The Use of Mobile Apps and Technologies in Child and Adolescent Mental Health: a Systematic Review

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Abstract

Question: This review will aim to critically evaluate the currently available literature concerning the use of online mobile-based applications and interventions in the detection, management and maintenance of children and young people's mental health and wellbeing.

Study Selection and Analysis: A systematic literature search of 6 electronic databases was conducted for relevant publications until May 2019, with keywords pertaining to mental health, wellbeing and problems, mobile or Internet apps or interventions and age of the study population. The resulting titles were screened and the remaining 92 articles were assessed against the inclusion and exclusion criteria with a total of 4 studies included in the final review.

Findings: In general, young people seem to engage very well with this type of tools and they demonstrate some positive effects in emotional self-awareness. There have been some studies about this matter and many of the outcomes were not significantly significative. However, it is still a sparsely documented area and more research is needed in order to prove these effects.

Conclusions: Mental health apps directed at young people have the potential to be important assessment, management and treatment tools, therefore creating easier access to health services, helping in the prevention of mental health issues and capacitating to self-help in case of need. However, a limited number of studies are currently available, and further assessments should be made in order to determine the outcomes of this type of interventions.

Keywords: child and adolescent mental health, mobile health apps, electronic health.

List of Abbreviations

MH: Mental Health

CYP: Children and Young People

NHS: National Health Service

Apps: Mobile or Internet Applications

CAMH: Child and Adolescent Mental Health

CAMHS: Child and Adolescent Mental Health Service

CBT: Cognitive Behaviour Therapy

h.apps: health apps

m.tech: mobile technologies

RCT: Randomised Controlled Trial

ESA: Emotional Self-Awareness

IVR: Interactive Voice Response

Summary Box:

What is already known about this subject?

- At present, child and adolescent mental health has constantly increasing needs in terms of resources and investigation.
- In the past few years, technology has become more and more present in our everyday routine and Internet and smartphones are now an ordinary tool on our daily basis. Consequently, health apps are also increasing every day.
- Incorporating health apps in screening, assessment and management of mental health issues in young people is now a promising field of study.

What are the new findings?

- There have been some studies about this matter and many of the outcomes were not significantly significative.
- However, it is still a sparsely documented area and more research is needed in order to prove this effects.
- In general, young people seem to engage very well with this type of tools and they seem to demonstrate some positive effects in emotional self awareness.

How might it impact on clinical practice in the foreseeable future?

Mental health apps directed at children and adolescents have the potential to be important assessment, management and treatment tools in this age group, therefore creating a more easy access to mental health services, helping in the prevention of more serious mental health issues and capacitating young people to help themselves in case of need.

BACKGROUND

Child and Adolescent Mental Health

Mental health (MH) and wellbeing is rapidly growing as the new frontier in child and adolescent health. The increased interest is justified by the publication of troubling statistics showing decreasing levels of happiness in children [1] and increasing recognition of their MH problems.

One in 10 children and young people (CYP) are estimated to present with a diagnosable MH condition by conservative estimates [2] however some studies have demonstrated a prevalence as high as 19% [4]. As an example, data from the United Kingdom shows that despite expansion of the teams and increased staffing levels[5] Child and Adolescent Mental Health (CAMH) teams are experiencing continuous surge in referral numbers (Figure 1).

It is difficult to definitively say if this corresponds with a true increase in the prevalence of mental health issues as this might be a reflection of greater societal awareness and reducing stigma around the topic. Equipping young people with knowledge and providing coping strategies is now a core component of education curriculums[7] and this is supplemented by easily accessible information and discussion forums on internet and media platforms which allows them become more active and seeking help when necessary.

Unfortunately, the increased numbers of CYP requiring CAMHS intervention is placing the service under untenable pressure. Taking Scotland as an example, one in five children referred to CAMHS breach the 18 week maximum waiting time goal set by the Scottish Government[8] and despite assurances that spending on MH would be increased as a priority, MH expenditure has gone down when compared to overall National Health System budgets[9]. This means that the service has to find ways to adapt in order to continue providing high quality care. The economic cost of poor MH in Scotland is currently estimated at around £10.7 billion[10] and this will only rise if nothing is done.

Mobile Applications (“Apps”) and their Utilization in Child and Adolescent Mental Health

Arguably the most significant and impactful change to society in the last 50 years has been the digital revolution, the introduction of digital technology and the Internet to all aspects of life; this includes interest in using them in the service of health; widely accepted applications already in use (Supplementary File 1: Digital Health Tool. Source: IQVIA Institute; The Growing value of Digital Health; 2017).

With the advent of smartphones, mobile telephones capable of computer functionality, digital health related content is in everyone's pocket: 64.3% of the UK population owns a smartphone, with an even larger proportion regularly going online[12], so it is not surprising that the market of downloadable applications or "apps" has also embraced digital health content. More than 318,000 health apps (h.apps) are currently available through multiple platforms (App Store, Google Play) with more than 200 new health related apps being added every day[13]. However, their market penetration is on the whole poor, with only 15% reaching more than 5000 downloads. Despite this, it was estimated that by the end of 2017, 50% of mobile phone users have downloaded at least one health app[14] (Supplementary File 2: The number of Digital Health Apps 2013, 2015 and 2017. Source: IQVIA Institute; The Growing Value of Digital Health; 2017). A recent Australian study [15] about adolescent´s perceptions of online therapies for m.health problems showed that 72.0% (n=217) said they would access an online therapy if they experienced a m.health problem and 31.9% would choose an online therapy over traditional face-to-face support. The most valued benefits reported were alleviation of stigma and increased accessibility and the knowledge of online therapies was found to positively predict perceived helpfulness and intended uptake. This suggests that h.apps are an acceptable resource and can be a useful vehicle for enhancing access to evidence-based monitoring and self-help.

There are significant obstacles to overcome before this goal can be achieved, the greatest of which concerns the oversight and regulation of h.apps. Apps developed in academia and supported in clinical trials are slow to reach the consumer marketplace; meanwhile, proliferation of industry-developed apps on consumer marketplaces has been high [16]. Anyone can create and upload an app for public consumption but there is, at present, little to no regulation or certification[17]. This is one of the greatest barriers to physicians recommending

apps to their patients; an American study found that 42% of physicians would not feel comfortable or safe prescribing use of apps without regulatory oversight[18], the risks of doing so, is succinctly put by Boudreaux et al. (2014) "*the decision to recommend an app to a patient can have serious consequences if its content is inaccurate or if the app is ineffective or even harmful*"[17,19]. It is also of note that high quality guidance on how to judge the validity of commercially available apps is severely lacking[17,20] with guidance limited to personal familiarity with apps or user ratings. Some tentative efforts have been made to address these problems. A UK Digital Health Apps Library[21] was launched in April 2017 and although still in its beta phase of testing, the website aims to provide information on which apps are accessible and safe to use, with apps listed as NHS approved or under testing.

In order to remain successful and relevant, apps creators must also embrace the constantly evolving technology and operating systems; if they don´t, apps can quickly become obsolete. It is therefore crucial that h.apps are constantly assessed and adapted to reflect advances in the health sector and the business/consumer sector[17]. Another important consideration is the language: 56% of the apps are only available in English[17], making use in an increasing multicultural society more difficult.

Approximately 60% of marketed h.apps come under the category of "*Wellness Management*" and are focused on health maintenance, facilitate tracking and modification of personal lifestyle behaviours. The remaining are categorised as "*Health Condition Management Apps*" some of which are disease-specific, the most popular being for MH and behavioural disorders (e.g. as autism and alternative communication, depression, anxiety and attention deficit and hyperactivity disorder)[17,23].

The CYP of today are ubiquitous consumers of technology; indeed this generation has been labelled as "iKids"[27] and "digital natives"[28] and children of all ages are spending ever increasing amounts of time online[29]. Around 69% of children use a mobile phone and by the age of 12, more than 80% of young people accessing the internet via smartphones download and use mobile apps[30].

There is also well-founded concern as to the effect of mobile technology usage on CYP. High frequency use of mobile phones has been related to sleep disturbance and depression[31] and less accurate response to higher level cognitive tasks[32] and more Facebook friends has been found to be predictive of personality disorders[30]. Despite these worries, it seems unlikely that CYP will be prised away from their mobile phones. In light of this, apps seem an ideal avenue to explore in the realm of CAMH maintenance and management (Supplementary File 3: Disease-Specific Apps by Therapy Area. Source: IQVIA Institute; The Growing Value of Digital Health; 2017).

OBJECTIVES

This systematic review aims to critically evaluate the current available literature concerning the use of apps in the detection, management and maintenance of CYPs' MH and wellbeing and more specifically, to determine if this type of intervention is yet effective and appropriate enough to be utilised by CAMH clinicians to support their activity.

STUDY SELECTION AND ANALYSIS

A literature search of 7 electronic databases was conducted for relevant publications between January 2007 and May 2019. Databases searched included: MEDLINE, PsychINFO, EMBASE, AMED (Allied and Complementary Medicine), Health Technology Assessment Guide, and the Cochrane Register of Controlled Trials. Searches were conducted with keywords pertaining to MH, wellbeing and problems, age of the study population and words pertaining to mobile or Internet apps or interventions (Supplementary File 4: Table with Search Terms Used).

Database specific filters of Human Population and English language were applied; following the database search reference lists were screened to ensure an exhaustive search. The resulting titles and abstracts were manually screened according to the inclusion and exclusion criteria detailed in Supplementary File 5 (Table with Inclusion and Exclusion Criteria).

Supplementary File 6 (PRISMA Flow Diagram) details the manual screening process of the search results against the inclusion and exclusion criteria. It should be noted that if at any stage there was equivocation around the suitability of

papers for inclusion they were advanced to the next stage of the process for more rigorous scrutiny.

Study Inclusion

Initial database searching with the filters of Human Population, English Language and 2007-2019 publication date identified 1013 results with 3 additional results identified through screening of appropriate reference lists. Duplicate results were removed yielding a total of 692 records for screening. The titles and abstracts of these unique citations were assessed for eligibility. After this process the remaining 92 full-text articles were assessed against the inclusion and exclusion criteria with a total of 6 articles included in the final review. From these six remaining articles, 3 of them reported about the same randomized clinical trial (ClinicalTrials.gov NCT00794222) and to avoid confusion, they were tabulated together since the research design and intervention are identical.

Study Characteristics

Study characteristics are detailed in Table 1.

Table 1: Study Characteristics and Findings

Author/ Year	*Study Purpose*	*Research Design*	*Intervention*	*Main Findings*
Jang et al. (2017)[34]	To examine the use of a smartphone app to screen for depression and suicide risk	**Design:** cross-sectional study **Sample:** 208683 (age 10+ years) **Location:** app available worldwide in Korean (so Korean speakers only)	**Technology:** Mobile app **Format:** Participants completed self-assessment of depression and suicide using validated measures on app that vary then analysed **Phone ownership:** personal	Positive self assessment scores on app were associated with significant increased risk of depression and suicide and were consistent with the population proportions seen in previously reported data
Johansson et al. (2013)[35]	To evaluate IVR as a method for collecting self-reported data following discharge from inpatient psychiatric care	**Design:** RCT **Sample:** 60 recent in-patients (age 13-17 years) **Comparison Group:** contacted every 4th day by IVR (compared to every 2nd day) **Location:** Sweden	**Technology**: automated telephone calls with IVR **Format:** automated calls to mobile phones asked patients to evaluate their current mood **Phone ownership:** mixed (personal mobile phones or borrowed from inpatient unit)	IVR is an appropriate follow-up method following inpatient psychiatric treatment in adolescents with no difference observed in mood if followed up every 2 days or every 4 days
Kauer et al. (2012)[36] **Reid et al. (2011)[37]** **Reid et al. (2013)[38]**	To examine: - the effect of a m.app based self-monitoring tool on ESA and depressive symptoms - the MH benefits of the m.app in the primary care setting - the effectiveness of the m.app as a clinical assistance tool in general practice and to aid in the development of doctor-patient rapport and pathway to care decisions	**Design**: RCT **Sample:** 114 patients (age 14-24 years) **Comparison Group:** Self-monitoring using abbreviated version of mobile-type app **Location:** Australia	**Technology:** Mobile app **Format:** participants self-reported data on mood, stress, daily activities and coping strategies which was available to their GP **Phone Ownership:** Research team (participant lent phone with preloaded app and given pre-paid SIM-card)	Self-monitoring of mood, stress and coping strategies significantly increased ESA with more comprehensive monitoring causing greater increases. Increased ESA was predictive of a decrease in depressive symptoms; however the intervention was not causally responsible itself for the decrease in depressive symptoms Intervention group showed significant increases in ESA. There were medium to large significant main effect for time for depression, anxiety and stress. Analysis suggested that participation in RCT itself enhanced mental health care and improved mental health outcomes Mobile-type program significantly assisted GPs in their clinical understanding and management of their patients but had no significant effect on doctor-patient rapport or pathways to care
Whittaker et al. (2017)[39]	To evaluate the effectiveness of a CBT-based depression prevention intervention delivered via multimedia mobile phone messages	**Design:** RCT **Sample:** 855 students (age 13-17 years) **Comparison group:** received placebo messages without CBT-based information **Location:** New Zealand	**Technology:** Mobile phones based multimedia messages **Format:** Program sent CBT-based multimedia messages (texts, video messages, cartoons) **Phone ownership:** personal	No significant effect of CBT-based program over control. Both programs demonstrated small improvements in depression score immediately after the intervention followed by a worsening of scores at 12 month follow-up

Study Risk of Bias

All studies were assessed using a tool adapted from the Cochrane Risk Of Bias Tool (http://handbook-5-1.cochrane.org/). In general, performance bias due to difficulties in blinding participants and personnel was an issue, as well as difficulty in assessing the use of selective reporting. Full results of the Risk of Bias assessment can be seen in Table 2.

	Jang et al. (2017)[34]	Johansson et al. (2013)[35]	Kauer et al. (2012)[36] Reid et al. (2011)[37] Reid et al. (2013)[38]	Whittaker et al. (2017)[39]
Random Sequence Generation (Selection Bias)	**N/A**	**–***	**–**	**–**
Allocation Concealment (Selection Bias)	**N/A**	**–**	**–**	**–**
Selective Reporting (Reporting Bias)	(?)*	(?)	(?)	(?)
Other Bias	(?)	**–**	**–**	**–**
Blinding of Participants and Personnel (Performance Bias)	(+++)*	(?)	(?)	**–**
Blinding of Outcome Assessment (Detection Bias)	(+++)	**–**	**–**	**–**
Incomplete Outcome Data (Attrition Bias)	(?)	**–**	**–**	**–**

Table 2: Risk of Bias in Selected Studies. Adapted from Moher et al. (2009)[37]**.**

***** (+++): High Risk of Bias; (?): Unclear risk of Bias; –: Low risk of Bias.

Study Participants

The studies included participants whose age ranged from 10 until 29 years old. Only 2 sampled exclusively participants between the ages of 13 and 17

years[35,39]. 81.4% of participants in the Jang et al. (2017) study were aged 10 to 29 years but no further breakdown of the groups composition in terms of ages was provided[34]. The sum mean age of participants in the mobile-type trial was 18.1 years[36-38]. Additional demographic data of participants was recorded in all studies, with none reporting any statistically significant differences between the comparison groups. However, in all of them the number of females was disproportionately greater than the number of males[34-38].

Two of the studies were exclusively comprised of data from participants with mild to severe emotional or MH difficulties, either formally diagnosed[35] or indicated by scores on a validated scale[36-38]. As the aim of the MEMO trial [39] was to evaluate the effectiveness of the intervention in preventing the onset of depression, prospective participants scoring in the clinical range as having MH difficulties on several validated scales were excluded.

Incentives to participation were employed in the design of some studies. The mobile-type studies offered $30 phone credit to reimburse the young participants and participating general practitioners received quality assurance points toward their continuing personal development [36-38], while the MEMO trial offered ringtones and games[39].

Mobile Technology Characteristics and Mobile Phone Ownership

Three studies utilised asynchronous features of mobile phones (apps and multimedia messaging)[34-38]; the remaining study concerned the use of a mobile phone based interactive voice response (IVR) system[35]. Studies evaluated the effect of use the mobile-type app[36-38], the MEMO-CBT multimedia mobile phone program[39], an unnamed depression and suicide screening app[34] and the IVR follow up system for reporting mood post discharge from inpatient care [35]. With the exception of the unnamed app described by Jang et al.[41], all technologies utilised were designed specifically for CYP[35-39]. At the time of writing, none of them is available for public consumption.

Mobile phones were required for participation in all included studies, some of which relied on participant personal mobile phone[41,39] and others worked in conjunction with mobile technology companies to provide participants with

mobile phones and pre-paid SIM cards[36-38]. The MEMO trial research team provided free internet access[39].

FINDINGS

Mental Health and Health Care Service Outcomes

All studies reported MH outcome data[34-39]. As evident in Table 1 the main area of intervention was depression, anxiety and suicide. One study also reported health service outcomes data[38] (Table 1).

Mobile Technology Usage

Few of the included studies reported data on the technology usage. Whittaker found that 19% of participants viewed more than half of the multimedia messages and reported that participants greatly overestimated the proportion of messages they viewed[39]. The mobile-type trial reported that only 52.6% of participants in the intervention group received what the researchers considered to be the minimum effective dose with the remainder of participants not active enough on the app to reach this dose level[37]. Johansson reported 71% of participants achieved an answering IVR call frequency of 100%[35].

Child and Adolescent Feedback

Although not the aim or primary outcome measure of any of the included studies, results of the MEMO-CBT included reports from the majority participants that they found the program to be helpful, with a slightly higher proportion (84%) of the intervention group giving positive reports than the control group (82%) but this difference was non-significant (p=.46). There were also non-significant differences between the intervention and groups in sharing of messages with others (37.9% and 40.0% shared messages respectively).

CONCLUSIONS

Discussion

For this review, a total of 6 articles met the inclusion criteria which are reflective of the fact that the study of mobile technologies in child and adolescent mental health is still in its relative infancy. The results indicate that while mobile technologies (m.tech) are an exciting new tool, caution must be exercised until further study is made of them. In line with previous reviews[41-42], trials of the MEMO-CBT program and the h.apps failed to demonstrate a significant effect upon depression and anxiety.

The significant increases in ESA demonstrated through use of the h.apps and their causal relationship in decreasing depressive symptoms is interesting[36]. It may be that the effects observed by Whittaker[39] and Reid[37] are due to the usage of an app that makes adolescents think about their MH; this alone may have a positive effect as explained by Whittaker who notes that "the attention control was equally efficacious"[39]. The very act of engaging with MH monitoring may be beneficial for CYP and relatively inexpensive and user friendly apps may be the ideal mode to deliver that benefit in a cost-effective and efficient manner.

The age of the population may also have had an unforeseen impact. It has been shown in longitudinal studies that there is generally a steep increase in depressive symptoms throughout adolescence[39,44] which was not adjusted for in any of the articles; so it could be argued that full effects of the interventions were obscured by the natural course of child development.

The use of m.tech for screening purposes is an interesting avenue for further exploration, the results of the cross sectional study by Jang et al. being encouraging[34]. Whether this method of app screening is appropriate for the paediatric population is difficult to determine, as the age range for the study was broad and no information as to particular screening questions or their applicability to CYP was described.

Mobile technologies also look to be appropriate for automated follow up after discharge from inpatient care. IVR was shown to be an effective follow up tool[35] and it may offer clinicians a helpful method of monitoring newly discharged patients without increased workload. They also appear to be useful as clinical assistance tools particularly in the primary care setting where clinicians are less familiar with MH conditions in CYP. An appropriately adjusted and

modified version can be used within education for pastoral care teachers to better identify pupils requiring support and refer with confidence to specialised services.

A significant disadvantage of the apps and technologies described is that they are not currently commercially available, meaning reviewers cannot assess them for their quality and user-friendliness. Thought must be given to all aspects of technology design and the vocabulary used must be appropriate. There are at present some validated tools for assessing the quality of h.apps and m.tech, such as Mobile App Rating Scale [45] and ENLIGHT [46].

Methodological concerns about the quality of research arose in this review. Reporting on demographic data was adequate, but sample sizes still tended to be small; also insufficient information on the participants MH problems was given. The included studies were also short in duration, meaning full effect may not have been achieved due to dose inadequacy.

As Grist noted, the availability of published academic literature on the matter "contrasts starkly with the large number (of m.tech and apps) available and raises questions about their safety, quality and efficacy" [48–49]. As so many of them have no information about their designers, design process or testing, clinicians should only recommend specific trusted and verified apps.

Despite these results, research and enquiry on this area should not be abandoned as there are promising kernels and there is an increasing evidence base for their use in adult MH [51]. Past literature has shown that apps and m.tech are considered acceptable and suitable methods of intervention for CYP who have a reasonable grasp of technology[52]. Even without an evidence base the public are rapidly adopting these technologies to improve and monitor their own health[14] and report being satisfied with the clinical results[53]. This "digital placebo effect"[54] looks unlikely to dissipate in the immediate future allowing time for a robust evidence base to be developed without losing public support and interest.

Limitations

There are several limitations to this review. Owing to time constraints only the results of "full" studies such as RCT and cross sectional studies were included; ideally results of all available literature would have been included.

In addition, confining the search to articles available in the English language may have limited the power of the review, particularly in the area of developing countries, applicability to low income countries being low. The small number of studies and small sample sizes also limits the power of the review, as does the varying quality and bias of the papers reviewed.

Also 4 out of 6 of the studies included participants over the age of 18 years and no study included any participants under the age of 10; therefore, they can only be applied to adolescents and young adults and not to the 'child' population. The focus of the majority of the included work on depression and anxiety disorders restricts broad application to all areas of MH.

It must also be noted that the evolving market and pace of technology development may mean that the literature included is already out-dated and obsolete [16] and without consulting experts on the relevance of the technology described it is impossible to know the value of the studies.

These limitations make the conclusions drawn tentative at best.

Recommendations for Future Research

As there is a distinct lack of research in the area in less developed countries, attention should be given to the use of these interventions those countries, where high penetration of m.tech has already been described[55].

The ethical issues involved do require further examination, not only confidentiality and clinical risk concerns, but also the potential to medicalise normal MH and put clinicians under increased pressure to keep up-to-date with all patient self-monitoring[55].

Currently, the interest for most researchers lies in the development and testing of apps they themselves have had a hand in developing. In the future, it may be of more benefit that existing technologies and apps are evaluated by diverse teams of researchers in order to properly evaluate them and come close to an "ideal app".

Scoping to understand adolescents' use and diversity of preferences should also be assessed to better inform planned co-design processes in creating digital mental health tools for CYP as an Australian study has already demonstrated[56].

In addition continued efforts must be made to make clinicians aware of available apps and an agreed and validated system for assessing their quality must be developed.

Conclusions

The so far available literature regarding the use of mobile apps and technologies in CAMH reports that despite promising initial reports, there is not yet sufficient evidence for widespread adoption of these technologies and further research must be done to determine their clinical benefit (if any). Clinical guidelines must also be developed and agreed upon for their use and oversight. This is a promising and important area of study, which should be at the forefront of health technology and MH research.

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Image and Supplementary Files References:

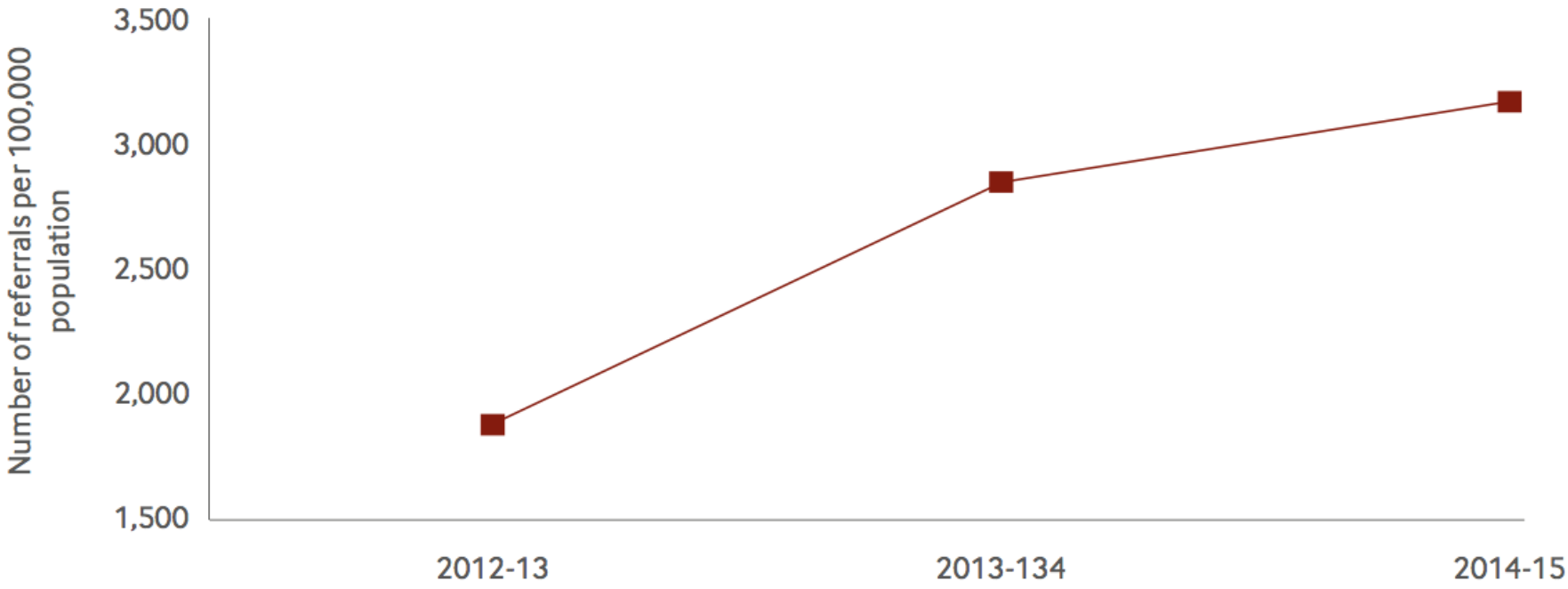
Figure 1: J. Children and Young People's Mental Health, 2016.

Supplementary File 1: Aitken M, Clancy B, Nass D. The Growing Value of Digital Health Evidence and Impact on Human Health and the Healthcare System. 2017.

Supplementary File 2: Aitken M, Clancy B, Nass D. The Growing Value of Digital Health Evidence and Impact on Human Health and the Healthcare System. 2017.

Supplementary File 3: Aitken M, Clancy B, Nass D. The Growing Value of Digital Health Evidence and Impact on Human Health and the Healthcare System. 2017.

Supplementary File 6: Moher D, Liberati A, Tetzlaff J, *et al.* Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *J Clin Epidemiol* 2009;62:1006–12. doi:10.1016/J.JCLINEPI.2009.06.005.



Source: NHS Benchmarking of UK wide services NB: The increases in referrals may be reflective of the different mix of providers taking part in the different years, as well as an overall increase in demand and service provision for CAMHS. However, the data does suggest that the referrals have increased from 2013-2015.

Figure 1: Referral to Community CAMH Services per 100,000 population. Source: Earle, J. Children and Young People's Mental Health (2016).