Current Digital Applications in Psychiatry, Specifically ADHD

These presentations took place as part of the 5th (Virtual) Meeting of the International Scientific Board of Experts on ADHD (ISBEA) held on 6th October 2020

TOBIAS BANASCHEWSKI[1], JAN BUITELAAR[2], MANFRED DÖPFNER[3], MICHAEL RÖSLER[4] AND THE INTERNATIONAL SCIENTIFIC BOARD OF EXPERTS ON ADHD (ISBEA)

[1] Medical Director and Deputy Director, Department of Child and Adolescent Psychiatry and Psychotherapy, Central Institute of Mental Health, Medical Faculty Mannheim, Heidelberg University.

[2] Department of Cognitive Neuroscience at the Donders Institute, Netherlands.

[3] University of Cologne, Germany.

[4] Saarland University, Forensic Psychology and Psychiatry, 66421 Homburg/Saar, Germany.

Received 16th March 2021; Accepted 24th June 2021.

Abstract

Many children and young people with ADHD cannot access treatments due to high clinical demand and lack of alternatives to stimulant and non-stimulant medication. Digital approaches may offer convenient solutions as they are accessible, affordable, scalable, and relatively easy to use. The opportunities with digital technologies span the ADHD disease spectrum, from digital phenotyping providing the potential to measure cognitive function under real-world conditions, to monitoring disease and predicting relapse via the use of passive, wearable technology. Support may be provided in the form of applications (apps) and gamification that may help to motivate children with ADHD and to support parents who are struggling with behaviour management. However, there are significant challenges in developing digital health interventions, and there is an urgent need to find, share, and adopt faster means of establishing a sound evidence-base for these interventions. Results presented here are from the 5th meeting of the International Scientific Board of Experts on ADHD.

KEYWORDS: ADHD; DIGITAL HEALTH INTERVENTIONS (DHIs); DIGITAL PHENOTYPING; METHODOLOGY; REMOTE MONITORING; WEARABLES

Corresponding author: Jan Buitelaar – Jan.Buitelaar@radboudumc.nl

Acknowledgements: Thanks is given to Scientific Writers Ltd., for medical writing assistance and Oruen Ltd., for editorial support in the preparation of this article.

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterised by impulsivity, hyperactivity,[1] and poor attention capacity.[2] It can negatively impact on one's ability to plan, prioritise and organise,[3] and affects around 5% of children globally.[1,4,5] ADHD is increasing among school-age children,[4] and places significant demands on children and young persons (CYPS) specialist mental health services.[6] Adults with ADHD are also at greater risk of developing conduct disorder and substance misuse disorders in later life.[3] Behavioural interventions such as parent training may be offered to families, particularly when preschool aged children are involved,[4,7] or where oppositional behaviours are present.[8] Stimulant and non-stimulant medications may be offered to young people and adults.[4] Non-stimulant medications are usually recommended as second-line treatments, except when comorbid conditions like substance abuse or tics are present, or when parents do not consent.[8,9] The demand for specialist services is now surpassing therapist availability and recommended medication titration regimes are rarely achievable in practice due to conflicting clinical priorities.[4] As medication is often not desired for school-age children due to possible side effects, digital applications (apps) are becoming increasingly popular alternatives.[7,9] It is important to consider how evidence-based treatment programs using digital approaches can be optimised and disseminated.[10]

Digital Health Interventions (DHIs) are wide ranging regarding scope, content and interactivity.[6] They typically provide information, and educational support for specific health problems via the internet, mobile phone apps, wearable devices, email, and text messaging.[10] Benefits may include better access to and uptake of therapy, reduced stigma and pressure associated with face-to-face consultations, increased efficiency because of the reduced need for in-person appointments,[6] strengthened self-help skills and relationships, and improved medication titration and monitoring capabilities.[7] Lack of empirical data because of variations in app design, classification, and purpose remains a problem for those working in digital technology health research.[6] Some new DHIs for ADHD are showcased in this article, as well as some practical and ethical challenges associated with their use.

Innovations in Digital Health

There are many types of digital app available today. In a 2017-19 systematic review of ADHD specific apps in iTunes/IOS (Apple App Store), Google Play and the Library of National Health Service Health Apps, 355 separate apps were found and 109 were reviewed based on their role in assessment, treatment, or both.[1] Most of the apps targeted health, lifestyle and medical conditions and others focussed on productivity, gaming and parenting skills.[1] The four most downloaded apps included three company-made apps: 'ADHD Adults', 'ADHD-Test Lite' and 'ADHD Self-Test', and an individually produced app called 'ADHD Test'.[1] Most apps were treatment-based (85/109), 13 focussed on assessment, 11 covered both assessment and treatment, and 12 apps monitored medication regimens. A total of 27 offered music therapy, 23 offered psychoeducation while 17 provided organisational skills training, and others offered cognitive training, neurofeedback and hypnosis. Despite the large quantity of apps available, few are licensed for use and there is a low evidence base supporting their use.[11]

Use of Digital Technology for the Assessment and Diagnosis of ADHD

Lack of objective measurement and over-reliance on potentially biased self-reporting in clinical psychiatry makes it incredibly difficult to diagnose and treat mental health conditions accurately.[12] Digital phenotyping may provide a solution via the use of sensors, voice recognition techniques, and human-computer interaction to measure real-world health data subtly and over a much longer period of time than can be achieved in patient consultations. Indeed, digital phenotypes may allow the traditional phenotypes described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5).[13] to be redefined or extended, and may lead to the identification of new types of biomarkers that facilitate early detection of ADHD and support or help refine diagnostic assessments.

Remote Measurement Technologies (RMT) can be worn passively and unobtrusively,[14] allowing much richer ecological experiences to be detected and deciphered.[12] By making better use of widely available items like keyboards, voice recognition software, and sensors, data collection parameters could be refined and standardised,[7] and perhaps combined with current assessment tools and self-reporting questionnaires to make for a fuller assessment experience.

Disease relapse indicators may also be detected earlier through quicker recognition of physical changes, picked up by sensors and/or machine learning.[15] Diagnostic assessment processes can be refined, and more personalised treatments and lifestyle interventions developed.

Use of Digital Technology for Monitoring

While traditional clinical approaches to monitoring patients with mental health conditions often rely on sparse, intermittent data, the use of wearable devices and smartphone technology can facilitate continuous, pervasive, and passive data collection throughout the course of a disease trajectory.[14,15] The use of such technology to monitor disease can provide a wide range of capabilities, such as assessing cognitive function and tremors, for example. Furthermore, a key advantage of such an approach is that it generally does not require active patient compliance.

RADAR (Remote Assessment of Disease and Relapse)-BASE is a digital data collection platform that securely collects passive (e.g., heart rate) and active data (e.g., questionnaires) with the aim of transforming patient care through the monitoring of wearable devices and smartphones **(Figure 1)**.[16] RADAR findings can be translated into effective real-world clinical applications, and the data also serves to improve understanding of the needs of patients, clinical services, and regulators.[15] Data from RADAR-BASE showed that the 2020 COVID-19 pandemic significantly impacted participants' behaviour, with many remaining at home, spending more time on digital devices, and reading major news events.[15]

RADAR-Central Nervous System (RADAR-CNS) is currently being used for the remote monitoring of three chronic

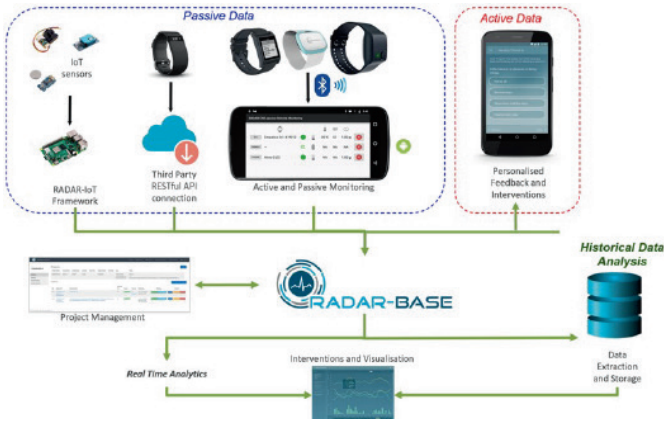

Figure 1. Overview of the RADAR-BASE platform.[15]

conditions: major depressive disorder (MDD), multiple sclerosis, and epilepsy.[17] A key aim is RADAR-CNS is to use the data to identify characteristic patterns ("biosignatures") predictive of relapse or deterioration in these chronic disorders. In RADAR-CNS, participants are being assessed in terms of sociability, GPS location, movements, step counts and speech measurement. Quality of life measures and cognitive testing through self-reporting were also conducted. Usability testing was an important part of the decision regarding which wearables to use in the study, and the input of the RADAR patient advisory board has been key in identifying barriers and facilitators. Participants wanted the option to turn off some features (e.g., voice sampling). While participants did not want access to data regarding mood as this had the potential to increase anxiety, they wanted to know about measures such as sleep and physical activity. The platform uses push notifications and reminders to encourage participants' involvement. The multi-parametric data from RADAR-CNS are being analysed collectively for the entire cohort but may also be analysed at an individual patient level. The ongoing 2-year RADAR-MDD study, which has recruited 632 patients with MDD, represents the largest study to investigate multimodal RMT in a clinical cohort. Its findings will generate an improved understanding of the role of large-scale RMT data collection and will also serve to assess the clinical ability of RMT to predict relapse in MDD.[14]

Digital Health Interventions for the Treatment of ADHD

In the last 10 years there has been a surge in the availability of mobile and web-assisted self-help programs for parents and children as adjuncts to medication.[18] Several telephone assisted computer based therapy (tCBT) and internet computer based therapy (iCBT) self-help apps have been developed, allowing users to take control and implement interventions on their own terms.[19] In a study of telephone-assisted self-help for parents of children aged between 6 and 12 years with ADHD and residual functional impairment despite methylphenidate treatment, parents received eight booklets and telephone-assisted self-help (TASH) via 14 telephone calls across 1 year. The telephone-assisted support was effective in improving parenting and reducing ADHD symptoms; residual symptoms were reduced in the families given telephone-assisted self-help (ANCOVA) $F = 5.60$, $df = 1$, $p = .02$, $n = .07$ **(Figure 2)**. For functional impairment, similar results were observed (ANCOVA) $F = 6.85$, $df = 1$, $p = .01$, $n^2 = .09$ **(Figure 3)**.[18]

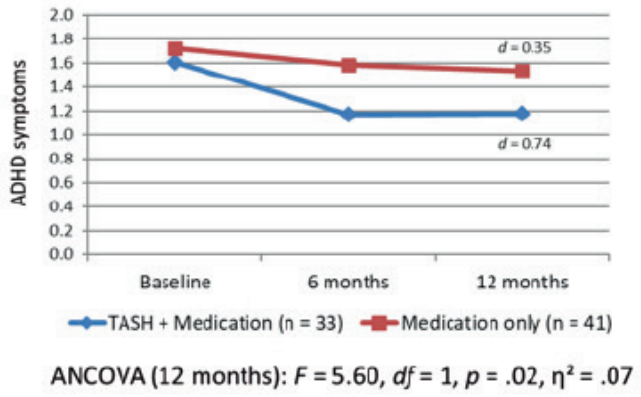

Figure 2. Effect of TASH + medication versus medication alone on ADHD symptoms. Adapted from results by Dose et al.[17]

Abbreviations: ANCOVA, analysis of variance (ANOVA) and regression; TASH, telephone-assisted self-help.

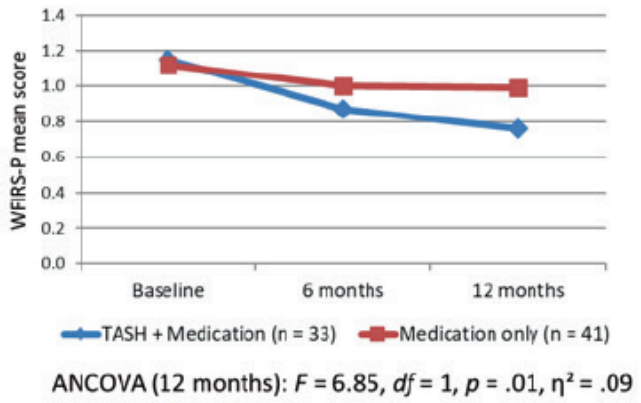

Figure 3. Effect of TASH + medication versus medication alone on functional impairment (WFIRS-P). Adapted from results by Dose et al.[17]

Abbreviations: ANCOVA, analysis of variance (ANOVA) and regression; TASH, telephone-assisted self-help; WFIRS-P, Weiss Functional Impairment Rating Scale-Parent Form.

An ongoing three-arm randomised controlled trial (RCT) will evaluate the efficacy of web-assisted self-help (WASH) for patients of children with ADHD. The WASH programme was developed to investigate the structural barriers around parent management training for ADHD and oppositional defiant disorder (ODD), and is currently being trialled in 495 children aged 6-12 years, with a possible or actual diagnosis of ADHD. Treatment as usual (TAU) will be compared to TAU plus WASH, and to TAU plus WASH plus telephone-based support (TAU + WASH + SUPPORT).[18]

The ORBIT trial was a 10-week, two-armed parallel-group, single-blind RCT with an embedded process evaluation.[18] The aim was to investigate the effectiveness of a blended approach with an online remote, therapist-supported, and parent-guided behavioural intervention for tics, prevalent in many children with ADHD. A total of 112 young people in the intervention group received ten chapters of online behavioural therapy over 12 weeks, using principles of Exposure and Response Prevention (ERP). The primary outcome was to reduce Total Tic Severity Scores (TTSS) at 3-months post-randomisation. The primary endpoint was an 80% retention target, and 90% was achieved. Recruitment was UK-wide, people could self-refer and the intervention sought to address the current lack of qualified behaviour therapists to treat Tourette syndrome.[19] The charity Tourettes Action actively promoted the trial and a designated trial manager also regularly monitored and distributed relevant communications. The blended approach was advantageous in facilitating both behavioural interventions and trial delivery in young people, particularly those already comfortable with digital technology. The next step is to scale up the trial and recruit from a wider geographical area. Most patients did not object to being randomised and for those in the non-treatment arm, families felt that some support was better than none.[19]

Use of Apps to Support Patients and Carers

The rapid development of digital technologies has the potential to revolutionise the way support is delivered to patients with ADHD and autism, and offers a number of potential advantages including convenience, accessibility, avoidance of lengthy waits for referrals, removal of the stigma associated with visits to healthcare professionals, and a reduction in demands on services. It also gives more knowledge to patients so they can use clinical assessment in the most effective way, as well as equipping them to better manage their condition. However, there are inherent weaknesses with digital approaches, including the fact that face-to-face interventions cannot simply be recapitulated using technology, and need to be optimised for the digital environment.[19]

STEPS App

The STEPS app is a simple, accessible digital tool to help parents manage oppositional behaviours in children with ADHD more effectively. Developed by a team from Southampton, Kings College London, and Nottingham Universities, the app has eight 20-minute 'steps' to follow

(Figure 4). Unguided parent training is delivered online through a smartphone or tablet device. For clinical optimisation, each 'step' must be performed in order:

- **Step 1** 'making a fresh start' reboots family life and fosters a non-blaming culture.
- **Step 2** focusses on parent wellbeing.
- **Step 3** surrounds getting the child's co-operation and is the first behavioural skill set.
- **Step 4** focusses on building confidence and self-esteem through praise.
- **Step 5** involves leading by example through effective role modelling.
- **Step 6** provides additional context and scaffolding of other steps and targets problem areas.
- **Step 7** teaches parents how to agree and implement rules consistently.
- **Step 8** aims to reduce conflict through active behaviour management and drives steps 1–7.

The app uses the concept of parenting buddies who play the roles of parents being challenged by their children's behaviours. Push notifications and reminders are employed to keep users engaged with the tool, and badges are awarded for completion of the individual steps.

Figure 4. STEPS app to help parents manage oppositional behaviours in children with ADHD.

Molehill Mountain App

The rationale for this universally available app is that anxiety is common among autistic children with pooled prevalence estimates of 30-40%.[7] Autism-adapted CBT is effective, but there are insufficient services, and as already discussed, a lack of trained clinicians to meet the current need.[20] The Molehill Mountain application bridges this gap. In pilot studies, adolescents used the self-guided app well. A trial version was launched in 2018, but in-application data analysis was limited due to study constraints. Users wanted the app to be more autism-specific, and more personalised with built-in emergency tips, and greater support around co-morbid conditions like alexithymia.[7] The full app provides interactive CBT exercises for generalised anxiety and social anxiety and has been positively received.[7] Requests have been made to include the app on the NHS clinically approved ORCHA directory of digital interventions.[21] Future directions include extending the app to different users for different purposes, optimising digital tools, reducing task complexity, and carrying out further research to understand its use and effectiveness.[20]

Other apps that have been tested in children with mental health disorders include the AUTHARK app, which provides adjunctive psychotherapy support for children with conduct disorders, anxiety disorders, depression, obsessive-compulsive disorders and ADHD, while the ScouT app provides computer-supported training for children with externalising behaviours and peer-related aggression.

Challenges and Solutions in DHI Research Methodology and Reporting

Digital trials were first published in the late 1990s.[6] Despite this, online trials still make up a tiny fraction of all trials conducted. RCTs are lengthy and traditionally challenging to recruit into, especially with vulnerable young people with neurodevelopmental issues who may find research intimidating or anxiety provoking.[6] In a recent meta-review of 30 RCTs assessing the clinical effectiveness of DHIs for children and young adults with ADHD, the authors found it difficult to elicit any benefits due to poorly defined comparators, small sample sizes, few blinded outcome assessments, and a lack of knowledge around the types and duration of augmented support given.[6] Methodological limitations can deeply damage clinical trial results, and lack of taxonomy, variable uptake, short term follow-up,[6] and the vast number

of apps on the market pose many challenges for researchers and users alike.[3]

In a systematic review of web-based interventions across six databases, many authors failed to report treatment doses (number of sessions completed) and very few included economic evaluations in their work.[6] This lack of reporting has serious implications for clinical practice, overall clinical trial efficiency, and eventual clinical uptake.[19] Researchers should now identify which distinct elements of DHIs impact on efficacy and those which influence uptake, adherence and usage.[6]

Collaboration between app developers, researchers and clinicians could help scale up existing processes and technologies,[1] through integration of methodologies from engineering, computer science, mental health service research and psychology,[6] to build highly intelligent and adaptable computer modelling systems, which can accurately identify ADHD symptoms and improve treatment duration and outcomes. Within individual trials, the possible superiority of digital interventions over (active) behavioural interventions must be quickly established if progress is to be made. Longer-term evaluations will also generate more cost-effective services and improved patient outcomes.[19] Standardisation benefits will also emerge once robust findings are replicated and validated in further studies. Machine learning and artificial intelligence (AI) data-driven diagnostics are currently propelling forward DHI development,[22] and should produce valuable results over the next few years.

Challenges and Solutions Around the Adoption of DHIs

When reviewing barriers around wearable health technology, repeated themes include the need for convenience and comfort.[15] Much could be learned from the correlative data arising from physiological measures collected by sensors and wearables, and by benchmarking these measures against self-reported questionnaires triangulation with other real world or study data is possible.[14] Devices used in future trials should continue to be commercially available because specialist technologies from multiple vendors make data aggregation incredibly difficult, especially if products are redesigned, updated, or become obsolete.[15] Many clinicians have expressed uncertainty around privacy, reliability and risks associated with digital mental health technology use and the vast amounts of data they produce.[23] This has implications for scalability, affordability and acceptability in the current social and political climate.[24] Parents occasionally struggle to use apps, as evidenced in 1-to-1 therapy sessions, but in these instances extra support can be given.[7] Additionally, efforts to increase and strengthen the engagement of parents and children with mental health apps have proven challenging, as they must compete with the tasks and distractions of daily life.[25] Gamification, a strategy where game play components are incorporated into activities,[9] may encourage users to complete tasks and gain associated social and psychological benefits.

Conclusion

There has been a rapid expansion in the use of digital technology in mental health across a wide range of applications.[6] These include digital phenotyping, disease monitoring, self-help programmes, treatment support, and training for patients and carers.[7,18-20] There are several benefits to using such an approach including increased reach, reduced stigma and pressure associated with face-to-face consultations, and increased efficiency because of the reduced need for in-person appointments.[6] However, despite the large number of apps that have been developed to support people with mental health disorders,[7] many remain unlicenced,[4] and few proceed to clinical adoption.[1,9] A key challenge is a lack of evidence supporting their use.[11] Meanwhile, smartphones and wearable technology are being used for the passive collection of data throughout the course of a disease trajectory. It is anticipated that new disease insights may be gleaned from RMT, including the potential to measure variables that may be associated with an increased risk of relapse, which may be used to prompt intervention with effective real-world clinical applications.[14-16] The evidence to support the use of such a DHI is eagerly awaited.

References

1. Păsărelu CR, Andersson G, Dobrean A. Attention-deficit/hyperactivity disorder mobile apps: A systematic review. *Int J Med Inform*. 2020;138:104133.

2. Kollins S, DeLoss D, Cañadas E, et al. A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): a randomised controlled trial. *Lancet Digit Health*. 2020;2(4):E168-E178.

3. Bul KC, Kato PM, Van der Oord S, et al. Behavioral Outcome Effects of Serious Gaming as an Adjunct to Treatment for Children With Attention-Deficit/Hyperactivity Disorder: A Randomized Controlled Trial. *J Med Internet Res.* 2016;18(2):e26.

4. Simons L, Valentine AZ, Falconer CJ, et al. Developing mHealth Remote Monitoring Technology for Attention Deficit Hyperactivity Disorder: A Qualitative Study Eliciting User Priorities and Needs. *JMIR Mhealth Uhealth.* 2016;4(1):e31.

5. Döpfner M, Wähnke L, Klemp MT, et al. Efficacy of web-assisted self-help for parents of children with ADHD (WASH) - a three-arm randomized trial under field/routine care conditions in Germany. *BMC Psychiatry.* 2020;20(1):76.

6. Hollis C, Falconer CJ, Martin JL, et al. Annual Research Review: Digital health interventions for children and young people with mental health problems - a systematic and meta-review. *J Child Psychol Psychiatry.* 2017;58(4):474-503.

7. Daley D, Van Der Oord S, Ferrin M, et al. Practitioner Review: Current best practice in the use of parent training and other behavioural interventions in the treatment of children and adolescents with attention deficit hyperactivity disorder. *J Child Psychol Psychiatry.* 2018;59(9):932-947.

8. The National Institute for Health and Care Excellence (NICE). Attention deficit hyperactivity disorder: diagnosis and management. https://www.nice.org.uk/guidance/ng87. Updated 2019. Accessed 08 December, 2020.

9. Benyakorn S, Riley SJ, Calub CA, Schweitzer JB. Current State and Model for Development of Technology-Based Care for Attention Deficit Hyperactivity Disorder. *Telemed J E Health.* 2016;22(9):761-768.

10. Andersson G. Internet-Delivered Psychological Treatments. *Annu Rev Clin Psychol.* 2016;12:157-179.

11. Marshall JM, Dunstan DA, Bartik W. Effectiveness of using mental health mobile apps as digital antidepressants for reducing anxiety and depression: protocol for a multiple baseline across-individuals design. *JMIR Res Protoc.* 2020;9(7):e17159.

12. Insel TR. Digital phenotyping: a global tool for psychiatry. *World Psychiatry.* 2018;17(3):276-277.

13. Matcham F, Barattieri di San Pietro C, Bulgari V, et al. Remote assessment of disease and relapse in major depressive disorder (RADAR-MDD): a multi-centre prospective cohort study protocol. *BMC Psychiatry.* 2019;19(1):72.

14. Sun S, Folarin AA, Ranjan Y, et al. Using Smartphones and Wearable Devices to Monitor Behavioral Changes During COVID-19. *J Med Internet Res.* 2020;22(9):e19992.

15. Ranjan Y, Rashid Z, Stewart C, et al. RADAR-Base: Open Source Mobile Health Platform for Collecting, Monitoring, and Analyzing Data Using Sensors, Wearables, and Mobile Devices. *JMIR Mhealth Uhealth.* 2019;7(8):e11734.

16. Remote Assessment of Disease and Relapse in central Nervous System (RADAR-CNS) [cited 2018 Jan 24]. Available from: https://www.radar-cns.org/

17. Dose C, Hautmann C, Buerger M, Schuermann S, Woitecki K, Doepfner M. Telephone-assisted self-help for parents of children with attention-deficit/hyperactivity disorder who have residual functional impairment despite methylphenidate treatment: a randomized controlled trial. *J Child Psychol Psychiatry.* 2017;58(6):682-690.

18. Hall CL, Davies EB, Andrén P, et al. Investigating a therapist-guided, parent-assisted remote digital behavioural intervention for tics in children and adolescents-'Online Remote Behavioural Intervention for Tics' (ORBIT) trial: protocol of an internal pilot study and single-blind randomised controlled trial. *BMJ Open.* 2019;9(1):e027583.

19. Simonoff E. Tackling anxiety in autistic people: the Molehill Mountain app. https://www.acamh.org/blog/addressing-need/. Published 2018. Accessed 17 February, 2021.

20. Downey A. ORCHA launches library of clinically approved COVID-19 apps. https://www.digitalhealth.net/2020/04/orcha-launches-library-of-clinically-approved-covid-19-health-apps/. Published 2020. Accessed 07 December, 2020.

21. Washington P, Park N, Srivastava P, et al. Data-Driven Diagnostics and the Potential of Mobile Artificial Intelligence for Digital Therapeutic Phenotyping in Computational Psychiatry. *BP:CNNI*. 2020;5(8):759-769.

22. Larsen ME, Huckvale K, Nicholas J, et al. Using science to sell apps: Evaluation of mental health app store quality claims. *NPJ Digit Med*. 2019;2:18.

23. Marshall JM, Dunstan DA, Bartik W. Clinical or gimmickal: The use and effectiveness of mobile mental health apps for treating anxiety and depression. *Aust N Z J Psychiatry*. 2020;54(1):20-28.

24. Baumel A, Muench F, Edan S, Kane JM. Objective user engagement with mental health apps: systematic search and panel-based usage analysis. *J Med Internet Res*. 2019;21(9):e14567.

