and December 2013)	6

Schlegl et al. (2015)	Systematic review	No restrictions on study design	Eating disorders	Review was with all populations: separate reporting of CAYP (adolescent) studies	Technology-based interventions	3 CAYP-only studies (up to August 2014)	3
Seko et al. (2014)	Scoping review	No restrictions on study design	Any mental health condition	Whole review was CAYP: 13 - 24 years Adolescents: 13 - 18 years Young adults: 19-24 years)	Mobile-based interventions (e.g. SMS, apps)	17 (up to June 2013)	n/a
Siemer et al. (2011)	Systematic review	Not defined	Any mental health condition	Whole review was CAYP	Internet-delivered interventions	20 (date not mentioned)	3
Ye et al. (2014)	Systematic review and meta-analysis	RCTs; RTs; Pre-Post comparisons; Observational studies	Anxiety Depression	Whole review was CAYP: aged <25 years, also included studies targeting parents of children with mental health-related issue	Internet-delivered interventions	7 (1990-2012)	8

*NB: The AMSTAR tool is used for assessing methodological quality of systematic reviews and meta-analyses only, and so were not performed for scoping reviews.

For systematic reviews without a meta-analysis: scores 0-3 indicates low quality, scores 4-7 moderate quality, and scores 8-9 high quality.

For systematic reviews with meta-analysis: scores 0-4 indicate low quality, 5-8 moderate quality, and 9-11 high quality.

Table 3. Summary of the study characteristics of RCTs included in the updated systematic review

Study	Trial arms and sample size	Age range (mean) and gender (nM/nF)	Target of DHI	Intervention				Comparator(s)				Withdrawals and dropout at post-intervention	ITT analysis
				Name	N	Frequency	Location and level of support	Name	N	Frequency	Location and level of support		
Attention Deficit Hyperactivity Disorder (ADHD) **Neurofeedback training**													
Arnold et al. (2013)	2 arms N=39	6-12 yrs (8.9) 31/8	Treatment: participants had diagnosis of ADHD	*SmartBrain®* videogame system	26	40 x 45 min sessions, either 2 or 3 times weekly	Unsure: states participants did not require a "coach"	Attention Placebo	13	Same as main intervention	Same as main intervention	Intervention: n=2 (1 to pursue medication; 1 due to distance and grades) Comparator: n=3 (1 lost; 2 to pursue medication)	No
Bink et al. (2014, 2015)	2 arms N=90	12-24 yrs (16.1) 90/0	Treatment: participants had diagnosis of ADHD	Unnamed neurofeedback training computer program + TAU	59	Up to 40 x 30 min session, either 2 or 3 times a week over approx. 25 weeks	Within a clinic; training was delivered by psychologist	TAU	31	Varied by each participant	Dependent on type of TAU	Intervention: n=12 (9 discontinued; 2 moved location; 1 for medical reasons) Comparator: n=5 (all discontinued)	No
Dongen-Boomsma et al. (2013)	2 arms N=41	8-15 yrs (16.1) 34/7	Treatment: participants had diagnosis of ADHD	*BrainMaster Atlantis®*	22	30 x 45 min sessions, twice weekly	Within a clinic: neurofeedback therapist delivered sessions	Attention Placebo	19	Same as main intervention	Same as main intervention	None	Yes

Li et al. (2013)	2 arms\n\nN=64\n\n54/10	7-16 yrs (10.6)	Treatment: participants had diagnosis of ADHD	Unnamed neurofeedback training computer program plus methyl-phenidate medication	32	40 x 25-35 min sessions, 2 to 5 times weekly	Unsure where training took place	Attention placebo plus methyl-phenidate medication	32	Same as main intervention	Same as main intervention	Intervention: n=1\n\nComparator: n=3	Unsure
Steiner et al. (2014)	3 arms\n\nN=104\n\n77/27	7-11 yrs (8.56)	Treatment: participants had diagnosis of ADHD	*Play Attention®* computer program	34	40 x 45 min sessions, 3 times a week over 5 months	In school: monitored by research assistant	1) *Captain's Log* cognitive training computer program\n\n2) TAU	1) 34\n\n2) 36	1) Same as main intervention\n\n2) Dependent on participants	1) Same as main intervention\n\n2) Dependent on TAU	Cognitive training comparator: n=2	Yes
Working memory training													
Chacko et al. (2014)	2 arms\n\nN=85\n\n66/19	7-11 yrs (8.4)	Treatment: participants had diagnosis of ADHD	*CogMed RM®* computer program	44	25 x 30-45 min sessions, over 5 days/weekly over 5 weeks	Participants' home: supervised by training aide (parent or guardian) with weekly phone calls from coach	Attention Placebo	41	Same as main intervention	Same as main intervention	Intervention: n=3 discontinued; n=3 parents, n=4 children + n=4 teachers lost to follow-up\n\nComparator: n=1 discontinued; n=4 parents, n=5 children + n=1 teachers lost to follow-up	Yes
Dongen-Boomsma et al. (2014)	2 arms\n\nN=51\n\n34/13	5-7 yrs (6.55)	Treatment: participants had diagnosis of ADHD	*CogMed JM®* computer program	27	25 x 15 min sessions, over 5 days per week	Completed in participants' home	Attention Placebo	24	Same as main intervention	Same as main intervention	Intervention: n=1 (discontinued)\n\nComparator: n=3 (discontinued)	No

Study	Arms	Age	Treatment	Intervention	n	Sessions	Location	Comparator	n	Comparator sessions	Comparator location	Attrition	
Egeland et al. (2013)	2 arms N=67 49/18	10-12 yrs (10.4)	Treatment: participants had diagnosis of ADHD	*CogMed RoboMemo*® computer program	33	30-45 min sessions, completed daily for 5-7 weeks	In school: supervised by teacher or parent	Waitlist	34	n/a	n/a	Intervention: n=2 (1 due to low attendance; 1 refused follow-up assessment)	No
Executive functioning training													
Dovis et al. (2014)	3 arms N=89 71/18	8-12 yrs (10.46)	Treatment: participants had diagnosis of ADHD	*Braingame Brian*® computer program	31	25 x 35-50 min sessions, over five weeks	Completed in participants' home: received weekly telephone calls (approx. 15 mins) from a Research Assistant coach	1) Partially-Active version of *Braingame Brian*® 2) Attention Placebo	1) 28 2) 30	1) + 2): 25 x 35-50 min sessions, over five weeks	1) + 2): Same as main intervention	Intervention: n=1 discontinued; n=1 parent + child and 3 teachers lost Attention placebo comparator: n=2 discontinued; n=2 parents + child and n=2 teachers lost	Yes
Video-conferencing													
Myers et al. (2015)	2 arms N=223 163/58	5.5-12 yrs (9.25)	Treatment: met diagnostic criteria for ADHD	*CATTS* telehealth video-conferencing service	111	6 sessions over 22 weeks: spaced 3-4 weeks apart	Unsure where videoconferencing took place	Attention Placebo	112	1 x video-conferencing session with psychiatrist	Unsure where video-conferencing took place	Intervention: n=15 did not complete all five assessments Attention placebo comparator: n=11 did not complete all five assessments	Yes
Autism Spectrum Disorder (ASD)													

Fletcher-Watson et al. (2015)	2 arms N=54	All ≤6 yrs (4.1) 43/11	Treatment: participants had diagnosis of an ASD, or on waiting list for diagnosis	Social communication skills training: *FindMe®* app	27	5 minutes per day for 2 months	Participants' home: level of support not stated	Waitlist + TAU	27	1-to-1 support (M=11.5 hours/week)	School/nursery	Intervention n=1 (discontinued)	Yes
Thomeer et al. (2015)	2 arms N=43	7-12 yrs (7.75) 38/5	Treatment: participants had diagnosis of an ASD	Emotion recognition training : *MindReading®* computer program	22	24 x 90 min sessions over 12 weeks (2 sessions weekly)	Computer lab, supervised by a staff clinician	Waitlist	21	n/a	n/a	None, but 1 (in comparator group) excluded from analysis due to medical issue	No
de Vries et al. (2015)	3 arms N=121	8-12 yrs (10.5) 82/8	Treatment: participants had diagnosis of an ASD	Working memory and cognitive-flexibility training: *Braingame Brian®* computer program	40	25 sessions over 6 weeks	Participants' home: weekly telephone calls with parents	1) Partially-active version of *Braingame Brian®* 2) Attention Placebo	1) 37 2) 38	1) + 2): 25 sessions over 6 weeks	1) + 2): Same as main intervention	Intervention: n=1 Partially active comparator: n=3 Attention placebo comparator: n=2	Yes[1]
Anxiety													
Attention bias modification													
Shechner et al. (2014)	3 arms N=63	6.5-18 yrs (11.5) 31/24	Treatment: participants had diagnosis of Separation Anxiety Disorder, Social Phobia, Specific Phobia, or Generalized Anxiety Disorder	Attention bias modification + CBT	15	16 x 50 minute sessions of CBT + ABM; variation in when ABM was administered	Clinic, delivered by therapist	1) Attention Placebo + CBT 2) CBT-only	1) 22 2) 18	1) Same as main intervention 2) 16 x 50 min sessions	1) + 2): Same as main intervention	Intervention: n=3 (all discontinued) Attention placebo + CBT comparator: n=3 (all discontinued) CBT-only comparator: n=2 (all discontinued)	Yes[1]
Cognitive bias modification													

Study	Arms / N	Age (mean); sex	Aim / Population	Intervention	n	Dosage	Delivery	Comparator	n	Comparator dosage	Setting	Attrition	RCT
Sportel et al. (2013)	3 arms N=240	12-15 yrs (14) 64/176	Prevention: Participants scored above threshold for social or test anxiety	Cognitive bias modification	86	20 x 40 min sessions, twice a week	Delivered online, accessed in participants' own location	1) In-class group CBT 2) No treatment control	1) 84 2) 70	1) 20 x 40 min sessions, twice a week 2) N/A	1) In school 2) N/A	Intervention: n=40 discontinued; n=13 quit participation. CBT comparator: n=20 discontinued; n=15 quit participation. No treatment comparator: n=12 quit participation	Yes
eCBT interventions													
Storch et al. (2015)	2 arms N=100	7–13 yrs (9.8) 56/44	Treatment: participants had Diagnosis of Separation Anxiety Disorder, Social Phobia, Generalized Anxiety Disorder, Specific Phobia, or Panic Disorder	*Camp Cope-A-Lot* in-person support and cCBT program	49	12 x 50-60 min sessions, delivered weekly	Health centre: first 6 sessions primarily computer-based; final 6 sessions therapist led	TAU	51	Dependent on TAU	Dependent on type of TAU	Intervention: n=4 Comparator: n=4	Yes

Vigerland et al. (2016)	2 arms N=93	8-12 yrs (10) 38/55	Treatment: participants had diagnosis of Separation Anxiety Disorder, Social Phobia, Generalized Anxiety Disorder, Specific Phobia, or Panic Disorder	Unnamed cCBT parent-child program	46	Completed at own pace; participants were given access for 10 weeks	Online and accessed at home: online contact with therapist and 3 telephone calls	Waitlist	47	N/A	N/A	Intervention: n=2 no primary outcome measure data; n=5 children and n=4 parents did not complete secondary measure Comparator: n=1 no primary outcome measure data; n=15 children and n=13 parents did not complete secondary measure	Unsure

Depression

Attention bias modification

Yang et al. (2014)	3 arms N=77	18-22 yrs (19.4) 22/55	Prevention: participants screened for mild, moderate or severe depression symptoms	Attention bias modification	27	8 x approx. 12 minute sessions: 4 sessions each week over 2 weeks	Laboratory; unsure of level of human support/input	1) Attention Placebo 2) No intervention	1) 27 2) 23	1) Same as main intervention 2) N/A	1) Same as main intervention 2) N/A	None: all completed post-intervention assessment	Yes

Solution-Focused Brief Therapy

Kramer et al. (2014)	2 arms N=263	12-22 yrs (19.5) 56/207	Prevention: participants had elevated depression symptoms	*PratenOnline* chatroom-based Solution-Focused Brief Therapy (SFBT) with healthcare professional	131	Each chat approx. 60 mins. Number of chats limited to 5	Online: participants accessed chat in own environment	Waitlist control	132	N/A	N/A	Intervention: n=56 did not complete post-intervention measures Comparator: n=55 did not complete post-	Yes[1]

												intervention measures	
eCBT interventions													
Lillevoll et al. (2014)	4 arms N=775 335/440	15-20 yrs (16.8)	Universal: no mental health-related inclusion criteria	*MoodGym* cCBT with 3 arms of email reminders: 1) No emails 2) Standard emails 3) Tailored emails	1) 176 2) 176 3) 175	5 modules (each approx. 30-45 mins), completed at own pace	Online and completed in participants' own environment, self-guided but with three different levels of email reminders	Waitlist control	180	N/A	N/A	Intervention: n=158 did not complete follow-up measures Comparator: n=46 did not complete follow-up measures	No
Smith et al. (2015)	2 arms N=112 N/S	12-16 yrs (N/S)	Prevention: participants had elevated depression symptoms	*StressBusters* cCBT	55	8 sessions (approx. 45 mins each), over 8 weeks	Computer-based, completed in school	Waitlist + TAU	57	N/A	N/A	Comparator n=2 not assessed at post-intervention	Yes
Stasiak et al. (2014)	2 arms N=34 20/14	13-18 yrs (15.2)	Prevention: participants had elevated depression symptoms	*The Journey* cCBT	17	7 modules (each 25-30 mins each) completed over 4-10 weeks	Completed at school with minimal oversight from counsellors	Attention Placebo	17	Same as main intervention	Same as main intervention	Intervention: n=1 withdrew from study Comparator: n=1 did not complete assessment; n=3 withdrew from study	Yes

Saulsberry et al. (2013)	2 arms N=84	14-21 yrs (17.39) 36/47	Prevention: participants had persistent subthreshold depression	Motivational interview (MI) with primary care practitioner + *CATCH-IT* internet-based program (based on CBT, humanistic and interpersonal training principles)	40	Primary care practitioner helps participant develop cost-benefit assessment towards completing CATCH-IT	MI was in primary care, but accessed CATCH-IT in own location; 3 motivational telephone calls from social worker case managers	Brief Advice with primary care practitioner + *CATCH-IT*	43	In initial consultation, primary care practitioner refers participant to CATCH-IT	BA (in initial consultation) was in primary care, but accessed CATCH-IT in own location	Intervention: n=6 lost; n=2 withdrew; n=2 dis-enrolled; n=1 died Comparator: n=7 lost; n=1 withdrew; n=1 dis-enrolled as did not meet criteria	Yes

Anxiety and depression eCBT interventions

Melnyk et al. (2015)	2 arms N=121	N/S (18.5) 19/102	Universal: no mental health-related inclusion criteria	*Creating Opportunities for Personal Empowerment ('COPE') cCBT*	82	7 Modules (approx. 30 mins each). Unsure how long participants had to access COPE	Online was self-guided, and modules were made available sequentially	Teaching-as-usual	39	Equal duration to main intervention	Self-guided	Not stated	Unsure
Sethi (2013)	4 arms N=89	18-25 yrs (20.8) 37/52	Prevention: participants had mild to moderate anxiety symptoms and / or depression symptoms	*MoodGym* + FtF CBT	22	5 x approx. 60 min sessions, delivered weekly (first and last sessions were 90 mins) over 5 weeks	Completed at youth centre or university and delivered in private rooms	1) FtF CBT 2) *MoodGym* 3) No intervention	1) 21 2) 23 3) 23	1) and 2): Same as main intervention 3) N/A	1) FtF CBT delivered by psychologist; same as main intervention 2) Same as main intervention 3) N/A	None	Yes

Study	Arms/N	Age	Type	Intervention	n	Sessions	Delivery	Comparator	n	Comparator details	Setting	Attrition	
Wong et al. (2014)	3 arms N=976 293/683	14-16 yrs (N/S)	Universal: no mental health-related inclusion criteria	*ThisWayUp Schools: Combating Depression and Overcoming Anxiety* Two arms: 1) Received 'anxiety' course 2) Received 'depression' course	1) 372 2) 380	One session (40 mins each) completed once a week over 6-7 weeks	Delivered in schools: second half of session involved teachers handing out worksheets to discuss and reinforce information from *ThisWayUp*	Teaching-as-usual	224	Not stated: assume it was weekly	In school with regular teacher	555 did not complete post-intervention assessments Due to loss of data/data corruption, post-intervention data only available for 265 participants	Unsure
Eating disorders													
eCBT interventions													
Kass et al. (2014)	2 arms N=151 0/151	18-25 yrs (21)	Prevention: participants had as high risk for eating disorder	*Student Bodies* coupled with moderated online discussion group	74	8 modules; each module released weekly over 8 weeks	Online and completed in own environment; discussion group was guided by a research assistant and clinician	*Student Bodies* without online discussion group	77	Same as intervention	None	Intervention: n=5 never logged into intervention; n=17 did not complete post-intervention assessments Comparator: n=2 dropped out; n=1 never logged into comparator; n=15 did not complete post-intervention assessments	Yes
Saekow et al. (2015)	2 arms N=65 0/65	18-25 yrs (N/S)	Prevention: participants screened as having subclinical anorexia nervosa, bulimia nervosa, binge eating	*Student Bodies*	31	10 modules; each module released weekly over 10 weeks, with a booster session offered at 2	Online and completed in own environment; all activities reviewed by coaches and addressed in weekly feedback to participants	Waitlist control	34	n/a	n/a	Intervention: n=6 lost to follow-up; n=6 discontinued Comparator: n=7 lost to follow-up	Yes[1]

			disorder, or purging disorder			months after final module							

Psychosis

Holzer et al. (2014)	2 arms N=32 18/14	13-18 yrs (15.4)	Treatment: participants had diagnosis of psychotic disorder, or screened as high risk of psychosis	*Captain's Log:* computer-assisted cognitive remediation software	18	16 x 45 min sessions, 2 per week over 8 weeks	Monitored setting with research psychologist	Attention Placebo	14	16 x 30 min sessions, 2 per week over 8 weeks	Same as main intervention	Intervention: n=3 discontinued Comparator: n=1 discontinued	Yes

Post-Traumatic Stress Disorder

Ruggiero et al. (2015)	3 arms N=987 465/522	12-17 yrs (14.5)	Prevention: participants included on basis of being exposed to tornado	*Bounce Back Now:* web-based intervention, based upon behavioural principles, motivational-enhancement and cognitive-behavioural approaches	364	4 modules; authors anticipated participants would only visit website once.	Online and accessed in participants' own environment (e.g. home)	1) *Bounce Back Now + Adult Self-Help* intervention 2) No intervention	1) 366 2) 257	1)Adult Self-Help intervention was accessed via *Bounce Back Now*, consisted of 7 self-help modules 2) N/A	1) Online 2) N/A	Unsure: n=233 families (teenager or parent) across two intervention trial arms did not complete >1 intervention module	Yes[1]

Abbreviations: CBT – cognitive behavioural therapy; cCBT – computerised cognitive behavioural therapy; DHI – digital health intervention; FU – follow-up;mth – month; nM/nF – number of males in sample / number of females in sample; N/A – not applicable; N/S – not stated in published paper; yrs = years old. Within the ITT analysis column: Studies marked with [1] indicate that separate analyses were also performed with 'completers' (as defined by authors; usually meant completing all or certain percentage of intervention). Studies marked as 'Unsure' indicate uncertainty about whether ITT analyses were performed due to discrepancies in reporting or insufficient information reported in paper.