PROCESS EVALUATION OF ONLINE REMOTE BEHAVIOURAL INTERVENTION FOR TICS (ORBIT)

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Thesis submitted to the University of Nottingham for the degree of Doctor of Philosophy

JULY 2021

"*A well-educated mind will always have more questions than answers*."

Helen Keller

Abstract

Background: Tic disorder is a highly debilitating condition that is more common in children and young people (CYP) than adults. A parent and therapist supported intervention called Online Remote Behavioural Intervention for Tics (ORBIT) was developed to meet the demand for behavioural therapy for CYP with tic disorders. Whilst a randomised controlled trial (RCT) assesses overall efficacy, a process evaluation is necessary to establish how and for whom an intervention works.

Methods: First, a systematic review and meta-analysis was conducted to assess the overall effectiveness of online interventions delivered to CYP with neurodevelopmental disorders (NDDs). Following this, the Medical Research Council's (MRC) 2015 guidelines were used for this two-part mixed-methods process evaluation. This involved analysing quantitative data, such as participants' usage of the intervention and baseline demographics as well as purposively sampled, semi-structured interviews. The first part explored the implementation and contextual factors of engagement whilst the second part analysed the mechanisms of impact underpinning the ORBIT intervention.

Results: A systematic review of 10 trials found that six (two aimed at tic disorders) were effective in improving outcomes in CYP. Part one of the process evaluation found the intervention was implemented with high fidelity, and participants deemed the intervention acceptable and satisfactory. Engagement was high with child participants completing an average of 7.5/10 chapters and 99/112 (88.4%) participants completing the minimum of first four chapters: the pre-defined threshold for effective dose. Parental engagement was the only significant independent predictor of child engagement. Part two demonstrated reduced tic severity post intervention and 36% of CYP had their overall clinical condition rated as

being very much or much improved post-treatment. Improvement was not moderated by the relationship between demographic or baseline clinical factors and engagement and no mediators were found. However, level of parental engagement was associated with overall clinical improvement and this relationship was illuminated by the qualitative data.

Conclusions: The findings provide promising evidence that an online behavioural intervention is acceptable and accessible amongst CYP with tic disorders, and engaging parents is the key to effective implementation and positive outcomes whilst highlighting that there is no particular subgroup that is more or less likely to engage or to find this treatment beneficial.

Publications and presentations arising from this thesis

The following publications and presentations have been produced from work within this thesis:

Publications

Chapter 4: Khan K., Hollis C., Hall C.L., Murray E., Davies E.B., Andrén P., Mataix-Cols D., Murphy T., Glazebrook C. (2021). Fidelity of Delivery and Contextual Factors Influencing Children's Level of Engagement: Process Evaluation of the Online Remote Behavioral Intervention for Tics Trial. *Journal of Medical Internet Research*;23(6):e25470. doi: 10.2196/25470

Chapter 3: Khan, K., Hollis, C., Hall, C.L., Davies, E.B., Mataix-Cols, D., Andrén, P., Murphy, T., Brown, B.J., Murray, E. and Glazebrook, C. (2020). Protocol for the Process Evaluation of the Online Remote Behavioural Intervention for Tics (ORBIT) randomized controlled trial for children and young people. *Trials*, 21(1). https://doi.org/10.1186/s13063-019-3974-3

Chapter 2: Khan, K., Hall, C.L., Davies, E.B., Hollis, C., and Glazebrook, C. (2019). The Effectiveness of Web-Based Interventions Delivered to Children and Young People With Neurodevelopmental Disorders: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research*, 21(11):e13478 https://www.jmir.org/2019/11/e13478/

Presentations

March 2021 - Khan K, Hall CL, Davies EB, & Glazebrook C. Process Evaluation of Online Remote Behavioural Intervention for Tics (ORBIT). Oral presentation delivered at the '*Sue Watson Event*', University of Nottingham.

June 2019 - Khan K, Hall CL, Davies EB, & Glazebrook C. Process Evaluation of Online Remote Behavioural Intervention for Tics (ORBIT). Oral presentation delivered and poster presented at the '*Medicine & Health Sciences Faculty Postgraduate Forum*', University of Nottingham.

December 2018 - Khan K, Hall CL, Davies EB, Hollis C, & Glazebrook C. Process Evaluation of Online Remote Behavioural Intervention for Tics (ORBIT). Poster presented at the '*MindTech Mental Health Technology Symposium*', Royal College of Physicians, London.

Abbreviations

ADHD	Attention-deficit hyperactivity disorder
ASD	Autism Spectrum Disorder
CAMHS	Child and adolescent mental health services
CBIT	Comprehensive Behavioural Intervention for Tics
CBT	Cognitive behavioural therapy
CGI-I	Clinical Global Impressions-Improvement Scale
CI	Confidence Interval
CTD	Chronic tic disorders
CYP	Children and young people
DHI	Digital health intervention
DSM	Diagnostic and Statistical Manual of Mental Disorders
ERP	Exposure and response prevention
ES	Effect Size
GOSH	Great Ormond Street Hospital, London
GP	General Practitioner
HRT	Habit reversal therapy
IAPT	Improving Access to Psychological Therapies
ICD	International Classification of Diseases
IMD	Index of Multiple Deprivation
JBI	Joanna Briggs Institute
MeSH	Medical Subject Headings

MFQ	Mood and Feelings Questionnaire
MRC	Medical Research Council
NDD	Neurodevelopmental disorder
NHS	National Health Service
OCD	Obsessive-compulsive disorder
ORBIT	Online Remote Behavioural Intervention for Tics
PPI	Patient and Public Involvement
PU	Premonitory urge
QMC	Queen's Medical Centre, Nottingham
RCT	Randomised controlled trial
SCAS	Spence Children's Anxiety Scale
SD	Standard Deviation
TAU	Treatment as usual
TS	Tourette syndrome
TTSS	Total Tic Severity Score
WLC	Wait-list control
YGTSS	Yale Global Tic Severity Scale

Acknowledgements

Firstly, I would like to thank my primary supervisor for this thesis, Professor Cris Glazebrook, for her invaluable support, guidance, and encouragement throughout this journey. Cris went above and beyond her role as a supervisor in supporting me during the Covid-19 pandemic and offered incredible support. I was extremely lucky to have not one but three fantastic supervisors and I would also like to extend my upmost gratitude to my supervisors, Dr Charlotte Hall and Dr Bethan Davies, who have both been amazing throughout this PhD by offering incredible kindness and positive encouragement every step of the way.

I am grateful for the financial support and studentship received from MindTech and I am looking forward to working with them in the coming years. The funders had no role in the process evaluation study design, data collection, data analysis, data interpretation, or writing of the thesis. I would like to thank all the participants who contributed their time and thoughts on the ORBIT trial and, without whose input, there would be no thesis at all.

I would also like to say a heartfelt thank you to my friends and family who have always supported and encouraged me. I really valued sharing my lunch times with my fellow PhD students at the Institute of Mental Health and it helped me get through some tough times. I especially want to thank my mother, my two brothers, and my two nephews, who always put a smile on my face!

Finally, this thesis is dedicated to my father, Mohammad Afzal Khan (January 1950 – October 2015). He always taught me from a young age that education is so vital and without his encouragement I do not think I

would have pushed myself to pursue further education and all the experiences and knowledge that have come with it. May he rest in peace.

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Chapter 1: Introduction and thesis outline

1.1 General introduction

Neurodevelopmental disorders (NDDs) such as autism, attention deficit hyperactivity disorder (ADHD) and Tourette syndrome (TS) are associated with a range of behavioural, motor, emotional and cognitive difficulties which can have a profound impact on children's quality of life, school experience and peer relationships. Behavioural and educational approaches are particularly useful for children with neurodevelopmental conditions where pharmacological therapies are associated with unwanted side effects and uncertain effectiveness. However, access to evidence-based therapies is limited due to the inadequate number of specialists and uneven geographical distribution of services relative to demand. Digital health interventions (DHIs) provide the opportunity to widen children and young people's (CYP's) access to psychoeducation and behavioural therapies and thus reduce the severity and impact of neurodevelopmental conditions such as tic disorders. The Online Remote Behavioural Intervention for Tics (ORBIT) is a randomised controlled trial (RCT) evaluating the effectiveness of a therapist supported, parent aided DHI designed to increase access to an evidence based behavioural therapy for CYP with tic disorders. However, even if shown to be effective, many DHIs are not implemented into routine clinical care. Consequently, there has been a shift to understand not just whether a DHI works but also in what circumstances and for whom it may be most or least effective. Where an intervention has multiple active components, a process evaluation to explore factors influencing uptake and impact can inform the further development and implementation of DHIs for CYP with NDDs.

This introductory chapter gives an overview of DHIs for CYP, discusses the range of modalities available, and considers the evidence for the

effectiveness of DHIs delivered to CYP. It then introduces tic disorders and its treatment before giving an overview of the ORBIT trial and its embedded process evaluation. The chapter ends with an outline of the thesis structure and overall aims.

1.2 Overview of digital health interventions for children and young people

Modern civilisations have become consumed by the technological age. Technology is an ever growing, exponential endeavour with a multitude of modalities to deliver whatever function developers wish to target. Advances in technology, combined with high rates of mental health and behavioural problems and substantial demands on stretched health services has provided the impetus for health scientists to collaborate with developers to create diagnostic tools, treatments, therapies, and medication adherence applications. Using the full spectrum of digital modalities allows health services to reach a larger proportion of the population: people who may be under provided for by standard face-to-face care.

CYP are known for their ubiquitous consumption of technologies as well as being in a vulnerable period of their lives regarding the onset and development of several psychiatric, behavioural, and neurological morbidities, including tic disorders. With CYPs brain in an active state of development and Magnetic Resonance Imaging (MRI) studies suggesting that physical, mental, and psychological factors influence brain maturation, it is clear that adolescence is a crucial period in implementing effective interventions. Therefore, it follows that digital platforms could be a particularly effective means of delivering therapeutic interventions to youth populations with physical and psychiatric disorders.

This introductory section provides an overview of DHIs delivered to CYP with physical and psychiatric disorders, describes the range of modalities and limitations of these, and outlines the main characteristics and features

of the relevant modalities. It synthesises the literature on DHIs for CYP with mental or physical health or behavioural diagnoses with a focus on efficacy and the important issue of engagement and then finishes with the role of the parent.

1.2.1 Background

DHIs refer to interventions delivered via technologies using a range of digital modalities, such as smartphones, applications ('apps'), wearable devices, robotics, websites, social media or text messaging. DHIs can be used as a platform to help treat a range of physical and psychiatric disorders (Andersson *et al.*, 2014) promote positive health behaviours (Free *et al.*, 2011) and even improve outcomes of people with long term conditions (Murray *et al.*, 2005). There is considerable optimism within the medical community that digital technologies — especially apps used on smartphones, tablets, and watches — could open up a new frontier for the implementation of interventions to aid in the recovery from a range of disorders (Ventola, 2014). Despite there being an estimated 350,000 health apps available to download across the major app stores (Research2Guidance, 2017), this optimism and potential has yet to be fully achieved.

As DHIs are a relatively new phenomenon, one does not have to look too far back to search for the first development of a digital intervention. It is believed that the first accessible digitally implemented support systems emerged at the beginning of the 1990s. These were computer-mediated support groups designed for people with human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS) (Brennan, Ripich and Moore, 1991; Bosworth and Gustafson, 2008). These platforms contained multiple components: psychoeducation, providing decision support, and social support through digital communication, which were accessed either locally on a personal computer or through a modem

connected to a centrally located server. As Barak (1999) identified, the capability offered by virtual communication and of communicating with other online users — while maintaining anonymity — seemed to have a unique impact on participants. The use of pseudonyms, for example, allowed patients to be anonymous thus increasing their ability to be more open in their communication. At a time when the AIDS epidemic was at its peak and patients were stigmatised, this online, anonymous platform offered a promising new development.

DHIs for CYP were developed some years after their first use on adult populations. In the early stages of digital development for youth populations, the focus was on somatic healthcare and medication adherence, including youth populations with diabetes (Franklin *et al.*, 2006) and HIV (Puccio *et al.*, 2006). However, in the past decade there has been a rapid increase in the number of digital therapeutic interventions aimed at CYP with psychiatric disorders (Hollis *et al.*, 2017), as mental health professionals have started to realise the potential benefits and reach of remote therapy. Indeed, the United Kingdom's (UK's) National Health Service (NHS) realised the potential of DHIs by developing the Improving Access to Psychological Therapies (IAPT) programme in 2008; where trained graduate workers deliver remote, low intensity cognitive behavioural therapy (CBT) to individuals with mild to moderate anxiety and depression. This transformed treatment of adult anxiety disorders and depression in England allowing up to 900,000 people access evidence-based treatment each year (Mental Health Taskforce, 2016). Subsequently, the NHS adapted the IAPT programme for CYP in 2011, which has resulted in an additional 70,000 young people receiving evidence-based treatments each year (NHS England, 2018). DHIs are intuitively attractive to the NHS and private healthcare companies, as they are considered more economical compared to face-to-face equivalents and can increase access to services

to a wider population of people who do not normally have access to such therapies due to geographical constraints (Christensen and Griffiths, 2002).

1.2.2 Modalities

Initially, DHIs could only be delivered through desktop computers either locally or via modem connectivity meaning that users needed to be in a specific location to access the intervention. However, technology has advanced to such a high level that the range of formats is now vast (Carey *et al.*, 2009; Hollis *et al.*, 2017). Moreover, the quality, affordability, and accessibility of relevant modalities has also improved. For instance, according to a report from the International Telecommunication Union, the number of Internet users has increased from 738 million in 2000 to 3.2 billion in 2015, which is a seven-fold increase bringing Internet penetration up from 7% to 43% of the global population (Sanou, 2017). The same report outlines that much of the growth in web connectivity has come from mobile technology. Mobile broadband penetration has gone up 12-fold since 2007, and in 2015, 69% of people worldwide were covered by 3G broadband. The main reason Internet access has taken off over the past 15 years is rising affordability. The International Telecommunication Union reports broadband is currently affordable in 111 countries, with a basic fixed or mobile plan costing less than 5% of Gross National Income per capita (Sanou, 2017). The Internet has developed from being an ambitious research idea to an affordable technology that is used by over 3.2 billion people worldwide in less than sixty years, which has meant that more people can access remote health interventions.

For CYP, in the early stages of DHIs the modality was mainly computerised CBT, which involved users accessing therapists online with set tasks to complete in between sessions, thus mimicking face-to-face CBT (Gratzer and Khalid-Khan, 2016) and similar to self-help books for depression and

anxiety. Due to the progress of digitised technology and programming algorithms, computerised CBT became more interactive and aesthetically attractive to CYP with the advent of 'serious games' (Fleming *et al.*, 2014). The idea behind 'serious games' is for there to be a primary purpose other than pure entertainment. For example, adding pedagogical elements making them more user friendly and enjoyable to use whilst teaching about important topics. As mobile technologies have become increasingly available and more popular to CYP — estimates suggest that around 86% of 12 to 18 year olds in the UK regularly use a mobile phone (Statista, 2018) — this led to the development of smartphone apps and wearable devices (e.g. smartwatches, fitness trackers, virtual reality headsets). Additionally, smartphones could now be integrated in order to send text messages or emails as an adjunct to regular face-to-face therapy or computerised CBT.

1.2.2.1 Advantages and Disadvantages

There are many advantages to using the different modalities of DHIs over other interventions. One such advantage is in the administration of questionnaires and outcome measures. The risk of missing items can be reduced significantly, and summary scores can be automatically generated allowing therapists to monitor progress thus saving time in analysing data. Moreover, crucial score items can be highlighted for clinicians to act upon. For example, red flags for an increased suicide risk (Andersson and Titov, 2014). Furthermore, these modalities offer improved access to evidence-based treatments as well as cost-effectiveness compared to face-to-face care. However, there are also disadvantages. The main limitation with DHIs includes security issues. This is not only relevant to data storage but also to methods of collection. For example, smartphones have been known to be compromised in recent years and if a patient has stored confidential data on their phones, hackers could potentially access this data. As medical

apps are increasingly used to support diagnosis and management of various conditions, facilitating the appropriate use of information technology becomes crucial. In 2012, a pharmaceutical-sponsored app designed to assess disease severity was recalled from app stores as it was giving patients erroneous scores compared to official formulas (Buijink, Visser and Marshall, 2013).

Another limitation of DHI modalities concerns the issue of sustainability. Digital technology evolves at a rapid pace meaning that as technology changes and interfaces are updated, it cannot be certain that a program that was effective five or ten years ago would be equally effective today. This means that many DHIs are simply not sustainable long-term. For example, DHIs providing a pedagogical service become out of date quite rapidly with new information being discovered all the time and this may be more difficult to update than a simple leaflet taken from the shelf (Raaff, Glazebrook and Wharrad, 2014). Research is a slow process, often taking years to establish efficacy of an intervention, making a particular digital modality potentially obsolete by the time effectiveness has been rigorously evaluated.

1.2.3 Characteristics and features

Potentially these limitations are outweighed by the advantages of using digital communication. For instance, DHIs can be used to present material in ways that face-to-face therapy simply cannot achieve. This means that developers of DHIs can use the breadth of interactive features in order to better engage users so that the content can be presented in a myriad of ways that correlate with users' preferences. For example, DHIs can include videos, auditory information, and animations; they can differ in their level of interactivity for the user; human supported or not; and for CYP, having a parent component or not. Furthermore, whereas face-to-face behavioural

therapy can only be delivered for a set number of sessions over a fixed period, users of DHIs can have access to the material contained within the intervention for years. This is advantageous for the patient, as they can revisit behavioural tools over a prolonged timeframe allowing the therapeutic techniques to become ingrained and more habitual (Gardner, Lally and Wardle, 2012).

Barak, Klein, and Proudfoot (2009) and Barak and Grohol (2011) identified how technological interventions differ in their level of interactivity and use of human support for the consumer. *Psychoeducational websites* refer to websites primarily designed to offer information to the patient about symptoms, treatment, and comorbid conditions through minimal interaction with the user. They may also contain an additional app for the user to download making the content easier to navigate. *Interactive, self-guided interventions* refer to a form of technology, most often a website, which allows an individual the opportunity to interact with a structured, self-guided online program. These programs often follow the principles of CBT and offer interactive exercises to the user. Such interventions may use other technologies to enhance their experience, such as through text messages or apps. These interventions typically do not offer human support; however, they may contain partial automated support, such as reminders. *Human-supported therapeutic interventions* are similar to *self-guided interventions* in that they tend to follow behavioural therapeutic principles, however they are more dynamic and incorporate a human (usually a healthcare professional) to provide support, guidance, and feedback. Although some human-supported therapeutic interventions may also contain automated elements, they are still primarily a human-supported intervention, which is usually delivered on a one-to-one basis by email, instant messaging or videoconferencing. Human contact within these

interventions can further be divided into those that involve real-time (synchronous) or delayed (asynchronous) interaction with patients. Very little literature exists on what are the most efficacious characteristics and features of DHIs for CYP, however for the purposes of this thesis, the section below will explore the effectiveness of therapeutic DHIs delivered to CYP with physical, behavioural and psychiatric conditions and the factors that influence their uptake and engagement as well as the role of the parent.

1.2.4 Effectiveness of therapeutic DHIs for CYP

In evaluating the effectiveness of DHIs designed for CYP the focus here will be on what Murray (2012) proposed as relevant outcomes for web-based interventions. Murray (2012) stated that in addition to measuring knowledge and understanding, relevant outcomes for web-based interventions include cognitive, behavioural, and emotional outcomes.

1.2.4.1 Cognitive outcomes

Cognitive outcomes include improving knowledge or understanding, intention (e.g. adopting a particular healthy behaviour) and self-efficacy (e.g. an individual's belief in his or her capacity to execute an intended task or behaviour). In the domain of DHIs, McPherson *et al.* (2006) carried out a RCT evaluating the impact of an educational multimedia program designed to promote self-management skills in children with asthma. They found that children who received the digital program had an improved sense of control and greater knowledge of asthma compared to the control group. Halpern, Mitchell, Farhat, and Bardsley (2008) aimed to improve teenage participants' knowledge of various sexual health issues, such as condom use and HIV testing. Using a web-based health education intervention called *TeenWeb*, they found that Kenyan students' knowledge in three emergency contraception items improved having received the

intervention compared to the control group. However, significant decreases were found in the Brazilian sample on two of the same measures showing that DHIs can be ineffective as well as effective.

1.2.4.2 Behavioural outcomes

Behavioural outcomes refer to any intervention that targets behaviour change. Examples in youth populations tend to focus on health-related behaviours, including healthy eating, physical activity, practising safe sex, and moderating smoking, drug, or alcohol use. As initially reported by Rose (2001), a small change across a large population can have a significant impact on public health. Thus, the positive findings from numerous systematic reviews and meta-analyses of the effects of DHIs on behaviours including health behaviour change (DeSmet *et al.*, 2014), practising safe sex (Guse *et al.*, 2012), smoking cessation and prevention (Isensee and Hanewinkel, 2012; Thomas, McLellan and Perera, 2013), alcohol use (Strøm *et al.*, 2014), and drug use (Faggiano *et al.*, 2014) are encouraging despite the effect sizes being relatively small.

1.2.4.3 Emotional outcomes

Emotional outcomes include any emotions that may be targeted by the DHI including sadness, anxiety, guilt, shame, and anger. DHIs for CYP have tended to focus on these areas with a multitude of interventions available for CYP with mental health issues, usually based on CBT principles. DHIs for CYP have been shown to be acceptable, effective, and cost-effective across a range of mental health issues, including mild to moderate depression, anxiety, obsessive-compulsive disorder (OCD), and phobias (Sethi, 2013; Storch *et al.*, 2015; Lenhard *et al.*, 2017). Arguably the most well-known DHI with the best evidence designed to target emotional outcomes is *MoodGYM*, which was developed by researchers at the Australian National University (Christensen and Griffiths, 2001). *MoodGYM*

was initially free to use, however now requires a paid subscription. It is an online-computerised CBT programme for depression and anxiety that can be provided with or without clinician guidance delivered across a range of age groups. It is thought to be the most widely used computerised CBT programme in the world, with over one million users worldwide, and its effectiveness is well-established for CYP and adults (O'Kearney *et al.*, 2009; Twomey and O'Reilly, 2017).

1.2.5 The issue of engagement and why it's important

Whilst DHIs for CYP have shown encouraging outcomes, there have been a number of issues relating to low engagement, which in the context of health services refers to a lack of uptake and poor adherence (i.e. continued use) to an intervention. Interestingly, industry research data found that 74% of users stopped engaging with health apps after just ten uses (Localytics, 2017). Difficulties with longer term engagement of DHIs are similarly problematic. For example, a study evaluating an iPhone app to track asthma symptoms initially enrolled around 7500 participants, however by the 6-month follow-up just 175 (2%) of those participants had engaged sufficiently enough to also take part in a survey (Chan *et al.*, 2017). In a systematic review of computerised CBT conducted by Waller and Gilbody (2009), they found that just 56% of participants completed all sessions. Indeed, even the initial step of downloading an app can often be a challenge. One clinical trial reported that just over 50% of participants in a study of an intervention for depressive symptoms never downloaded the app in the first instance (Arean *et al.*, 2016). The main difficulties with engagement seem to centre on how people use DHIs differently in real-world settings compared to trial conditions (Fleming *et al.*, 2018). However, the importance of engagement with DHIs cannot be overstated, as research suggests that greater adherence and engagement is generally

associated with more positive clinical outcomes (Christensen, Griffiths and Farrer, 2009; Donkin *et al.*, 2011; Baumel and Yom-Tov, 2018).

Several studies have found that engagement and adherence to an intervention may relate to characteristics of the intervention, characteristics of the user, or characteristics of the condition targeted. For example, a number of studies of online therapy have identified reasons for poor engagement, including participants finding the intervention too demanding and being unable to find time to complete tasks (Anderson *et al.*, 2005), preferring face-to-face therapy with a human therapist (Lange, van de Ven and Schrieken, 2003), and experiencing problems with the computer or poor Internet access (Kiropoulos *et al.*, 2008). In a study evaluating CYPs engagement with *MoodGYM*, the researchers found that adolescents in the school-based sample completed significantly more exercises than community users (M = 9.38, SD = 6.84 vs. M = 3.10, SD = 3.85, p<.001), indicating the importance of a monitored setting on CYPs motivation and interest (Neil *et al.*, 2009). A multiple linear regression found that females (p<.001) were more likely than male adolescents to complete the program and the two other predictors of adherence among the adolescent sample were living in a rural area (p<.001) and having a lower level of anxiety at pre-test (p =.04) (Neil *et al.*, 2009). Better engagement amongst those in rural areas may reflect the gap in adolescent mental health services in these remote areas, which is known to be a common issue in Australia (see: https://www.aph.gov.au/DocumentStore.ashx?id=3e1d8adf-61a3-44ab-a41c-ad4d08d9daff&subId=612895). Although it must be noted that the factors investigated in this study only accounted for 21% of the overall variance, suggesting there were other predictive variables of adherence to the *MoodGYM* program that were simply not explored. Poor attrition rates

were further observed in another study evaluating adherence and engagement of youth participants from Norway to the *MoodGYM* program (Lillevoll *et al.*, 2014). Just 8% (n = 45) of the 527 participants in the intervention group actually signed on and used *MoodGYM*. Of 527 participants randomised to the intervention group, 70% (n = 369) returned post-intervention questionnaires and only 40% (n = 212) reported post-intervention data regarding non-use. The researchers concluded that self-directed interventions might not be the most appropriate procedure to engage youth populations, as their motivation levels and persistence with the intervention may fluctuate. However, this was not based on evidence as motivation was not specifically measured in this study.

For mental health apps in particular, reasons identified for low engagement include poor usability (i.e. difficult to use or unenjoyable content), lack of user-centric design (i.e. not meeting the needs of the user), concerns about privacy and trust, and unhelpfulness in emergencies (Torous *et al.*, 2018). Creating and maintaining interest for CYP is of immense importance when designing DHIs. Indeed, Ritterband *et al*. (2003) argued the need for three main components (or what are often termed "essential ingredients") in order to provide a more immersive and engaging environment:

- Multimedia (e.g. audio, visual, and image components)
- Interactivity
- Personalisation

Although these components were not specified to any age group in particular, CYP tend to prefer audio, visual and interactive programs. For example, one of the world's most engaging and popular apps for CYP in recent times is *Pokémon GO* and that uses a full range of multimedia, augmented reality and interactive features (Althoff, White and Horvitz, 2016).

Another major factor of patient engagement with DHIs is the adoption and attitudes towards these by health professionals. There have been many studies in different countries assessing clinician attitudes towards DHIs — mainly focussing on computerised CBT — and although results vary between studies some common themes emerge. Whitfield and Williams (2004) found that clinicians reported a number of concerns that would need to be addressed before they adopted computerised CBT, such as receiving appropriate training and additional research demonstrating effectiveness. In this survey of CBT therapists in the UK, they found that just over 2% of those surveyed used computerised CBT and only 1% were using this instead of face-to-face therapy. In a survey carried out by MacLeod, Martinez, and Williams (2009), they found that UK based therapists had a number of concerns about computerised CBT, including a lack of technological knowledge, absence of a therapeutic relationship, and poor motivation from patients. Moreover, mental health workers believe in the superiority of face-to-face therapy compared to computerised CBT, with only 17-33% reporting that computerised CBT can produce equivalent outcomes to standard practice (Donovan *et al.*, 2015).

It also appears that mental health workers are more likely to use DHIs as adjuncts rather than as substitutes for regular face-to-face therapy (Perle *et al.*, 2013; Sinclair *et al.*, 2013). This particular issue may relate to how health workers may feel threatened about losing their role as practising psychotherapists if DHIs are routinely disseminated in health services. However, dissemination into primary care depends on the willingness of practitioners to refer patients to DHIs and this may prove difficult to coordinate unless sufficient training is provided and diagnostic guidelines are well established (Clark, 2011). While DHIs seem to be effective for a number of conditions and allow better access to evidence-based treatments

to a larger population, it is clear that more education about these interventions should be provided to health workers and clinical guidelines need to be established. This would allow better adoption rates and more positive attitudes towards DHIs by health workers, which would subsequently improve uptake and engagement for patients alike.

With regards to engagement with DHIs, many studies refer to 'sufficient use' (Yardley *et al.*, 2016). However, what constitutes 'sufficient use' of DHIs is not well understood. Within the domain of DHIs, research on engagement has tended to focus on the extent to which participants adhere to the usage recommendations and expectations set forth by developers (Alkhaldi *et al.*, 2016; Yardley *et al.*, 2016). Based on this operationalisation of engagement, there have been studies which have identified factors associated with engagement in order to understand how and why interventions are used differently by users. For example, research has demonstrated that variables including age, gender, and level of education are associated with higher engagement with DHIs across a diverse range of conditions (Verheijden *et al.*, 2007; Strecher *et al.*, 2008; Couper *et al.*, 2010; Hasson, Brown and Hasson, 2010; Riet, Crutzen and Vries, 2010). In a systematic review of DHIs for depression and anxiety, the researchers found that disease severity and treatment length predicted levels of engagement (Christensen, Griffiths and Farrer, 2009). However, due to various concerns with the 'sufficient use' definition of engagement, there has been a paradigm shift in recent years to focus instead on 'effective engagement'. This refers to that which can be demonstrated to mediate positive outcomes and, as such, is defined in relation to the aims of each individual intervention (Yardley *et al.*, 2016).

There is strong evidence from the literature to suggest that engagement with an intervention is a crucial factor for not only successful

implementation but also for positive outcomes. For instance, patient engagement has been repeatedly linked to better health outcomes (Birnbaum *et al.*, 2015) and higher levels of engagement with DHIs is consistently recognised as a prerequisite for effective outcomes (Yardley *et al.*, 2016). Levels of engagement across a broad range of DHIs have also consistently been shown to be the main predictor of successful outcomes (Bennett and Glasgow, 2009). Despite this, the finding that usage metrics are often associated with better outcomes should be interpreted with caution. Effect sizes within such studies are often small and highly variable across different conditions (Webb *et al.*, 2010). Moreover, the majority of the evidence is correlational and thus does not imply causation and it could be that these associations are due to confounding variables (Yardley *et al.*, 2016). Whilst it seems that engagement with DHIs is important for positive outcomes and there are some insights into factors that may affect this, exactly 'how much' engagement (i.e. dosage) is necessary to achieve successful outcomes is not entirely apparent.

In conclusion, user engagement appears to be crucial in successfully implementing digital interventions and for positive outcomes. However, the majority of the literature to date has been on factors affecting engagement and adherence for adult populations and there is paucity of studies on CYP. More research needs to be conducted in this area, as factors that may affect adult populations may not necessarily relate to a youth population. As developers of DHIs need to understand what the essential components are to better engage users, it is clear that more studies need to carry out rigorous evaluations to determine these factors.

1.2.6 The role of the parent

From the literature, it seems that engagement is a crucial factor for both successfully implementing an intervention but also for effective outcomes.

There is also consistency across different forms of interventions that parental involvement is particularly important for younger CYP to assist with their engagement, which in turn leads to better outcomes. Within the realm of remotely delivered bibliotherapy (i.e. the use of literature to help provide information, support, and guidance) for CYP with anxiety disorders, studies have shown that when these are parent assisted there is a greater reduction in anxiety symptoms. One such study found that a parent delivered CBT intervention for 27 children aged between 7 and 14 years with an anxiety disorder showed a significantly greater improvement in anxiety symptoms post-treatment compared to those who received a clinician delivered CBT intervention (69% anxiety diagnosis free in the parent delivered condition vs. 57% in the clinician delivered condition) (Leong *et al.*, 2009). Using the same intervention, another study found that parent assisted bibliotherapy for 55 children with anxiety indicated a significantly greater reduction in anxiety diagnosis post-treatment compared to a wait-list control condition (95% anxiety diagnosis free vs. 0% anxiety diagnosis free, $p<.001$) (Cobham and Cobham, 2012). Although these studies provide strong evidence that parents play a crucial role in the successful outcomes of interventions, the findings should be assessed with caution as both studies were underpowered with small sample sizes.

A highly powered study using a similar intervention was carried out by Lyneham and Rapee (2006), who evaluated remote therapist-supported parent-implemented CBT for 100 children aged 6-12 years with anxiety disorders. Program implementation was high with 89% of participants in the telephone assisted CBT condition deemed treatment completers (i.e. 8 out of the 12 weeks had been completed). Moreover, 50% of children who received the parent-implemented intervention were anxiety diagnosis free

post-treatment compared to 0% in the wait-list control, supporting the proposed importance of the parental role in both successful implementation and outcomes (Lyneham and Rapee, 2006). Another study evaluated the efficacy of low-intensity guided parent-delivered CBT treatments for 194 children with anxiety disorders who were randomly allocated to fully guided parent-delivered CBT (four face-to-face and four telephone sessions) or briefly guided parent-delivered CBT (two face-to-face and two telephone sessions), or a wait-list control group (Thirlwall *et al.*, 2013). The researchers found that 50% of those in the fully guided CBT group had recovered from their primary diagnosis at post-treatment, compared with 39% in the briefly guided CBT group, and 25% in the wait-list control. This suggests that guided, parent-delivered CBT can be an effective and inexpensive treatment for child anxiety.

Although most of the research on the role of parental engagement to date has focused on anxiety disorders, there have been various reviews which have paid due attention to the importance of engaging parents across a range of child psychiatric disorders. In a meta-analysis of 49 youth treatment studies, the authors found that parent willingness to participate in treatment (i.e. acceptability of treatment and desire/commitment to participate in therapy) was correlated (ES = 0.34, SD = 0.12) with therapeutic process variables, including treatment acceptability, perceived barriers to treatment, treatment dropout, and treatment participation (Karver *et al.*, 2006). Additionally, it was found that parent participation in treatment (i.e., effort, involvement, collaboration, cooperation, and engagement in therapy) and positive youth outcomes varied widely across studies, with effect sizes ranging from 0.03 to 0.54. In another review which included a moderator analysis of 48 child psychotherapy outcome studies, the findings indicated that the overall more effective treatments

tended to include parent participation (Dowell and Ogles, 2010). In a separate review examining whether parental engagement was associated with improved outcomes for CYP with a variety of psychiatric and NDDs, the researchers found that there was a consistent link in nine studies between parental engagement and positive outcomes in child functioning and impairment (Haine-Schlagel and Walsh, 2015). Overall, these reviews are promising as they suggest that engaging parents is an effective method for producing successful outcomes in CYP with a range of disorders, however the effect sizes in the included studies were small thus results should be interpreted with caution.

The previous section discussed the role of the parent in face-to-face and telephone assisted therapy, however, within the domain of DHIs for CYP, less is known about the role of parental engagement or participation. One review which aimed to determine the effectiveness of mobile health interventions in improving health-related outcomes in youth 18 years or younger also conducted a subgroup analysis to assess potential moderator variables (Fedele *et al.*, 2017). They found studies that involved parents either guiding or delivering the intervention produced larger effect sizes (n = 16; Cohen *d* = 0.28; [0.18, 0.39]) compared with those that did not (n = 21; Cohen *d* = 0.13; [0.02, 0.25]). However, it must be noted that nine of the 16 mobile health interventions that included parents targeted children 5 years or younger — a developmental period during which caregivers are primarily responsible for their child's health. Another more recent review found no association between parents who guided/delivered the intervention and better treatment outcomes for children and adolescents who received Internet based interventions (Domhardt, Steubl and Baumeister, 2020). Overall, it remains an open question as to whether

parental involvement increases the effect of DHIs beyond the technology alone when CYP are the main recipients of the intervention content.

In summary, a wide variety of DHIs can be effective in treating a range of disorders in CYP, which is positive as they can potentially increase accessibility to evidence-based treatments to people who cannot usually access them. Whilst engaging the child seems to be an effective means for successful implementation and positive health outcomes, less is known about the role of the parent. However, research from other forms of therapy suggest engaging the parent is key to positive outcomes. Given the relatively early stage of DHI research, it appears necessary to replicate and extend on these findings to determine whether the extent to which parental involvement in the intervention is a driver for effectiveness. This would allow developers of such interventions to ensure that the parent is suitably engaged in order to implement and produce positive outcomes in CYP.

1.3 Introduction to tics

Tics are sudden, brief, rapid, and recurrent nonrhythmic movements or vocalisations (American Psychiatric Association, 2013) that are more common in CYP than in adults (Martino and Leckman, 2013). Tic onset typically occurs between the ages of 3 and 8 years (mean age onset is 6 and 7 years) (Freeman *et al.*, 2009) with the reported average age of greatest tic severity around ages 9 to 11 years (Leckman *et al*., 1998). Tics are categorised into simple and complex movements or vocalisations, which wax and wane over time. Simple tics usually involve one muscle group, whereas complex tics are more orchestrated, patterned movements or sounds. Examples of simple motor and vocal tics include eye blinking, nose twitching, throat clearing, and sniffing. Complex motor and vocal tics include echopraxia (repetition of another person's behaviour or

movements), gyrating, copralalia (obscene language), and sudden changes in volume or pitch. Table 1 shows common examples of simple and complex motor and vocal tics.

Table 1. List of simple and complex tics

Simple motor tics	**Complex motor tics**
Eye blinking	Writing tics
Eye squinting	Dystonic or abnormal postures
Nose movements (e.g. twitching)	Bending or gyrating
Teeth baring	Rotating
Facial grimace	Tic-related compulsive behaviours (e.g. touching, tapping, grooming, evening-up)
Head jerks or movements	
Shoulder shrugs	Copropraxia (obscene gestures)
Flexing or extending arms	Self-abusive behaviour
Abdominal tensing	Echopraxia (repeating others' actions)
Knee bending	
Simple vocal tics	**Complex vocal tics**
Coughing	Syllables
Throat clearing	Words
Sniffing	Coprolalia (obscene words)
Animal or bird noises	Echolalia (repeating others' words)
	Palilalia (repeating your own words)
	Disinhibited speech
	Sudden changes in volume or pitch

Individuals with tics report an unpleasant sensory experience that usually precedes the movement or sound, which has been described as an "itchy or funny feeling" and usually occurs in the area where the tic happens (Cavanna and Nani, 2013). This is referred to as the *premonitory urge* (PU) (Leckman, Walker and Cohen, 1993) and this feeling usually dissipates once the tic has been actioned. The exact cause of tic disorders is unknown. In terms of neural correlates, the most consolidated evidence

base is of a direct involvement of the basal ganglia and the dopaminergic system, deep structures of the brain that are involved in motor and cognitive functions (Perrotta, 2019). There is some research to suggest there is a genetic basis to tic disorders whilst premonitory urges, which can be seen as either a symptom expressed alongside tics or as part of the mechanism leading to their manifestation, appear to be mediated by sensory, limbic, and paralimbic brain areas (Yael, Vinner and Bar-Gad, 2015). Although the cause of tic disorders and expression is unknown there is research to suggest that tics are triggered or intensified by contextual variables (i.e. external stressors), such as exam periods or stressful family situations (Conelea and Woods, 2008; Hoekstra *et al.*, 2013).

1.3.1 Diagnosis

In the UK, a general practitioner (GP) initially assesses an individual with tics and, if deemed necessary, makes a referral to a tic disorder specialist, such as neurologist, psychiatrist, or paediatrician for further examination and possible diagnosis. A diagnosis of a tic disorder is made based on the history and routine physical examination of the patient (Murphy, Masumova and Budman, 2018). A physician or tic specialist may also assess the patient for any common medical and psychiatric conditions that often co-occur with tic disorders. However, due to limited number of tic specialists and uneven geographical distribution of services, there is often a delay in getting a diagnosis from symptom onset. As GPs often do not have expertise in tics, they may frequently dismiss tics as something less severe, such as an allergy. This can lead to an even greater delay in receiving a diagnosis. The importance of receiving a diagnosis of a tic disorder cannot be understated, as it can result in an improved understanding of related behaviours and actions for the individuals as well as those around them (e.g. family, friends etc.) leading to a decrease in

stigmatisation and embarrassment for the individual. It can also provide more suitable access to support services and greater provision of care. Once a referral is made to a tic specialist, they will often use a diagnostic tool or rating scale to help with the assessment and potential diagnosis. In the USA, the official classification for clinical diagnosis is the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) (American Psychiatric Association, 2013) whereas much of Europe, including the UK, tends to favour the International Classification of Diseases 11 (ICD-11) to help make a diagnosis (Tyrer, 2018).

According to the DSM-5, tic disorders are categorised into three distinct types: Tourette's Disorder, persistent (chronic) motor or vocal tic disorder, and provisional tic disorder. In Table 2, Table 3, and Table 4 the diagnostic criteria according to the DSM-5 for each of these categories is listed.

Table 2. Diagnostic criteria for Tourette's Disorder

1. Both multiple motor and one or more vocal tics have been present at some time during the illness, although not necessarily concurrently.
2. The tics may wax and wane in frequency but have persisted for more than one year since first tic onset.
3. Onset is before the age of 18 years.
4. The disturbance is not attributable to the physiological effects of a substance (e.g. cocaine use) or another medical condition (e.g. Huntington's disease, postviral encephalitis).

Table 3. Diagnostic criteria for Persistent (Chronic) Motor or Vocal Tic Disorder

1. Single or multiple motor or vocal tics have been present during the illness, but not both motor and vocal.
2. The tics may wax and wane in frequency but have persisted for more than one year since first tic onset.
3. Onset is before the age of 18 years.
4. The disturbance is not attributable to the physiological effects of a substance or another medical condition.
5. Criteria have never been met for Tourette's disorder.

Table 4. Diagnostic criteria for Provisional Tic Disorder

1. Single or multiple motor and/or vocal tics.
2. The tics have been present for less than one year since first tic onset.
3. Onset is before the age of 18 years.
4. The disturbance is not attributable to the physiological effects of a substance or another medical condition.
5. Criteria have never been met for Tourette's disorder or persistent (chronic) motor or vocal tic disorder.

According to ICD-11 criteria, tic disorders are classified as a movement disorder and are further split into primary tics or tic disorders and secondary tics. Primary tics or tic disorders refer to Tourette's Disorder, chronic motor or phonic tic disorder, transient motor or phonic tics, and adult-onset tics. Secondary tics refer to a tic disorder that is a direct physiologic consequence of an antecedent infection or illness, such as tics due to encephalitis or prion disease (e.g. Creutzfeldt-Jakob disease), drug-induced tics, and tics due to a stroke, which is not covered in the DSM-5.

The ICD-11 describes primary tics or tic disorders as the following:

> Primary tics or tic disorders are characterised by the presence of chronic motor and/or vocal (phonic) tics. Motor and vocal tics are defined as sudden, rapid, non-rhythmic, and recurrent movements or vocalisations, respectively. In order to be diagnosed, tics must have been present for at least one year, although they may not manifest consistently.

As well as using a diagnostic tool, a tic specialist may also administer a rating scale as part of an assessment. The most widely used rating scale for tics is The Yale Global Tic Severity Scale (YGTSS) (Leckman *et al.*, 1989). The YGTSS is a clinician administered semi-structured interview schedule focusing on motor and vocal tic number, frequency, intensity, complexity, and interference over the previous week. These domains

combine to give a Total Tic Severity Score (TTSS), which has a range of 0-50. A separate tic-related impairment score is given (0-50), when combined with the TTSS, gives the Global Severity Score, which has a range of 0-100. A higher score on all scales suggests more severe tics, or a greater impact the tics have on the individual. The YGTSS is not a diagnostic tool; however, it is predominantly used in clinical practice to track changes in an individual's tic behaviour or to evaluate if a treatment is having the desired effect on reducing symptoms (Storch *et al.*, 2011).

1.3.2 Prevalence

Tic disorders are more common in special education populations than in general populations of CYP and are more common in boys than girls (Knight *et al.*, 2012). In a sample of 9,117 CYP aged between 5 and 19 years within the UK, tic disorders were the most prevalent (0.6%) amongst the other less common disorders (including psychosis, and stereotypic or social disorder) and were also more common in boys (1.1%) than girls (0.6%) and highest in White British CYP (2.7%) and lowest in those who were Black/Black British (0.3%) (NHS Digital, 2017). Whilst Autism Spectrum Disorder (ASD) was more common in low income than high-income households, there was no association with income for tic disorders. Interestingly, CYP whose parents had a high level of psychological distress were more likely to meet the criteria for a less common disorder than CYP whose parents had a lower level of psychological distress.

Transient tic disorders are the most common type of tic disorders amongst CYP, followed by chronic tic disorders (CTD) and TS (also referred to as Tourette's disorder or Tourette's). Although precise prevalence rates for all tic disorders are difficult to establish, the most common type — transient tics — are estimated to affect as many as 20% of school-aged children (Scahill, Specht and Page, 2014). Prevalence rates for CTD are divided into

motor-type and vocal-type, with estimates ranging from 3 to 50 per 1000 people for chronic motor tic disorder and 2.5 to 9.4 per 1000 people for chronic vocal tic disorder (Scahill, Specht and Page, 2014). Large-scale prevalence studies have shown that the prevalence of TS in school-aged children seems to fall between 4 to 8 cases per 1000 (Scahill, Dalsgaard and Bradbury, 2013). In the UK, it is estimated that TS affects one school-aged child in every 100 cases and more than 300,000 children and adults live with the condition in the UK (Robertson, Eapen and Cavanna, 2009).

1.3.3 Comorbidities

The most common comorbidities of tic disorders and TS include ADHD, obsessive compulsive disorder or behaviours (OCD/B), and ASD, whereas some of the common co-occurring problems individuals with tic disorders face include anxiety, depression, substance abuse, childhood conduct disorder, and personality disorder (Robertson, 2015). A community based sample of 1596 children, of whom 21% had tics, found that behavioural problems — including ADHD, OCD, and oppositional defiant disorder (ODD) — were more frequent in children with tics than in those without tics (Kurlan *et al.*, 2002). These complex comorbidities can cause great difficulties for individuals with tics and, indeed, for their families. Tic disorders occurring on their own can cause individuals to suffer from low self-esteem, poor social functioning, and low mood; however, when there is an additional complexity, such as ADHD or OCD, this can have profound consequences that can lead to poorer quality of life and impact on school or work life (Eapen *et al.*, 2013). Furthermore, the wider family's quality of life may also be diminished due to receiving blame for a delayed diagnosis or guilt from genetic attribution, whilst co-occurring conditions, such as ADHD and OCD features, may affect the parents' ability to 'care' for the young person (Eapen, Cavanna and Robertson, 2016).

1.3.4 Impact

The overall impact on individuals with tic disorders and their families can be profound. Although the spectrum of tic severity and its impact is wide, tics can be associated with difficulties in self-esteem, family life, social acceptance, school or job functioning, including depression with suicidal ideation, and a restricted life due to social stigma and social avoidance (Eapen, Cavanna and Robertson, 2016). This can even result in being home schooled or persistent unemployment (Evans, Seri and Cavanna, 2016). In a meta-synthesis of lived experiences of people with TS carried out by Smith, Fox, and Trayner (2015), they found that the negative impact of TS across the lifespan in organisations such as school or the workplace resulted in low self-esteem and self-acceptance. As one child from the study remarked:

> "...In class I felt embarrassed, I couldn't pay attention because I heard a laugh and I thought my colleagues were laughing at me and I always kept an eye on what my colleagues thought, said, or did and I had a bad time." (Smith, Fox and Trayner (2015) quoting an adolescent from the study, p.623)

Furthermore, due to the way TS is often portrayed in the media, a common misconception about TS is the strong presence of obscene language (copralalia), when in actuality only 10% of TS patients exhibit this symptom (Freeman *et al*., 2009). This lack of knowledge and negative media portrayal of TS often instigates suboptimal social experiences for people with TS, leading one young person in a qualitative study carried out by Wadman, Tischler, and Jackson (2013) to remark:

> "It gets me a bit annoyed 'cause it's like they're like making assumptions and saying what they think they know and it's not

> actually true, it's just what they've heard." (Wadman, Tischler and Jackson (2013) quoting a young person from the study, p.883)

Parents of children with TS also report on how they have great difficulties making friends, including being rejected by their peers and even bullied (Packer, 2005; Storch *et al.*, 2007). These issues can affect the young person into their adult life. In a longitudinal study carried out by Byler *et al.* (2015), they found that 90% of a subsample of patients who completed a survey reported that tics affected everyday life and identified with the statement "my life is not what I want it to be." One patient described their life as severely limited by tics. Although one must be cautious with these findings, as the sample size was very small (n = 10).

Due to the complications and impact that tic disorders can have on people, it is thus imperative that a timelier diagnosis is made, and appropriate treatment given for both the tic disorder and associated conditions to improve quality of life across the lifespan and overall burden of care.

1.3.5 Treatment

Although most CYP with tics only require education as the main form of treatment (Shprecher and Kurlan, 2009), there are a number of interventions available for patients with more severe or disabling tics. Historically, pharmacotherapy, such as antipsychotics, has been the first line of treatment for severe tics; however, they often have undesirable side effects, such as dyskinesia, weight gain and sedation. An appealing alternative to pharmacotherapy are behavioural interventions (Cuenca *et al.*, 2015), which generally do not have the unwanted side effects however, they do require the patient to practise and invest time and energy (McGuire *et al.*, 2015).

1.3.5.1 Pharmacotherapy

There are pharmacological interventions for tic disorders that have been shown to be effective (Roessner *et al.*, 2011), however, clinicians must be careful in their considerations, particularly when comorbidities are present. Dopamine antagonists are generally considered as the first line of treatment for tic disorders without comorbidities. This includes second (e.g. risperidone, olanzapine, and quetiapine) and third (e.g. aripiprazole) generation antipsychotics. Where comorbidities such as ADHD are present, alpha-2 agonists (e.g. clonidine and guanfacine) are more likely to be administered (Murphy, Masumova and Budman, 2018). A meta-analysis of five RCTs of antipsychotic medications identified a statistically significant moderate reduction in tic severity relative to placebo (*ES* = 0.58), with no significant differences between medication types (Weisman *et al.*, 2013). In addition, a meta-analysis of six RCTs of alpha-2 agonists identified a statistically significant reduction in tic severity relative to placebo (*ES* = 0.31) that was increased to a moderate effect (*ES* = 0.68) when limited to RCTs in which individuals had both CTD and ADHD (Weisman *et al.*, 2013). Although shown to have good efficacy for tic disorders, dopamine antagonists and alpha-2 agonists can cause severe side effects, such as acute dystonia (involuntary contraction of muscles), neuroleptic malignant syndrome, tardive dyskinesia (uncontrollable stiff, jerky movements), sedation, weight gain, and cardiac arrhythmias (Kenney, Kuo and Jimenez-Shahed, 2008).

Whilst medications can be effective in reducing tics, clinicians must factor in how medications can affect common comorbidity symptoms as well as having a longer lasting effect on tic symptoms. In a qualitative study using thematic analysis, Cuenca *et al.* (2015) found that CYP who took medication perceived it to have limited benefit for their tics. Some participants stated that they found the medication helpful at the beginning,

however, after some time, it stopped having the same efficacy and thus they would discontinue the medication. Due to the side effects and perceived lack of or limited benefit of medication, behavioural interventions are more desirable to individuals with tics and their carers (Cuenca *et al.*, 2015).

1.3.5.2 Behavioural therapy

For individuals with tic disorders, there are three main types of behavioural interventions: habit reversal therapy (HRT), exposure and response prevention (ERP) and Comprehensive Behavioural Intervention for Tics (CBIT), which includes HRT. Although behavioural treatments for tic disorders have existed for several decades, only recently have they been investigated using RCT designs (Verdellen *et al.*, 2011; McGuire *et al.*, 2015). The core principle underlying the main behavioural therapies is targeting the PUs, focussing on the "tic cycle" (Figure 1) (sometimes referred to as the "negative reinforcement cycle"; Brandt *et al.* (2016)).

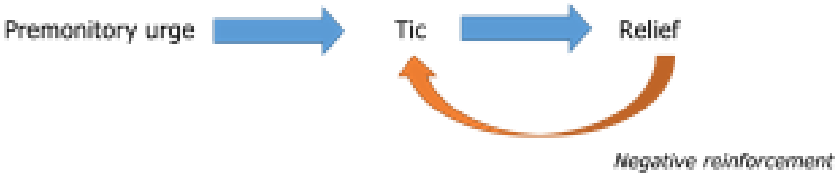

Figure 1. The tic cycle

The following section will briefly describe the three main behavioural therapies offered to patients with tic disorders.

1.3.5.2.1 Habit reversal therapy

HRT is considered one of the most efficacious strategies in dealing with tics and is the most researched of all behavioural interventions for CTDs and TS, having first been mentioned as early as the 1970's (Azrin and Nunn, 1973). HRT consists of several components, including awareness training

with self-monitoring, relaxation techniques and competing response strategies (Azrin and Peterson, 1988). Regardless of the way in which HRT is administered (e.g. either alone or as part of a treatment package), awareness training and competing response strategies are widely accepted to be the two core components (Azrin and Nunn, 1973; Woods and Miltenberger, 1995). Awareness training involves the patient identifying all of their tics in detail, then selecting one specific tic to work on — usually the most severe tic — with the help of a trained therapist. This involves being cognisant of when the tic is about to occur thus increasing awareness of their PUs. The next stage is finding a competing response. This trains the patient to perform an intentional movement that is incompatible with the tic movement, meaning that the tic cannot occur at the same time. The patient attempts to hold the competing response for as long as is needed for the urge to decrease. For example, a child with a neck-jerking tic may be taught to look forward with their chin slightly down, while gently tensing neck muscles for one minute or until the urge goes away. This approach is then applied to each tic until the patient becomes more aware of the urges and the principles of competing responses, which additionally helps the patient when new tics emerge. Although the majority of studies on the efficacy of HRT have involved small sample sizes, its effectiveness is well established in the literature with RCTs and systematic reviews showing HRT can significantly reduce tic severity in both adults and children with TS and other CTDs (Wilhelm *et al.*, 2003; Deckersbach *et al.*, 2006; Dutta and Cavanna, 2013; Wile and Pringsheim, 2013; Hollis *et al.*, 2016). See Table 5 for a summary of key studies on behavioural therapy for tic disorders.

Table 5. Summary of studies on behavioural therapy for tic disorders

Study	Study design and sample size	Population	Treatment/comparator group	Mean (SD) baseline TTSS	Results
Wilhelm et al. (2003)	Parallel RCT, N = 32	Adults – Mean age (SD) years = 34.9 (12.5), 48% on medication	HRT vs. SP	28.8 (7.5)	Large within-group effect for HRT group on TTSS (*d* = 1.50); the effect size in the SP group was small (*d* = –0.03).
Verdellen et al. (2004)	Parallel RCT, N = 25	Children – Mean age (SD) years = 11.9 (2.7), 30% OCD, 48% on medication	ERP vs. HRT	19.6 (5.8)	Both groups showed reduced tic severity at follow-up with larger effect found in ERP group. ERP: *d* = 1.42 HRT: *d* = 1.06
Deckersbach et al. (2006)	Parallel RCT, N = 32	Adults – Mean age (SD) years = 35.1 (12.2), 30% OCD, 53% on medication	HRT vs. SP	28.5 (6.1)	HRT patients exhibited lower tic-severity than SP patients at follow-up. HRT: 29.3 to 18.3 on TTSS SP: 27.7 to 26.8 on TTSS (*d* = -1.42)
Piacentini et al. (2010)	Parallel RCT, N = 126	Children – Mean age (SD) years = 11.7 (2.3), 26% ADHD, 19% OCD, 37% on medication	CBIT vs. SP	24.7 (6.1)	Between-group effect CBIT: 7.6 points reduction on TTSS SP: 3.5 points reduction on TTSS (*ES* = 0.68)

Wilhelm et al. (2012)	Parallel RCT, N - 122	Adults and children – Mean age (SD) years = 31.6 (13.8), 28% ADHD, 18% OCD, 25% on medication	CBIT vs. SP	22.9 (6.6)	CBIT was associated with a significantly greater decrease on the TTSS from baseline to end-point compared with SP (*ES* = 0.57).
Nissen et al. (2019)	RCT, N = 59	Children – Mean age (SD) years = 12.2 (2.3), 34% ADHD, 42% on medication	Intervention: combined HRT and ERP, individual vs. group	23.9 (6.8)	No between-group effect on the TTSS. Large within-group effects on the TTSS for both the individual (*ES* = 1.21) and the group format (*ES* = 1.38).
Andrén et al. (2020)	Pilot RCT, N = 23	Children – Mean age (SD) years = 12.3 (2.5), 39% ADHD, 13% OCD, 13% on medication	Internet-delivered HRT vs. internet-delivered ERP	23.6 (5.2)	Large within-group effect (*d* = 1.12) on the TTSS for the ERP group at the 3-month follow-up.

Rachamim et al. (2020)	RCT, N = 41	Children – Mean age (SD) years = 11.3 (1.9), 44% ADHD, 32% OCD, 25% on medication	Internet-delivered CBIT vs. waitlist	22.7 (6.4)	Large within-group effect (*d* = 2.25) was found for the CBIT group on TTSS at the 6-month follow-up.

Note: SP - supportive psychotherapy; ERP - exposure with response prevention; TTSS - Total Tic Severity Score; RCT – randomised controlled trial; HRT – Habit reversal therapy; OCD – Obsessive compulsive disorder; CBIT - Comprehensive Behavioural Intervention for Tics.

1.3.5.2.2 Exposure and Response Prevention

ERP was initially developed for OCD and has shown positive effects in several RCTs for people with OCD (Abramowitz, 2006). The mechanism underlying ERP for OCD is that the response prevention of the compulsion leads to exposure to objects or situations that trigger anxiety-inducing obsessions. In time, an increased exposure to obsessional cues results in a reduction of anxiety and changes in distorted beliefs of anxiety (Hezel and Simpson, 2019). Although tics are experientially different from compulsions in OCD (Cath *et al.*, 2000), tics share similarities with compulsions with regard to their reinforcing character (Conelea *et al.*, 2014). Put simply, the underlying theory of ERP for tics is an interruption in the association between unpleasant PUs followed by the release of a motor or vocal tic, which relieves this sensation (Bliss, Cohen and Freedman, 1980; Leckman, Walker and Cohen, 1993). By performing the tic and relieving the unpleasant sensation, the patient is negatively reinforced thus repeating the tic. Through ERP treatment and with the aid of a trained therapist, the patient is instructed to provoke PUs and practise suppressing their tics. Although the exact mechanism of action of ERP is unclear, there is some

evidence to suggest disruption to the negative reinforcement cycle (as shown in Figure 1). The patient also gains mastery in tolerating the urge, controlling the tics, and is able to do so for increasingly longer periods. By targeting their PUs in this way, this provides a method in which to train individuals to gain some influence over their tics.

Although there is limited RCT evidence for the effectiveness of ERP, in a review of the literature, researchers concluded that ERP satisfies the requirements for 'efficacious treatment' according to the American Psychological Association's criteria (Cook and Blacher, 2007). This finding was based on only one study (Verdellen *et al.*, 2004), however the conclusion was reached centred on the fact that ERP was able to produce comparable results to the well-established treatment of HRT using a RCT design. Since then, there is some evidence showing an inclination towards the efficacy of ERP over HRT (see Table 5) (Verdellen *et al.*, 2011; van de Griendt *et al.*, 2018; Andrén *et al.*, 2020). However, a recent study conducted in Denmark compared combined HRT and ERP in a group setting versus in an individual setting and found no significant difference in total tic scores (Nissen *et al.*, 2019). Overall, ERP has been less well evaluated than other behavioural treatments for tics and its superiority for tics against an active control intervention is largely unknown.

1.3.5.2.3 Comprehensive Behavioural Intervention for Tics

In 2001, the Tourette Association of America published a large-scale study showing that CBIT was a promising new non-pharmacological development in reducing tic severity and has consistently showed effectiveness for both adults and adolescents (Piacentini *et al.*, 2010; Wilhelm *et al.*, 2012; Hollis *et al.*, 2016). In essence, CBIT is an extension of HRT — patients are taught awareness of tics, competing response strategies, and relaxation techniques — with the added elements of psychoeducation and functional

analysis. Psychoeducation provides disorder-specific information about the course, genetic factors, and underlying neurophysiology of tic disorders and the rationale for current treatments. Functional analysis refers to the identification of situations and events that lead to an increase in tic severity and the patient is taught strategies for coping with these situations. For example, a patients' tics may increase when in a crowded place and therefore a therapist may teach relaxation techniques or to observe the environment in a different way. The support of the child's family, friends, and teachers are also critical to the mechanisms of impact of CBIT. CBIT generally consists of eight sessions over 10 weeks encompassing the aforementioned elements (Woods, Piacentini and Walkup, 2007).

Its effectiveness and lack of side effects are clear benefits of CBIT, and are advantageous over current medications, offering a competitive, evidence-based alternative for treating tic disorders. CBIT has shown good efficacy in well-powered RCTs in both children and adults with tic disorders (see Table 5) (Piacentini *et al.*, 2010; Wilhelm *et al.*, 2012), with benefits persisting over a period of three and six months. Accordingly, in the latest guidelines – including those of the European Society for the Study of Tourette Syndrome (ESSTS) – behavioural therapy with either CBIT or ERP is now recommended as the first-line treatment for tic disorders (Pringsheim *et al.*, 2012). Even more recently, the American Academy of Neurology (AAN) — endorsed by the Child Neurology Society and the European Academy of Neurology — published guidelines recommending CBIT as the first line treatment for all tic disorders (Pringsheim *et al.*, 2019). Despite the benefits and evidence-based effectiveness of behavioural therapies over medication for tic disorders, there is still great difficulty in patients accessing behavioural treatments due to a lack of

trained therapists relative to demand. As discussed in the previous section, one promising development in increasing accessibility to evidence-based behavioural treatments is the use of DHIs, which have shown to be effective for CYP with tic disorders. In the next section, the ORBIT trial will be described and the rationale for why it is needed.

1.4 Overview of the ORBIT trial

1.4.1 Rationale

As described (see 1.3.5), the treatment of tic disorders usually involves pharmacological interventions; however, these medications are associated with adverse side effects, such as weight gain and dyskinesia. A more attractive alternative to medication for patients with tic disorders is behavioural therapies, such as HRT, ERP, and CBIT which have already demonstrated effectiveness in various studies (Piacentini *et al.*, 2010; McGuire *et al.*, 2014; Hollis *et al.*, 2016). Despite the European clinical guidelines (Verdellen *et al.*, 2011) and AAN (Pringsheim *et al.*, 2019) recommending that behaviour therapy should be offered as a first-line intervention for tics in CYP, only one in five young people with TS are currently able to access behavioural therapy and about 50% of these are given medication (Cuenca *et al.*, 2015). As mentioned, (see 1.2), there is growing optimism that DHIs can be used to increase access to evidence-based treatments for CYP with a range of disorders. Indeed, two RCTs comparing CBIT delivered remotely via videoconferencing compared to face-to-face therapy in children with TS showed significant reduction in tics for both groups, with no difference between the modality of delivery (Himle *et al.*, 2012; Ricketts *et al.*, 2016). The pilot study carried out at the Karolinska Institutet in Sweden (Andrén *et al.*, 2019), on which the ORBIT trial is based, developed an online platform for delivering behavioural therapy for CYP with tic disorders called BIP (*Barninternetprojektet*,

Swedish for Child Internet Project; see: http://www.bup.se/bip). The study compared remote therapist supported ERP to remote therapist supported HRT delivered to CYP aged 8-16 years. They found that participants in both groups showed an improvement post-treatment, however only participants in the ERP arm showed significant reduction in tic severity as measured on the YGTSS TTSS (*d* = 1.12). The positive effects were maintained at least 12-months post-treatment. More recently, a study in Israel evaluated the feasibility and potential effectiveness of an Internet-based, self-help CBIT program for youth with tic disorders guided by parents with minimal therapist support (Rachamim *et al.*, 2020). The results demonstrated clinically meaningful reductions in tic severity and improved youth global impairment and functioning with gains maintained over a 6-month follow-up period (*d* = 2.25).

The studies mentioned all show promising findings that tic severity can be reduced in CYP with the use of remote therapist supported behavioural therapy. However, the sample sizes in all studies were small, thus limiting statistical power, making generalisations to the youth tic population as a whole highly problematic. Moreover, the uptake and use of DHIs is known to be highly dependent on context (Kaplan *et al.*, 2010; Lau *et al.*, 2016), therefore it would be inappropriate to ascertain that DHIs which were effective in different countries would be equally effective in the UK. It is clear there is a need for a highly powered RCT assessing a remote behavioural intervention for CYP with tic disorders, specifically in the UK.

1.4.2 The ORBIT intervention

The ORBIT trial and its intervention have been described in detail previously as part of the main trial protocol (Hall *et al.*, 2019). A brief summary is given here to provide context to the process evaluation and overall thesis. The ORBIT trial was a 10-week, parallel group, single blind,

RCT with an internal pilot. ORBIT aimed to evaluate the effectiveness of an online, remote, therapist supported and parent-guided ERP intervention for tics. The comparator was an online, remote, therapist supported and parent-guided psychoeducation program for tics. Participants were recruited from clinics, Patient Identification Centres (PICs) across NHS Trusts, or from the two study sites involved in the trial (Queen's Medical Centre (QMC), Nottingham and Great Ormond Street Hospital (GOSH), London), or via a tic disorder charity (*Tourettes Action*), the ORBIT study website, or social media (i.e. Facebook, Twitter). Participants were aged 9 to 17 years and were suspected or confirmed as having TS or CTD (assessed by scores on the YGTSS) and must not have had any form of behavioural treatment for tics in the last 12-months or a change (i.e. start/stop) in medication for tics in the previous two months. Participants were followed-up mid treatment, and at 3-, 6-, 12-, and 18-months post-randomisation.

Participants were randomised to one of two groups. The intervention group received 10 self-help modules ('chapters') of behavioural therapy delivered over a period of 10-12 weeks, which were accessed via a secure online platform (Andrén *et al.*, 2019). The behavioural therapy followed evidence-based ERP therapeutic principles, whereby patients learned strategies for managing their tics through allowing PU sensations to come to the fore and actively tolerate the PUs and suppress their tics. In doing so, the child masters their ability to tolerate the urge, control their tics, and is able to do so for an increasing amount of time in a hierarchical manner. ERP was selected for use in ORBIT based on the findings from Andrén *et al's* (2019) study where ERP showed superiority over HRT and that unlike HRT/CBIT, no competing response is trained in ERP, potentially making it easier to deliver with minimal therapist input. The child also received education

about tics for the family and others, such as teachers, friends, and family. The parent components contained information about how to support their child and various coping strategies for themselves. The breakdown for the module content is as follows:

1. *Child*: Learn about tics. *Parent*: Introduction
2. *Child*: More about tics. *Parent*: Supporter's thoughts and behaviours
3. *Child*: Practicing stopping your tics. *Parent*: Praise
4. *Child*: Making the practice more difficult. *Parent*: Prompts
5. *Child*: Continued practice. *Parent*: Situations and reactions
6. *Child*: School. *Parent*: Trouble shooting
7. *Child*: Talking about your tics. *Parent*: Continued practice
8. *Child*: Continued practice. *Parent*: Continued practice
9. *Child*: The final spurt. *Parent*: Continued practice
10. *Child*: Plan for the future. *Parent*: Plan for the future

Appendix A provides example screenshots from the ORBIT intervention.

The amount of contact the therapist had with the family throughout the 10-12 weeks was generally determined on an individual basis by the therapist. However, participants were able to make contact with their therapist at a time that was convenient to them. Results from the pilot study suggested that on average the therapist had approximately 24 minutes of contact each week with the family. Any phone calls made outside of the online platform were not logged in the system, but these were recorded manually in a data file. A parallel comparator consisted of psychoeducational information about TS and co-occurring conditions. For both the intervention and the comparator, treatment completion was defined as completion of the first four child chapters. The first four chapters contained the active exposure and response prevention components of the intervention and was thus considered the minimum therapeutic dose. The primary outcome

measure was the severity of tics as measured on the TTSS subscale of the YGTSS (Leckman et al., 1989). There were a number of other outcomes measured throughout the trial, including anxiety, quality of life, PUs, and health service use. Based on power calculations and allowing for 20% dropout rate, the target sample size for the ORBIT trial was 220 participants. Figure 2 shows the trial flow chart.

Overall, the ORBIT trial aimed to evaluate the clinical effectiveness (i.e. reduction in tics as measured by the TTSS) of an online ERP treatment for CYP with tics compared to online tic-related education. Furthermore, the trial aimed to evaluate the cost-effectiveness of the online treatment and to estimate the longer-term impact on patient outcomes and health service costs.

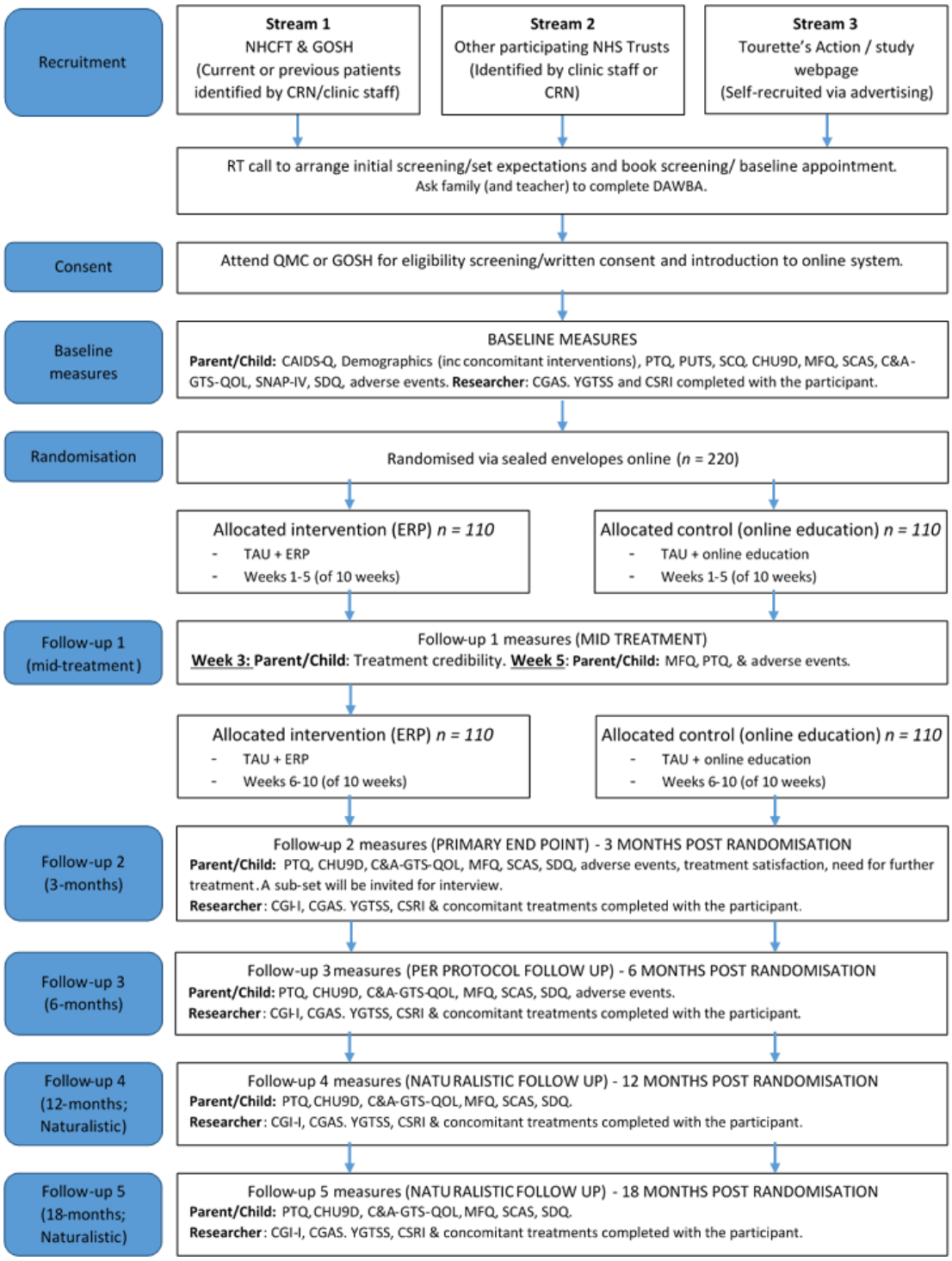

Figure 2. ORBIT trial flow chart

Note: C&A-GTS-QOL - Child and adolescent version of the Gilles de la Tourette Syndrome Quality of Life Scale; CAIDS-Q - Child and Adolescent Intellectual Disability Screening Questionnaire; CGAS - Children's Global Assessment Scale; CGI-I - Clinical Global Impressions-Improvement; CHU9D - Child Health Utility 9D; CSRI - Client Service Receipt Inventory; DAWBA - Development and Wellbeing Assessment; ERP – Exposure and response prevention; MFQ - Mood and Feelings Questionnaire; PTQ - Parent Tic Questionnaire; PUTS - Premonitory Urge for Tics Scale; RT -

research team; SCAS - Spence Child Anxiety Scale; SCQ - Social Communication Questionnaire; SNAP-IV - Swanson, Nolan and Pelham Rating Scale; SDQ - Strengths and Difficulties Questionnaire; YGTSS - Yale Global Tic Severity Scale.

1.4.3 Process Evaluation

Parallel to the main ORBIT RCT, a process evaluation was undertaken, which followed the guidelines as recommended by the Medical Research Council's (MRC) framework on process evaluations of complex interventions (Moore *et al.*, 2015). ORBIT is regarded as a complex intervention because it is composed of multiple components with the potential for interactions between them and with a number of possible outcomes (Richards and Hallberg, 2015). The MRC guidelines stipulate that in order to carry out a process evaluation of a complex intervention the following three key functions must be examined: i) implementation (identifying what was delivered and how this was done or achieved), ii) mechanisms of impact (factors that contributed to the delivered intervention producing or not producing change) and iii) context (contextual factors external to the intervention which affected implementation, intervention mechanisms, outcomes and vice versa). Figure 3 outlines the key functions of a process evaluation and Chapter 3 describes the methodology of the process evaluation in the form of a protocol paper.

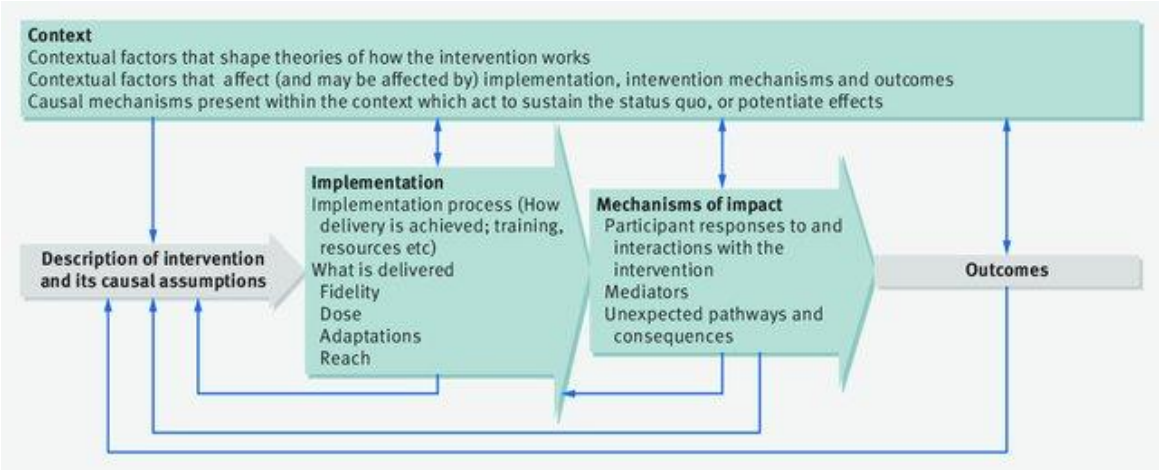

Figure 3. Key functions of a process evaluation (adapted from Moore et al., 2015)

1.4.3.1 Implementation fidelity

Implementation can refer to how an intervention can be implemented within routine clinical practice. However, this can only be achieved once an intervention has shown efficacy in an outcome evaluation. Implementation can also refer to how the delivery of an intervention was achieved within the context of an RCT and the structures and processes through which an intervention was delivered as intended (Moore *et al.*, 2015). This is often termed 'implementation fidelity'. In short, implementation fidelity refers to the degree to which a study was implemented according to design or protocol. If an intervention is designed according to well established theoretical and empirical underpinnings, including identifying 'essential ingredients' and their subsequent relationship to the intended outcomes, implementation fidelity is seen as crucial (Bragstad *et al.*, 2019).

There are multiple benefits to a trial which rigorously assesses implementation fidelity. These include improving the validity of intervention outcomes (Hulscher, Laurant and Grol, 2003; Carroll *et al.*, 2007), enabling replicability (Montgomery *et al.*, 2013), and aiding in the understanding of why an intervention succeeded or failed in its intended outcome (e.g.

symptom reduction) (Hasson, 2010). For example, a study may erroneously determine that the lack of impact of an intervention was caused by particular elements of the program itself if no process measures were evaluated (i.e. a Type III error) (Dobson and Cook, 1980). Therefore, it is essential that an RCT which includes a process evaluation should contain a rigorous analysis of implementation fidelity.

An intervention may have limited effects as a result of inadequacies in its design or because of poor implementation (Steckler and Linnan, 2002). Conversely, an intervention can have positive outcomes despite not being delivered as fully intended (Moore *et al.*, 2013). Thus, in order to understand what works and how, a process evaluation captures fidelity (whether the intervention was delivered as planned), dose (the quantity of intervention implemented) and reach (whether the intended population comes into contact with the intervention, and how). This can provide necessary information to policy makers and clinicians as to how an intervention might be replicated, as well as generalisations on how complex interventions are implemented.

1.4.3.2 Mechanisms of impact

The second key component is exploring the mechanisms through which the intervention produces change. This is crucial to understanding how the effects of the intervention occurred and how these effects might be replicated in future iterations of similar interventions (Grant *et al.*, 2013). By exploring the mechanisms of potential impact of an intervention, a process evaluation can better understand the causal pathways and identify any unexpected consequences (Bonell *et al.*, 2012). There are two main theories for evaluating the mechanisms of impact of an intervention as described in the MRC report: theory-based evaluation (Weiss, 1997) and realistic (or realist) evaluation (Pawson and Tilley, 1997).

Theory-based evaluation attempts to examine how hypothesised causal pathways develop in practice. This allows for data to be gathered about the stages at which the causal pathways might break down or have been implemented unsuccessfully (Weiss, 1997). Hence, theory-based evaluation may focus on the mechanisms through which intervention events produce change ('intervention theory'), how successful implementation is achieved ('implementation theory') or a combination of the two. Similar to theory-based evaluation, realist evaluations places change mechanisms at the core of assessment. However, where it differs to theory-based evaluation is that it emphasises interventions as working by introducing mechanisms that are suited to their particular context in order to produce change (Pawson and Tilley, 1997). Thus, evaluation aims to uncover context-mechanism-outcome structures, which is known as the 'realist evaluation cycle'. This is an approach which is useful in understanding how intended outcomes are achieved and how unexpected consequences emerge. However, realist evaluations somewhat conflict with RCT designs as the configurational analysis of realist evaluations demands an identification of the dynamic interplay between intervention, actors, context, mechanisms, and outcomes whereas an RCT design is somewhat limited in unpacking this. The process evaluation conducted in this thesis, therefore, takes a more 'critical realist' approach to assessment, which is concerned with real systems and real people whilst also treating the services involved as holistic. Critical realism views the study findings as very real but complex with interacting phenomena between individuals and external factors thus providing a basis to describe how and why a complex intervention did or did not work (Byng, Norman and Redfern, 2005).

1.4.3.2.1 Mediators

Part of MRC guidance for conducting an analysis of impact is to assess the extent to which the causal assumptions underpinning the intervention can be tested through mediation. Mediator analysis refers to the examination of the mechanisms into an intervention's theory of change. This means extending the fundamental assumptions from 'if intervention A is implemented then B will occur' to 'if intervention A is implemented, this will lead to a change in the mediating variable or variables, which will lead to a change in outcome B' (Figure 4) (Baron and Kenny, 1986). For example, in the ORBIT intervention, it could be hypothesised that high levels of satisfaction with the intervention lead to better outcomes in tic severity change for the child. Mediator analysis is useful as it can uncover *how* an intervention produces change and mediators generally occur *during* treatment.

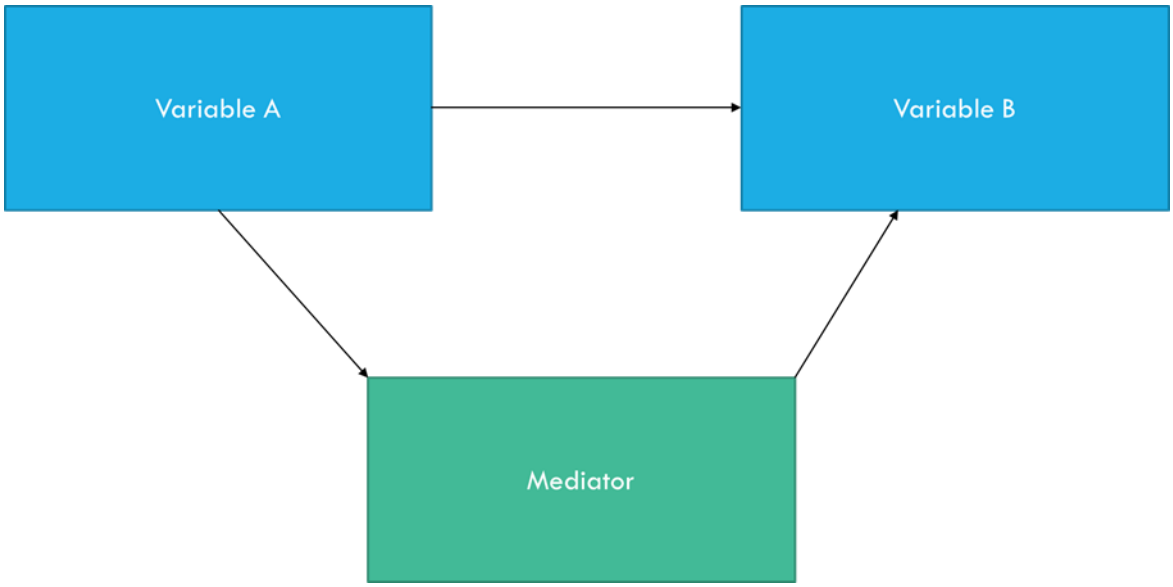

Figure 4. Diagram of a basic mediator model

Mediation is generally introduced when there is a strong relationship between the independent and the dependent variables (Baron and Kenny, 1986). Although modern mediator analysis does not demand that there is a

relationship between the independent and dependent variable, as there can be an 'indirect effect' of the mediator (Agler and De Boeck, 2017).

1.4.3.2.2 Moderators

Evaluation theorists argue the need to move beyond simply viewing contextual factors as moderators of implementation to also viewing them as moderating outcomes (Pawson and Tilley, 1997). Thus, there is an overlap between moderators and contextual factors. Moderator analysis typically involves assessing *who* benefits from an intervention and a moderator generally *precedes* treatment (Figure 5). This involves an assessment of any pre-existing characteristics of the sample which may predict who will gain the most from an intervention. For example, in the ORBIT intervention, it may be that age is a potential moderator and that younger children have more positive outcomes. Moderators are typically presented when there is an unexpectedly weak or inconsistent relationship between an independent and a dependent variable (e.g. an effect is observed for one subgroup but not for another). In the ORBIT trial, child and parent participants as well as therapists' background, beliefs, and circumstances may have dictated the way in which they interacted with the intervention. Thus, it is important to the evaluation of an intervention to pursue contextual factors and moderation configurations in order to understand potential variability in outcomes. Understanding context is therefore pertinent in interpreting the findings of the ORBIT intervention and generalising beyond it.

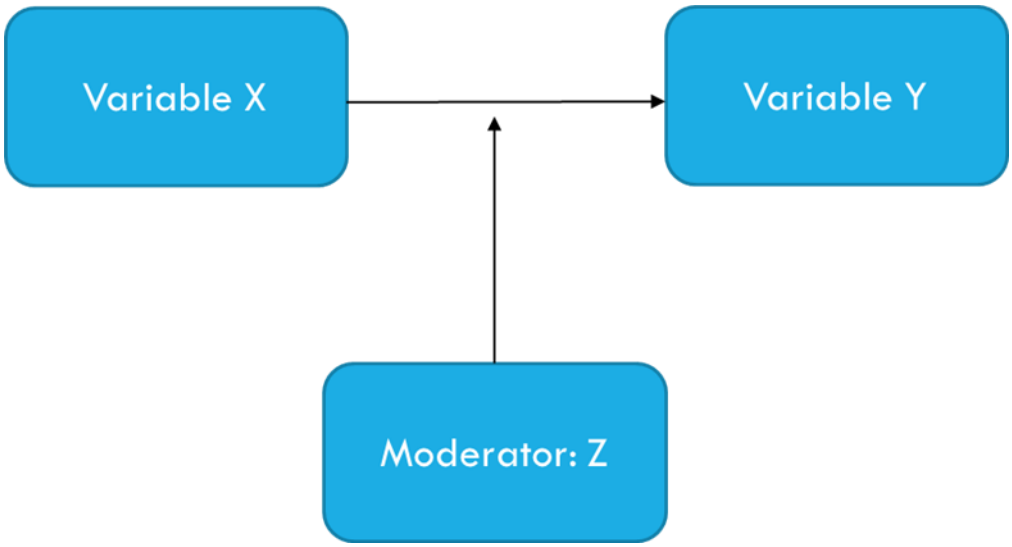

Figure 5. Diagram of a basic moderator model

Overall, mediator and moderator analyses are key to understanding how and for whom an intervention does or does not work, which allows for an identification of 'essential ingredients'. This will ensure that an intervention is implemented on a wider scale with only the essential components being delivered and targeted at the people who will benefit most.

1.4.3.2.3 Unintended pathways and consequences

Earlier frameworks of process evaluations of complex interventions did not include capturing unintended or unanticipated consequences. This was rectified in the updated MRC guidelines (Moore *et al.*, 2015a) based on the recommendations of Grant *et al*. (2013). Grant *et al*. (2013) emphasised the need for process evaluations to systematically identify and quantify unexpected unintended outcomes. They outlined that all interventions have the potential to cause unintended consequences, which can be beneficial or harmful to the participants and that these must be measured. For example, within pharmacological trials it is common practice to measure potential side effects that may harm the patient. For complex interventions, such as ORBIT, potential unintended consequences may be anticipated, however

there will also be those that are unanticipated thus it is crucial to capture these using both quantitative and qualitative methods.

1.4.3.3 Context

The final component is context, which refers to any factors external to the intervention that may have acted as a barrier or facilitator to the way it is implemented or to the outcomes. As mentioned, the uptake and use of DHIs is largely dependent on context, thus understanding context is crucial in interpreting the findings and making generalisations beyond it. In conclusion, a process evaluation of a complex intervention such as ORBIT is crucial to explaining trial outcomes and will aid in understanding its overall implementation.

1.5 Summary and thesis outline

Digital health technologies are a promising method for delivering evidence based therapeutic interventions to CYP with a range of conditions including NDDs. Tics are a common and distressing symptom for children and often co-occur with other NDDs. Although behavioural therapies are effective for CYP with tic disorders, access is limited due to various barriers thus a therapist supported, parent aided online intervention called ORBIT was developed which was evaluated in a RCT design. An RCT is considered the "gold standard" for evaluating effectiveness but despite the economic and clinical advantages of effective DHIs, there are significant barriers to adopting them into routine clinical practice. There is a need to break down these barriers by understanding not only whether they work in the context of a randomised trial but also how they work, for whom, and in what circumstances are they most effective.

Therefore, the first study aims to review the evidence for the effectiveness of online interventions for CYP with NDDs and identify the main components of effective interventions by conducting a systematic review

and meta-analysis (Chapter 2). In order to understand more clearly how effective DHIs might work in clinical practice a further aim is to design a process evaluation to understand how they work, under what circumstances, and for whom in particular. Thus, Chapter 3 outlines the process evaluation methodology. The success of any remotely delivered therapy for CYP hinges particularly on whether it was delivered with fidelity and the extent to which users engage with the technology and so the second study aims to assess the quality of what was delivered and to explore the level of uptake and factors influencing engagement (Chapter 4). The third study aims to evaluate the impact of ORBIT on tic severity and the potential mechanisms for that impact (Chapter 5). The final chapter of this thesis aims to summarise the overall findings from all of the studies in order to make recommendations for the implementation of ORBIT into routine clinical practice (Chapter 6).

Chapter 2: The effectiveness of online interventions delivered to children and young people with neurodevelopmental disorders: a systematic review and meta-analysis

Khan, K., Hall, C., Davies, E., Hollis, C., and Glazebrook, C. (2019). The Effectiveness of Web-Based Interventions Delivered to Children and Young People With Neurodevelopmental Disorders: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research*, 21(11):e13478 https://www.jmir.org/2019/11/e13478/

2.1 Abstract

Background: The prevalence of certain neurodevelopmental disorders (NDDs), specifically autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD), has been increasing over the last four decades. Non-pharmacological interventions are available which can improve outcomes and reduce associated symptoms such as anxiety, but these are often difficult to access. Children and young people (CYP) are using the internet and digital technology at higher rates than any other demographic, but although online interventions have potential to improve health outcomes in CYP with long-term conditions, no previous reviews have investigated the effectiveness of online intervention delivered to CYP with NDDs.

Objective: To review the effectiveness of randomised controlled trials (RCTs) of online interventions delivered to CYP with NDDs.

Methods: Six databases and one trial register were searched in August-September 2018. RCTs were included if they were published in a peer-reviewed journal. Interventions were included if they (1) aimed to improve the diagnostic symptomology of the targeted NDD and/or associated psychological symptoms as measured by a valid and reliable outcome measure, (2) delivered online, (3) targeted at a youth population (age ≤18

years old or studies that reported a mean age of ≤18 years old) with a diagnosis or suspected diagnosis of an NDD. Methodological quality was rated using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for RCTs.

Results: Of 5140 studies retrieved, 10 fulfilled inclusion criteria. Half of the interventions were delivered to CYP with autism spectrum disorders (ASD) with the other five targeting attention-deficit/hyperactivity disorder (ADHD), tic disorders, dyscalculia, and specific learning disorder. Six of the ten trials found that the online intervention was effective in improving condition-specific outcomes or reducing comorbid psychological symptoms in CYP. The four trials that failed to find an effect were all delivered by apps. The meta-analysis was conducted on five of the trials and did not show a significant effect, with a high level of heterogeneity detected (n = 182, 5 RCTs, pooled standardised mean difference (SMD) -0.39, CI [-0.98, 0.20], Z = -1.29, p = .19 (I^2 = 72%, p = .006).

Conclusions: Online interventions can be effective in reducing symptoms in CYP with NDDs; however, caution should be taken when interpreting these findings due to methodological limitations, the minimal number of papers retrieved, and small samples of included studies. Overall, the number of studies was small and mainly limited to ASD, thus restricting the generalisability of the findings.

2.2 **Introduction**

Online interventions for CYP with physical and psychological problems are relatively new phenomena, with the first trials of internet-delivered therapies being conducted in the late 1990s (Barak, 1999). However, they are a very important development in the access and treatment for CYP with long-term, chronic health conditions. NDDs are a group of disorders that typically manifest early in development and are characterised by deficits in cognitive function, motor function, verbal communication, social skills and behaviours (Ahn and Hwang, 2017). Common NDDs include ASD, ADHD, specific learning disorder (including dyscalculia and dyslexia), intellectual disability (ID) and tic disorders including TS and CTD (American Psychiatric Association, 2013). NDDs frequently co-occur; for example, individuals with ASD often have IDs, and many children with ADHD have a specific learning disorder (American Psychiatric Association, 2013). CYP with NDDs also have complex comorbidities and related symptoms, such as depression and anxiety (King, 2016). There is growing evidence that the impact of NDDs are lifelong for many individuals (Kirby, 2018) and, although exact prevalence rates of NDDs vary considerably between countries, researchers suggest that the prevalence of certain NDDs, specifically ASD and ADHD, has been increasing over the last four decades (Rutter, 2005; Grandjean and Landrigan, 2006; McCarthy *et al.*, 2012).

Psychological therapeutic interventions exist for a range of NDDs. These include therapies to manage NDD symptoms, such as HRT for tic disorders; behavioural therapy to alleviate common associated symptoms, such as CBT for anxiety symptoms; and psychoeducation to facilitate the management of NDDs. Due to their complexity and chronic nature, pharmacotherapy may often be used as part of a treatment plan (Homberg *et al.*, 2016). However, pharmacological interventions are considered

undesirable for children due to the associated side effects (Whittington *et al.*, 2016) therefore psychological treatment is more desirable. A major barrier to psychological treatment is difficulty accessing appropriately trained therapists, due to the limited numbers of therapists in child mental health services relative to demand and uneven geographical distribution of services. It is likely that online therapy can help increase the availability and uptake of evidence-based interventions, offering the opportunity to deliver less therapist-intensive but effective interventions over long distances. Given that online technology is a ubiquitous part of everyday life and young people are by far the highest users (Pew Research Center, 2018), online delivered therapy is intuitively attractive for CYP.

Online interventions are self-guided or therapist-assisted programs with the aim of improving knowledge, providing support, care, or treatment to a diverse population with a range of health problems. In the field of psychological and neurodevelopmental health, online therapeutic interventions have been designed for CYP with a range of problems including ADHD (Dovis *et al.*, 2015), anxiety (Spence *et al.*, 2011), depression (Whittaker *et al.*, 2012), and OCD (Lenhard *et al.*, 2017). These interventions all differ in the type of therapy delivered, their level of participant interaction with the program, number of sessions (dosage), level of trained expert support, structure, modality, and whether there is a parent component or not. However, little is known about what characteristics are integral to efficacious online interventions, especially for CYP. There is some literature in adult populations to suggest that guided online interventions are more efficacious than self-guided or unguided interventions (Baumeister *et al.*, 2014) and the most effective interventions tend to be individualised to the user and more intensive (Rogers *et al.*, 2017). In order to improve the future developments of

online interventions, it would be beneficial to synthesise the evidence for characteristics of effective interventions in CYP to minimise the risk of developing inadequate and ineffective interventions.

A preliminary search conducted in PROSPERO, the Cochrane Database of Systematic Reviews, and the Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports indicated that there are no systematic reviews in progress or already published on CYP with NDDs[1].

The objective of this review is to evaluate the effectiveness of online interventions for CYP with NDDs and conduct a meta-analysis of the most effective intervention characteristics (e.g. therapist supported vs. stand-alone) with the aim of informing the future development of technologies. The findings will also be useful to healthcare providers, commissioners, and clinicians in informing future clinical developments in the delivery of care.

2.3 **Methods**

The systematic review was registered on PROSPERO (registration number: CRD42018108824) and conducted in accordance with the Joanna Briggs Institute (JBI) methodology for systematic reviews of effectiveness evidence.

2.3.1 ***Search strategy***

An initial limited scoping search of MEDLINE was undertaken to identify relevant articles. The text words contained in the titles and abstracts of relevant articles, and the index and Medical Subject Headings (MeSH) terms describing the articles were used to develop a full search strategy, which was then tailored for each included information source (see Appendix

[1] Correct as of September 2018

B for full search strategy). Search terms related to neurodevelopmental disorders, online/internet interventions, and adolescence.

Six electronic databases — including PsychINFO, PubMed, Embase, Central, Web of Science, and Medline — were searched in August-September 2018. One trial register (clinicaltrial.gov) was also searched. The reference list of all studies selected for critical appraisal was screened for additional studies and several specialised journals, publisher websites, and published reviews were hand-searched. As online interventions are a recent development and older interventions will now be obsolete, the year of publication was limited to the year 2000 to 5th September 2018. There were no restrictions on the language of publication.

Studies were included if they met the following criteria:

1. The intervention aimed to improve the diagnostic symptomology of the targeted neurodevelopmental disorder as measured by a valid and reliable outcome measure.
2. The intervention was delivered online via a website, mobile application ("app"), social media, email, or personal digital assistant. The intervention could include human support in its delivery.
3. The study was an RCT design and published in a peer-reviewed journal. Trial arms needed to consist of an experimental group compared to no treatment and/or another active intervention or treatment as usual (TAU) or waitlist control.
4. The intervention was targeted at a youth population (age ≤18 years old or studies that reported a mean age of ≤18 years old) with a diagnosis or suspected diagnosis of the following neurodevelopmental disorders:

- communication disorders (e.g. language disorder, stuttering)

- autism spectrum disorder (ASD)
- attention-deficit/hyperactivity disorder (ADHD)
- specific learning disorder (e.g. dyslexia, dyscalculia)
- motor disorders
- tic disorders
- Other neurodevelopmental disorders (e.g. neurodevelopmental disorder associated with prenatal alcohol exposure)

These disorders were selected based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria (American Psychiatric Association, 2013).

Secondary outcomes of interest were comorbid and/or associated psychological symptomology and any adverse events. Papers had to report on either primary or secondary outcomes of interest in order to be included in this review. Studies were excluded if: the intervention was not delivered online or was primarily aimed at the parent or caregiver. Furthermore, studies were excluded where the participants were diagnosed with IDs, as intervention characteristics that meet the needs of children with significant IDs would be difficult to generalise to a youth population as a whole. Moreover, studies on NDDs frequently exclude CYP with any form of learning difficulty due to their unique complexity (Bishop, 2010).

Once duplicates were removed (N = 2,142), a total of 5,140 titles and abstracts were retrieved. Titles were initially screened against the eligibility criteria by one assessor (screening phase, N = 4,985 ineligible). Subsequently, 155 titles and abstracts were then screened against the eligibility criteria by two independent assessors (CLH and EBD). Any conflicts concerning eligibility were resolved by group discussion. There was agreement on seven papers to be included, 121 to be excluded, and

27 papers requiring further discussion. Following discussion between the assessors, the full text of 19 papers was obtained for further analysis and coding. A consensus was reached between the assessors on nine papers to be excluded, as they did not meet eligibility criteria, leaving 10 papers for analysis. Figure 6 shows the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow chart (Moher *et al.*, 2009).

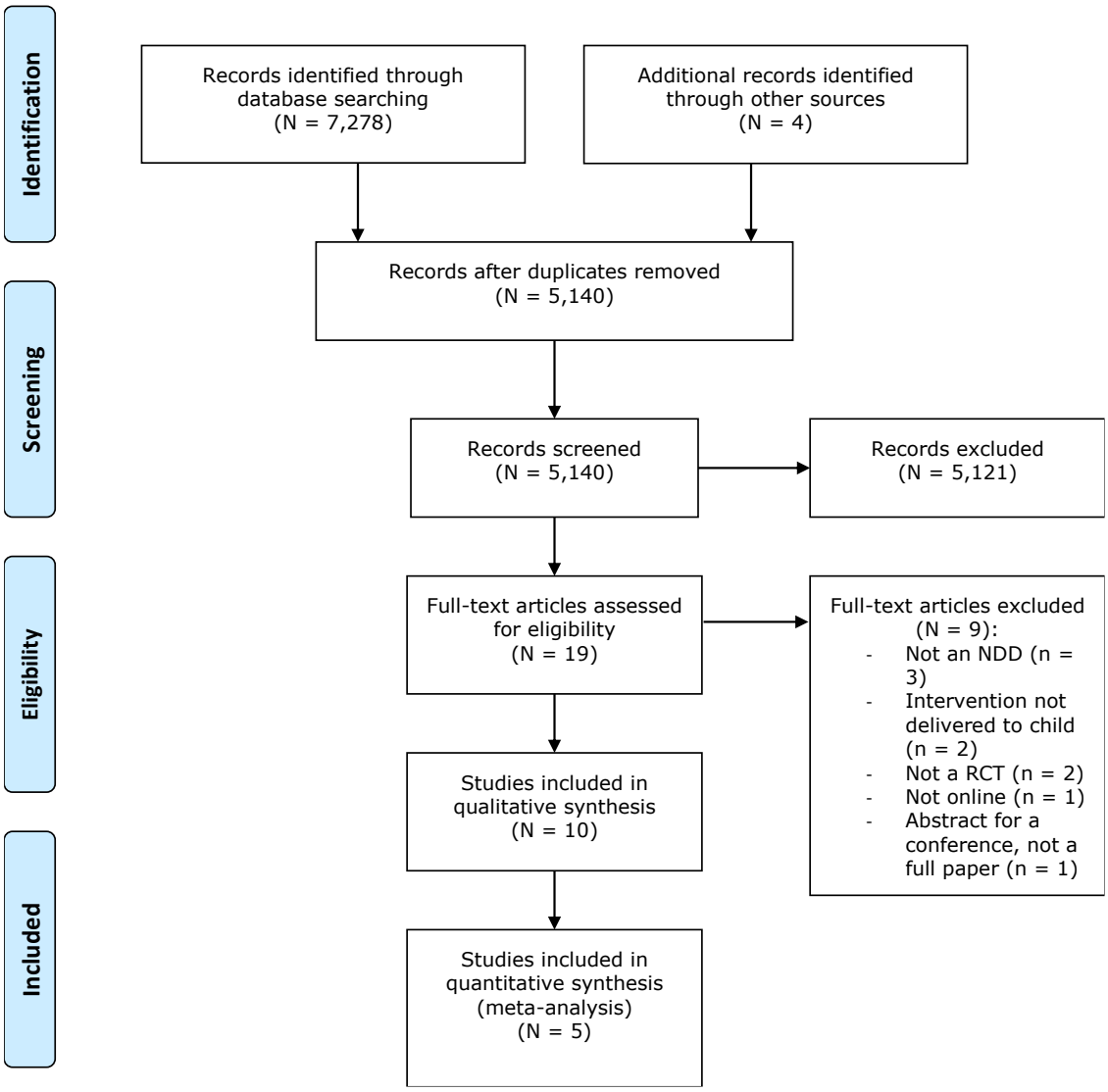

Figure 6. PRISMA flowchart outlining the process for systematic review and meta-analysis

2.3.2 ***Data extraction***

The first assessor (KK) extracted the following data from all included studies: specific details about the study (authors, year, number of study arms, location and online program name), population demographics (N, age, gender), study methods, interventions and comparisons, length of treatment/dosage, condition treated (e.g. ASD, ADHD etc.), outcome measures, type of analysis (e.g. intention-to-treat) and primary and

secondary outcomes of significance to the review. This data was extracted and inputted into JBI SUMARI software (JBI-SUMARI, 2016). Missing data were obtained from the manuscripts and, where this was not documented, the primary authors were contacted for relevant information.

2.3.3 *Assessment of methodological quality*

Two independent assessors (CLH and EBD) examined the methodological quality of included studies using the JBI RCT appraisal tool in JBI SUMARI. This tool includes 13 questions, which aid in the understanding of trial quality by assessing study bias across the following domains: random sequence generation, allocation concealment, blinding, incomplete follow-up data, selective reporting, and the reliability of outcomes measures, appropriateness of statistical analysis utilised, and appropriateness of trial design to the particular study. Blinding is further divided into 'blinding of participants', 'blinding of those delivering treatment' and 'blinding of outcome assessors.' Criteria were scored as being 'met', 'not met', 'unclear' or 'not applicable' by the two assessors independently, with any disagreements being discussed or, where necessary, a third assessor was consulted. By using the JBI RCT appraisal tool instead of the Cochrane Risk of Bias Tool was a deviation from the protocol for this review. The reason for this deviation was that the JBI RCT appraisal tool is more comprehensive and for reasons of consistency in using JBI methodology throughout this review.

2.3.4 *Meta-analysis*

Continuous variables were examined using standardised mean differences (SMD) with 95% confidence intervals (CI). Extracted continuous data were tested for normality using skew plots. Random effects meta-analyses were performed to compute overall estimates of treatment outcomes. The effect sizes of the primary studies are presented in a forest plot. Heterogeneity

was examined with the I^2 statistic (Higgins and Thompson, 2002). The I^2 statistic calculates the degree to which there is heterogeneity, with 25% suggesting low heterogeneity, 50% indicating moderate, and 75% is the threshold for high heterogeneity. The *Q* statistic was also calculated and provides the statistical significance (*p*-value <0.05) of heterogeneity.

In the protocol, subgroup analyses were planned to be conducted according to the main intervention characteristics that were shown to be most effective, for example, therapist support vs no support, parent component vs no parent component and so on. However, due to the low number of included studies in the review, this was deemed unsuitable and is therefore a deviation from the protocol. All data for the meta-analysis were conducted using JBI SUMARI.

2.4 Results

2.4.1 *Study characteristics*[2]

The search generated 10 studies. Five interventions targeted ASD [1-5], two were aimed at CYP with TD [6, 7], one for ADHD [8], one for specific LD with poor visual-motor integration (VMI) [9], and the other targeting dyscalculia [10]. All but one of the interventions focussed on treating the primary diagnosis with the other focussing on treating comorbid anxiety [1]. All studies used the standard RCT design, except for one study, which employed a crossover RCT design [8].

In five studies, NDD diagnosis was confirmed by DSM-IV or DSM-5 criteria [2, 4-6, 8] with the other studies using disorder-specific diagnostic tools [1, 3, 9, 10]. All 10 studies contained two trial arms with the intervention being compared to another active intervention, which was not online [6, 9,

[2] For the purposes of clarity, the 10 included studies will be cited using bracketed, numbered referencing in the 'Results' section only. Each number corresponds with a citation presented in Tables 5-7.

10], TAU, which was either standard therapy or participants were not prevented from using therapy however they were told not to use any apps designed for ASD therapeutic use [2, 5, 8], or waitlist control [1, 3, 4, 7]. A summary of the characteristics of each study is shown in Table 6.

Table 6. Characteristics of included studies

[citation number] Study	**Design, number of arms (N per arm), sample size and study location**	**Sample demographics and condition treated**	**Control/comparator group**	**Outcome measures**	**Summary of main findings/Effect of intervention**
[1] Conaughton et al., 2017	RCT 2 arms: Intervention (21), control group (21), N = 42, Australia	Children (8-12 yrs old, *M* = 9.74, 85.7% male) with HFASD and an anxiety disorder	WLC	ADIS–C/P, CGAS, CBCL, SCAS-C, satisfaction with treatment	9.5% of the intervention group vs. 0% of the WLC group had lost all anxiety diagnoses at post-assessment, with 14.3% of the intervention group being free of all anxiety diagnoses at 3-month follow-up. The intervention had a positive effect (*d* = −.39)

[2] Esposito et al., 2017	RCT 2 arms: Intervention (15), control group (15), N = 30, Europe	Children (2-5 yrs old, *M* = 3.92, 90% male) with ASD who followed face-to-face ABA treatment	TAU	Measured attention, imitation of actions with objects, receptive identification of objects	Intervention group, who had daily practice of attention and identification of objects on tablet apps, showed greater progress within standard ABA therapy than the TAU group for all three programs investigated however this did not exceed the significance level (all *p*-values >.05). The intervention had no effect
[3] Fletcher-Watson et al., 2016	RCT 2 arms: Intervention (27), control group (27), N = 54, Europe	Children (<6 yrs old, *M* = 4.13, 79.6% male) with ASD	WLC	ADOS, BOSCC, MCDI, CSBS-DP, parent impressions of the app	Change scores on all outcomes measures revealed no significant differences between intervention and WLC groups (all *p*-values >.05). The intervention had no effect

[4] Fridenson-Hayo et al., 2017	RCT 2 arms: Intervention (43), control group (40), N = 83, Europe	Children (6-9 yrs old, *M* = 7.29, 79.5% male) with ASD	WLC	ER tasks, WISC-IV or WPPSI-3, SRS-2, VABS-II	Pairwise comparisons for the time by group interaction revealed that significant improvement over time was found on all ER tasks for the intervention group (Face: Mean difference = 2.17, S.E. = .56, *p*<.001; Voice: Mean difference = 2.19, S.E. = .59, *p*<.001; Body: Mean difference = 4.63, S.E. = .64, *p*<.001; Integrative: Mean difference = 1.83, S.E. = .56, *p*<.01), but not for the WLC group. The intervention had a positive effect
[5] Whitehouse et al., 2017	RCT 2 arms: Intervention (41), control group (39), N = 80, Australia	Children (<4 yrs old, *M* = 3.32, 78.7% male) with ASD	TAU	ATEC, MSEL, VABS-II, MCDI, CSBS, RBS-R, BFRSR	No significant differences were observed between groups for any of the four ATEC subscales at either the 3- or 6-month assessments, although the 3-month Communication subscale showed a trend towards greater improvement in the intervention group, 2.1 units (95% CI: [4.5, 0.3], *p* = .08). The intervention had no effect

[6] Himle et al., 2012	RCT 2 arms: Intervention (10), comparator group (10), N = 20, North America	Children (8-17 yrs old, *M* = 11.6, 94% male) with TD or CTD	Face-to-face CBIT	YGTSS, CGI-I, PTQ, TAQ	The videoconferencing group showed a mean YGTSS reduction of 6.4 points vs. 4.2 points for the face-to-face group at follow-up. Both interventions were effective in reducing tics (*ES* = .42) however there was a slightly better effect on the intervention group at both post-treatment and follow-up compared to the face-to-face group.
[7] Ricketts et al., 2016	RCT 2 arms: Intervention (12), control group (8), N = 20, North America	Children (8-16 yrs old, *M* = 12.16, 64.9% male) with TD or CTD	WLC	YGTSS, CGI-I, PTQ, CPTR, CSQ, TAQ, VSQ	In the intervention group, there was a statistically significant decrease of 7.25 points in YGTSS total scores from baseline to post-assessment (*d* = .90). In the WLC group, the 1.75-point decrease on the YGTSS total scores from baseline to post-assessment was not significant. The intervention had a positive effect

[8] Bul et al., 2016	Cross-over RCT 2 arms: Intervention (88), comparator group (82), N = 170, Europe	Children (8-12 yrs old, *M* = 9.85, 80.6% male) with ADHD	TAU crossover group	Time management questionnaire, BRIEF (subscale plan/organise), SSRS (subscale cooperation), IATQ, self-efficacy, satisfaction	Intervention group achieved significantly greater improvements on the primary outcome of time management skills compared to TAU crossover group (parent-reported; *d* = .39, *p* = .004) and on secondary outcomes of responsibility (parent-reported; *d* = .04, *p* = .04), and working memory (parent-reported; *d* = .51, *p* = .02). The intervention had a positive effect
[9] Coutinho et al., 2017	RCT 2 arms: Intervention (10), comparator group (10), N = 20, North America	School-aged children (4-7 yrs old, *M* = 6.18, 12 males) with a specific LD such as dyspraxia or speech delay with poor VMI skills	Traditional OT sessions	Beery VMI, M-FUN, intervention appreciation scale	There were some improvements in VMI skills in both groups; however, the finding was not statistically significant. The intervention had no effect

[10] De Castro et al., 2014	RCT 2 arms: Intervention (13), control group (13), N = 26, South America	Primary school children (7-10 yrs old, M=8.11, 16 male) with dyscalculia	Traditional teaching techniques	SPT	The intervention using the virtual environment yielded a significant score improvement (p<.001) with an average score improvement of 5.09 post-test, whereas the CG did not show a statistically significant score improvement (p = .054). The intervention had a positive effect

Note: **Abbreviations:** RCT – randomised controlled trial; TAU – Treatment as usual; ADHD – Attention deficit hyperactivity disorder; ITT – intention-to-treat analysis; WLC – wait-list control; HFASD – High-functioning Autism Spectrum Disorder; CBT – cognitive-behaviour therapy; OT – Occupational Therapy; LD – Learning Disorder; VMI – visual-motor integration; CG – control group; ASD – Autism Spectrum Disorder; ABA – Applied Behaviour Analysis; ER – emotion recognition; CBIT – Comprehensive Behavioural Intervention for Tics; TD – Tic Disorders; CTD – Chronic Tic Disorders

Outcome measures: BRIEF – Behaviour Rating Inventory of Executive Function; SSRS – Social Skills Rating System; IATQ – It's About Time Questionnaire; ADIS – Anxiety Disorders Interview Schedule; CGAS – The Children's Global Assessment Scale; CBCL – Child Behaviour Checklist; SCAS-C – Spence Children's Anxiety Scale – child; M-FUN – The Miller function & participation scales; SPT – Scholastic Performance Test; ADOS – The Autism Diagnostic Observation Schedule; BOSCC – Brief observation of social communication change; MCDI – MacArthur Communicative Development Inventory; CSBS-DP – Communication and Symbolic Behaviour Scales – Developmental Profile; WISC-IV – Wechsler Intelligence Scale for Children; WPPSI-3 – Wechsler Primary and Preschool Scale of Intelligence; SRS-2 – Social Responsiveness Scale; VABS-II – Vineland Adaptive Behaviour Scales; YGTSS – Yale Global Tic Severity Scale; CGI-I – Clinical Global Impression-Improvement Scale; PTQ – Parent Tic Questionnaire; TAQ – Treatment Acceptability Questionnaire; CPTR – Children's Perception of Therapeutic Relationship; CSQ – Client Satisfaction Questionnaire; VSQ – Videoconferencing Satisfaction Questionnaire; ATEC – The Autism Treatment Evaluation Checklist; MSEL – The

Mullen Scales of Early Learning; RBS-R – Repetitive Behaviour Scale-Revised; BFRS-R – Behaviour Flexibility Rating Scale

2.4.2 *Modality, location, and duration of intervention*

Four interventions were delivered via apps [2, 3, 5, 9], two were serious games [4, 8], two used videoconferencing [6, 7], one was a virtual environment with playable games [10], and the other was an online CBT intervention [1]. The majority of the interventions were accessed from participants own homes, except three studies where participants were based in a rehabilitation centre [9], school [10] and hospital or clinic setting [6]. Interventions either had a varying range of components (i.e. tasks to be completed) — two [3, 8], three [2], and four [4, 5] components respectively — or sessions, ranging from eight [6, 7] to ten [1, 9, 10] sessions. All trials instructed participants on an optimum length of time to access the intervention: ranging from five minutes per day or ten minutes every other day [3], twenty minutes daily [5] and 30 minutes per day [2], to approximately two hours per week [4], one 60-minute session per week [1], two 40-minute sessions per week [9], 60 minutes twice per week [10], and 65 minutes three times per week [8]. The two trials comparing online CBIT for tics stated that participants received six weekly sessions followed by two bi-weekly sessions [6] and two 1.5-hour sessions followed by six 1-hour sessions [7] respectively. The intervention delivery period ranged from four [2] to 24 weeks [5], with a median length of ten weeks.

A summary of the characteristics of each intervention is shown in Table 7.

Table 7. Characteristics of interventions

[citation number] Study	Intervention, modality, and aim of the intervention	Length/dosage, follow-ups	Therapist Supported	Parent component
[1] Conaughton et al., 2017	Internet trans diagnostic cognitive-behavioural intervention aimed at improving comorbid anxiety symptoms	10 weeks, 10 sessions - one 60-minute session per week	Yes	Yes
[2] Esposito et al., 2017	Tablet apps aimed at improving attention and identification of objects	4 weeks, 3 app components - 30 minutes daily	Yes	Yes
[3] Fletcher-Watson et al., 2016	iPad app aimed to improve social communication skills	2-months, 2 parts - five minutes per day, or ten minutes every other day	No	No
[4] Fridenson-Hayo et al., 2017	An internet-based serious game aimed at improving emotion recognition	8–12 weeks, 4 components - 2 hours per week	No	Yes
[5] Whitehouse et al., 2017	iPad app aimed at improving developmental skills relevant to autism	6 months, 4 components - 20 mins per day	No	Yes
[6] Himle et al., 2012	Internet-accessed Videoconference aimed at improving tic severity	10 weeks - 6 weekly sessions followed by 2 bi-weekly sessions	Yes	Yes
[7] Ricketts et al., 2016	Internet-accessed Videoconference (Skype) aimed at improving tic severity	10 weeks - two 1.5-hour sessions followed by six 1-hour sessions	Yes	Yes

[8] Bul et al., 2016	An internet-based serious game aimed at improving time management and planning skills	10 weeks, 2 game components - 65 minutes approximately 3 times per week	No	No
[9] Coutinho et al., 2017	Multiple iPad apps aimed at improving visual motor skills	10 weeks, min of 8 and max of 12 sessions - two 40-min sessions per week	No	No
[10] De Castro et al., 2014	Internet accessed virtual environment aimed at improving mathematical skills	5 weeks, 10 sessions - 60 minutes twice a week	No	No

2.4.3 ***Use of human and technical support***

Four interventions were therapist assisted [1, 2, 6, 7]; however, these all differed in the level of involvement of the therapist within the interventions. The contacts ranged from once weekly contact [1], two hours per week [2] and the two trials of CBIT were exclusively therapist-delivered [6, 7].

One of the major factors that developers need to consider when creating an online intervention is the ease with which non-technologically advanced individuals can access and use the program. Thus, it is crucial to provide technical support, as and when needed. Seven of the ten included studies reported the use of technical support. In two trials [1, 7], participants had weekly access to a therapist, who was able to offer any technical assistance within the sessions. One trial [9] took place within a rehabilitation centre with an occupational therapist (OT) constantly present to offer any assistance. Two trials reported the use of monitoring phone calls from research personnel to check for any issues, which were offered either fortnightly [5] or once a week [4]. In both of these trials, parents

were also encouraged to contact research staff with any queries or issues in between monitoring calls. In one trial [6] research personnel were available to manage any technical difficulties. In the other trial [2] parents were fully trained in the apps by research staff and taught how to handle technical difficulties.

2.4.4 *Participant characteristics*

A total of 545 participants consented and were randomised to a trial arm. Sample sizes ranged from 20 [6, 7, 9] to 170 [8] participants. Four trials had sample sizes of >50 participants [3-5, 8]. Overall, 523 participants were explicitly included in analyses. Five studies stated analysis was conducted on participants who completed pre-post intervention measures only [2, 4, 6, 9, 10], whilst five conducted intention-to-treat (ITT) analyses [1, 3, 5, 7, 8]. All ten trials reported participant dropout/withdrawal data, with dropout rates ranging from 0% [2, 7, 10] to 18% (N = 31) of the sample [8]. Reasons for participant withdrawal included lack of motivation or disinterest [4, 8], lack of enjoyment with the intervention [3, 5], and personal reasons [5].

In the ten trials, participants ranged in age from two to 17 years, with a mean age ranging from 3.32 to 12.16 years. Males were the majority in all studies, with gender balance varying from 62.5% [10] to 94% [6] of the sample being male. Four trials were conducted in Europe [2-4, 8], three in North America [6, 7, 9], two in Australia [1, 5], and one used participants from South America [10].

2.4.5 *Provider characteristics*

The majority of trials recruited participants from clinics [1-4, 8], with three studies [4, 5, 7] recruiting via advertisements, and one study [7] recruiting participants through solicitations mailed to health care professionals. One study [5] recruited participants through referrals from diagnosing

clinicians, and another study [1] utilised referrals through general practitioners, mental health professionals, school guidance officers, teachers, parents, and media publicity.

2.4.6 *Adverse events and outcome measures*

Only one study [8] explicitly stated they recorded and reported adverse events. The crossover trial investigating the effects of a serious game as an adjunct to TAU for children with ADHD reported ten adverse events in the trial that could be related to the intervention, which parents, teachers, or participants themselves reported. Adverse events were registered as mild (n = 5) or moderate (n = 5) in severity and examples included pain in the fingers, irritability, and headache. One participant could not concentrate at school and therefore discontinued from the trial due to this adverse event; however, no serious adverse events were reported.

Response burden refers to the extent to which participants are strained by completing measures, such as the length and intensity of the outcome measure. RCTs, in particular, must consider this, as participants typically complete measures at multiple time-points, which may result in large attrition rates. The calculated number of items participants completed was through totalling the approximated number of items within administered measures in the included studies.

It was estimated the outcome measurement battery ranged from 16 [3] to 175 items [5] at each time point of the studies. The estimated median number of questions administered to participants was 56 items. All studies administered outcome measures at baseline and post-treatment, one study [5], also had a mid-point follow-up and four studies had follow-up points at three [1], four [6], five [8], and six [3] months. A variety of measures was employed to assess outcomes. The majority of trials administered a combination of clinician, self and parent report measures — one study [8]

utilised a teacher report measure as well — which were administered either through hard copies or through online access. In all but two studies, measures used were standardised measurements, except one study [10], which employed a standardised arithmetic test specific to Brazilian schools, and another study [2], which gave children specific targets to achieve within the app.

2.4.7 *Methodological quality and risk of bias*

The JBI Critical Appraisal Checklist for RCTs provided a framework for scoring the quality of the included studies by addressing different aspects of the research such as randomisation, allocation concealment, blinding, and follow-up data. The methodological quality of included studies was felt to be moderate, mostly due to trials providing insufficient details or being unclear in their reporting (see Table 8). Only five of the ten studies reported their randomisation methodology [1, 3, 7-9]. Blinding was the main issue of quality in included studies. Six trials stated that participants were not blind to treatment assignment with the other four trials being unclear in their reporting. Only one study [2] reported those delivering treatments were blind to treatment assignment with the others stating researchers delivering treatment were either not blinded or it was unclear. Half of the trials [1-3, 5, 6] reported outcome assessors were blind to treatment assignment with all of these studies employing independent researchers to carry out assessments.

Table 8. Critical appraisal of included studies

[citation number] Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
[1] Conaughton et al., 2017	Y	Y	Y	U	N	Y	N	Y	Y	N	Y	Y	Y
[2] Esposito et al., 2017	U	U	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y
[3] Fletcher-Watson et al., 2016	Y	Y	Y	N	U	Y	Y	Y	Y	Y	Y	Y	Y
[4] Fridenson-Hayo	U	U	Y	N	N	U	Y	Y	U	Y	Y	Y	Y

et al., 2017													
[5] Whitehouse et al., 2017	U	U	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
[6] Himle et al., 2012	U	U	Y	N	N	Y	Y	Y	N	Y	Y	Y	Y
[7] Ricketts et al., 2016	Y	U	Y	N	N	U	Y	Y	Y	Y	Y	Y	Y
[8] Bul et al., 2016	Y	N	Y	N	U	U	Y	Y	Y	Y	Y	Y	Y
[9] Coutinho et al., 2017	Y	U	Y	U	U	U	Y	Y	Y	Y	Y	Y	Y
[10] De Castro	U	U	Y	U	U	U	Y	Y	U	Y	Y	Y	Y

et al., 2014													
% Met	50	20	100	0	10	50	90	100	70	90	100	100	100

Y – Yes, N – No, U – Unclear

Criteria for the critical appraisal of RCTs:

Q1 = True randomisation

Q2 = Allocation concealed

Q3 = Treatment groups similar at the baseline

Q4 = Participants blind to treatment

Q5 = Those delivering intervention blind to treatment

Q6 = Outcome assessors blind to treatment

Q7 = Treatment groups treated identically

Q8 = Follow up complete and if not, differences between groups adequately described and analysed

Q9 = Participants analysed in the groups to which they were randomized

Q10 = Outcomes measured in the same way for groups

Q11 = Outcomes measured reliably

Q12 = Appropriate statistical analysis

Q13 = Appropriateness of trial design and any deviations from RCT design accounted for

2.4.8 *Effectiveness of online interventions*

Six of the ten trials found that online interventions were effective in reducing NDD or associated symptoms in CYP [1, 4, 6-8, 10]. Two were serious games, two were delivered by videoconferencing, one was a virtual environment, and the other was an internet-delivered CBT intervention. Targeted NDD conditions of the effective interventions included ASD [1, 4], TD [6, 7], ADHD [8], and dyscalculia [10]. All but two of the effective interventions were delivered over a period of ten weeks and these two were delivered over five weeks with ten sessions [10] and 8-12 weeks with

four components [4]. The four trials, which did not find that online interventions had an effect on NDD symptoms, were all delivered by apps [2, 3, 5, 9]. All but one of these was designed for CYP with ASD, the other being designed for specific LD with VMI [9].

2.4.9 ***Primary outcomes***

Four of the ten interventions in the included studies were aimed at a youth population with ASD; however, just one [4] of these trials found that online interventions were effective. In the study by Fridenson-Hayo et al. [4], children with ASD who received an internet-based serious game improved in ER tasks compared to a WLC who received TAU. Three studies [2, 3, 5] comparing iPad/tablet apps to WLC/TAU groups for children with ASD found no difference in outcome between the groups.

Both studies evaluating the effectiveness of internet delivered CBIT via videoconferencing for young people with TD/CTD showed it could be effective for reducing tic symptomology. Overall, the studies were of similar design but used different comparators with Himle et al. [6] using face-to-face CBIT in their study whereas WLC was utilised in Ricketts et al. [7]. The YGTSS was the main primary measure in both trials.

There were three other studies that looked to improve primary symptoms in CYP, and these were targeted at CYP with NDDs other than ASD or TD. One study showed improvements in time management skills for children with ADHD [8] and another study found improvements in mathematical skills for children with dyscalculia [10]. The other study found no effect in VMI scores [9].

2.4.10 Secondary outcomes

Secondary outcomes of significance were comorbid psychological symptoms targeted and only one of the ten studies aimed to reduce this.

In the study by Conaughton et al. [1], children with HFASD and comorbid anxiety in the completer sample were free of their primary anxiety diagnosis at post-treatment compared to the WLC group (20% vs 0%), with 38.9% of the intervention group being free of their primary anxiety diagnosis at 3-month follow-up. With respect to loss of all anxiety diagnoses, 10% of the intervention group versus 0% of the WLC group had lost all anxiety diagnoses at post-assessment, with 16.7% of the intervention group being free of all anxiety diagnoses at 3-month follow-up.

For the ITT sample, a higher percentage of participants in the intervention group (19%) were free of their primary anxiety diagnosis at post-assessment compared to the WLC group (0%), with 33.3% of the intervention group being free of their primary anxiety diagnosis at 3-month follow-up. With respect to loss of all anxiety diagnoses (for the ITT sample), 9.5% of the intervention group versus 0% of the WLC group had lost all anxiety diagnoses at post-treatment, with 14.3% of the intervention group being free of all anxiety diagnoses at 3-month follow-up.

2.4.11 ***Satisfaction/Acceptability of intervention***

Four trials included participant satisfaction measures [1, 3, 5, 8] and two trials administered participant acceptability questionnaires [6, 7]. In the study by Bul et al. [8], both children and parents reported moderate to high satisfaction with receiving the serious game intervention. In the study by Conaughton et al. [1], children and parents reported moderate levels of satisfaction following treatment. In the study by Fletcher-Watson et al. [3], parents gave verbal comments on the app and what they perceived to be their child's response to it. Replies were categorised as 'Positive, Mixed or Negative' and there were positive responses to questions on overall experience with the app, whether the child and parent liked the app, and

ease of use. In the other study to measure participant satisfaction [5] caregivers of children in the Therapy Outcomes By You (TOBY) intervention group were asked to list up to three features that they liked or disliked about the app. The most frequent 'like' statement related to TOBY providing a helpful therapy-planning tool with new ideas for therapy and activities. Other common statements were that TOBY was easy to use and that the app provided a positive learning experience for their child with an attractive structure and layout. The most common 'dislike' statement was that the offline iPad activities were too time-consuming to prepare. The two trials evaluating videoconferencing administered CBIT [6, 7] gathered acceptability ratings from participants. In both studies, children and parents gave high acceptability ratings for the intervention.

2.4.12 ***Meta-analysis***

In studies that used a valid and reliable outcome measurement of NDD and associated symptoms, a meta-analysis was undertaken. All outcomes were continuous and scale-based and were extracted as end-point average scores with lower scores indicating less severe symptomology. The outcomes combined for the meta-analysis were anxiety [1], social communication [3], developmental skills [5], and tic severity [6, 7]. Negative SMD values support the intervention in the presented analyses. Figure 7 shows the forest plot for the data.

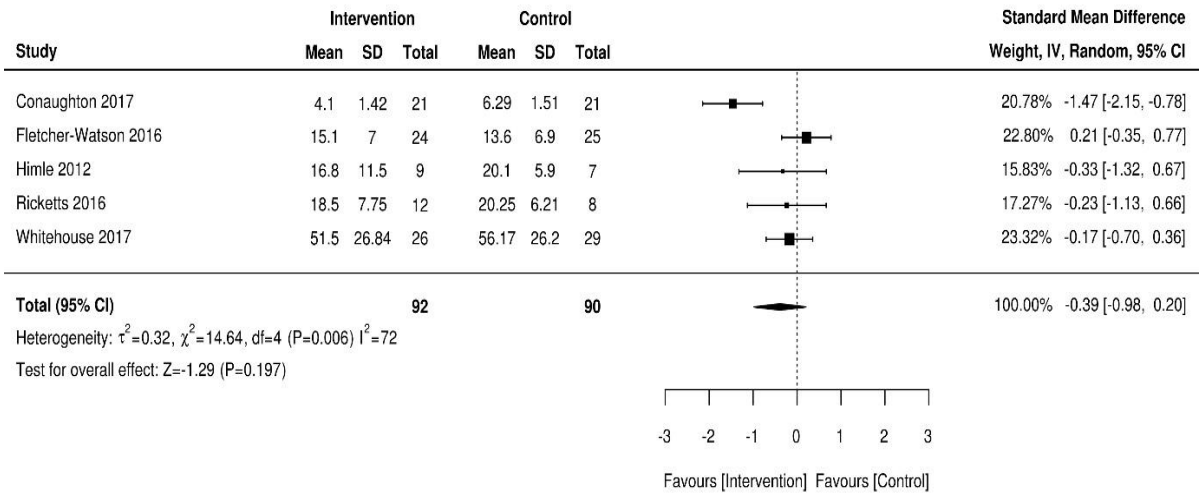

Figure 7. Forest plot of post-intervention NDD outcomes for intervention compared to controls

Five trials investigated the effects of online interventions on NDD symptoms using a valid, standardised outcome measure to explore symptom reduction. Within the five trials, neither intervention nor control was favoured, with a high level of heterogeneity detected: n = 182, 5 RCTs, pooled SMD -0.39, CI [-0.98 to 0.20], Z =-1.29, p = .19 (I^2 = 72%, p = .006).

2.5 Discussion

2.5.1 *Principal findings*

This study set out to evaluate whether RCT evidence showed online interventions were effective for CYP with NDDs and/or associated symptoms. The current review retrieved ten studies in total. A further meta-analysis was conducted on five of the ten studies. The majority of interventions targeted ASD in CYP. Overall, the meta-analysis indicated no difference between the intervention and control groups, however, with six of the ten retrieved papers showing a positive effect, the findings suggest that online interventions can be effective in reducing NDD symptoms in CYP. However, the evidence is inconclusive due to the limited number of

retrieved studies and small sample sizes in included trials. The findings indicate the need for further research in the use of online interventions aimed at CYP with NDDs.

Furthermore, one of the initial aims was to evaluate the main characteristics of effective online interventions. A parent component as an adjunct to the main intervention was utilised in four of the six effective trials, indicating the potential importance of assisted interventions and in line with previous research (Richards and Richardson, 2012; Johansson and Andersson, 2012; Baumeister *et al.*, 2014). Having a parent component within the interventions is unsurprising given the young age of participants in the included studies. It is more likely that younger children will require some form of parental assistance with digitised interventions and, more generally, therapeutic interventions. Indeed, Thirlwall, Cooper, and Creswell (2017) found that younger children showed a greater improvement in anxiety symptoms having received a parent-delivered CBT intervention. From the present review, it is unclear whether a therapist supported online intervention is more efficacious than one without, as only half of the effective interventions were therapist supported. Another important characteristic to consider is the length of the intervention. Five of the six effective interventions were delivered over a period of 10-12 weeks, with the other having ten sessions delivered over five weeks. This suggests that 10-12 weeks/sessions is the optimum length for an online intervention. However, given the high heterogeneity between the online interventions and number of multi-faceted aspects to these interventions in the present review, caution should be taken when trying to establish certain characteristics that may be relevant in determining effectiveness.

All four of the included interventions delivered by apps were unsuccessful in yielding statistically significant outcomes. This suggests apps may not be

a promising platform for delivering therapeutic interventions, at least to CYP with NDDs. Indeed, recent systematic reviews (Payne *et al.*, 2015; Byambasuren *et al.*, 2018), have shown there is inconclusive evidence on the efficacy of mobile apps utilised as health interventions, despite the high user acceptability ratings of smartphone apps. One interpretation of this finding is that because apps are a relatively new phenomenon — the first mobile apps being developed in 2008 with the advent of Apple's App Store (Yoo, 2013) — little is known about their mechanisms of impact, especially in the healthcare domain. There are over 10,000 mental health apps commercially available (Torous *et al.*, 2019), with 52% of smartphone owners using their phones for health purposes and 19% using health apps (Smith, 2012), it is clear more high-quality research needs to be conducted. As three out of the four apps that found no effect were targeted at CYP with ASD, another interpretation of this finding could be that apps are an insufficient modality for producing positive outcomes in autism-related disorders. This corroborates the results of a study conducted by Grynszpan, Martin, and Nadel (2008). They found that adolescents with ASD performed poorly on rich multimedia interfaces, such as apps, as they lacked the required initiative in organising information given within the multimodal sources.

Half of the included interventions were delivered to CYP with ASD and much of the research to date evaluating digital technologies administered to NDDs has focussed on ASD (Bölte *et al.*, 2010; Ploog *et al.*, 2013; Aresti-Bartolome and Garcia-Zapirain, 2014). One possible explanation for this is that computer technology can help compensate verbal and social interaction difficulties and enable facilitation of exchanges between people with ASD, experts, and others (Ramdoss *et al.*, 2011). The vast potential of technology for ASD has been realised by researchers, as technologies can

enable new ways of communicating for people with ASD, socialising, and even learning. Despite this, many studies still lack scientific rigor to allow for concrete support for the use of technology in aiding people with ASD (Ploog *et al.*, 2013). In the present review, two of the five RCTs found online interventions were effective for CYP with ASD and one of these targeted CYP with HFASD who had a comorbid diagnosis of an anxiety disorder.

The RCTs included in this review were assessed as being of acceptable quality for an effectiveness review. However, the main methodological issues centred on the lack of blinding of participants and of those delivering treatment. All studies had a control group, which was either active or inactive, with half of the trials using valid, standardised outcome measures. Most trials had low attrition rates thus improving the overall quality of the included studies. Only one of the ten trials explicitly recorded and reported adverse events (Bul *et al.*, 2016). They reported on ten adverse events that could be related to the intervention however, none were regarded as serious. Insufficient reporting of adverse events in psychological treatments has been documented in the literature (Duggan *et al.*, 2014) and it is clear that future trials should be more explicit in their reporting.

2.5.2 ***Strengths and Limitations***

Some limitations of this review and meta-analysis need to be considered. A major limitation is the minimal number of studies retrieved meaning that any conclusions drawn from this review must be met with caution. In order to provide an expansive overview of the effectiveness of online interventions for CYP, it included trials targeting a myriad of NDDs, which may have equilibrated disorder-specific effects of online interventions. As there were very few RCTs evaluating the effectiveness of online interventions in CYP with NDDs, it would have been impractical to carry out

a review focussing on one NDD only. This review could have increased the number of NDDs by also including trials focussing on CYP with learning disabilities; however, this would have further increased the heterogeneity and added to the problems of generalisability due to the complexity of this particular population. The search was conducted on multiple databases and updated through a repeated search, thus ensuring a comprehensive overview of the topic. A particular strength of the present review was the use of two independent reviewers screening relevant papers, with discrepancies between the reviewers discussed. This ensured a structured, meticulous approach was undertaken in study selection, therefore, improving review quality.

For the meta-analysis, data from five of the ten trials was only included, meaning the pool of data from included interventions was small and limited the overall power. Moreover, there was a high level of statistical heterogeneity detected in the meta-analysis, which may have been due to the types of comparison to the interventions or differences in baseline symptomology (Grist and Cavanagh, 2013). There is mixed literature on whether a meta-analysis should be conducted at all in the event of high heterogeneity; however, experts recommend using the random effects model (Higgins and Thompson, 2002; Higgins and Green, 2011) which is what was conducted in the present review. Finally, a major strength of this review was that it was based on a priori protocol, which decreases the potential for reviewer bias.

When interpreting the findings, some inherent methodological issues of the included studies must also be considered, as methodological flaws of the primary trials can have a considerable impact on the review results. One intrinsic methodological limitation of many therapeutic intervention trials is the lack of blinding of participants and those delivering treatment

(Baumeister, Hutter and Bengel, 2012), thus introducing a high risk of bias. As already mentioned, most of the included trials had very small sample sizes, which makes the generalisation of findings highly problematic. All interventions used different content and modalities of delivery, which could have affected participant interaction and consequently, effectiveness (Gulliver *et al.*, 2012). Another limitation is with the RCT design itself. Given that the most effective interventions are individualised to the user (Rogers *et al.*, 2017), this is often difficult to assess using an RCT design meaning the interventions reviewed mostly fell short on this dimension.

Gender balance was a potential issue of bias in included studies, as the majority of trials had more male participants than female. However, this is not surprising given that NDDs are more common in males than females (Nugent *et al.*, 2018). Baseline symptomology was also a potential source of bias, as this may have caused difficulties comparing intervention effectiveness in improving NDD outcomes. Some trials recruited participants with minimal symptoms, while others recruited those experiencing high levels of NDD symptoms. Despite these limitations, the overall reporting of the included trials was of a high standard and methodologically sound.

2.5.3 ***Implications for practice***

As some of the interventions found positive outcomes, healthcare professionals working with CYP may want to consider utilising online and digital resources to support their patients, especially those with tics. The NHS has already developed IAPT services for young people with mental health problems and are aiming to incorporate this into practice nationwide within the coming years (NHS England, 2016). If successful in reducing the burden on healthcare services and shown to be cost effective, this could

lead to promising new developments for digital resources to be used on other populations. None of the included studies assessed the cost-effectiveness of online interventions, which is likely to be an important consideration for policymakers. All of the efficacious interventions in this review contained an element of human interaction, either with a real person by videoconferencing or a simulated person in a virtual environment or serious game. The best improvement in outcomes, therefore, may be achieved through a combination of online intervention and human support. As technology evolves rapidly, future online interventions will be more dynamic, perhaps including real-time clinician/therapist input and integrated synchronous crisis support. A promising new development is the use of virtual reality, which has had positive results on children with ADHD (Bashiri, Ghazisaeedi and Shahmoradi, 2017), adults with anxiety disorders (Reger *et al.*, 2011) and a range of other mental health problems (Valmaggia *et al.*, 2016). Developers could utilise virtual reality to its full effect and enable a simulated, life-like human therapist to support CYP with NDDs and common comorbidities, thus cutting waiting lists whilst improving outcomes.

2.5.4 ***Implications for research***

Future studies of online interventions for CYP with NDDs must have larger sample sizes in order to generate a reasonable degree of statistical power and allow for an increase in generalisability. They must also consider including long-term follow-up assessments to evaluate whether effects are maintained over a prolonged period. A cost-effectiveness evaluation would also be appropriate and much needed in future research. Furthermore, qualitative feedback in the form of a process evaluation would be useful in addressing the intervention's mechanisms of impact and usability.

The current review found multiple methodological issues with the included trials. Sources of high risk of bias in the RCTs included failure to blind participants and personnel to the online intervention and inadequate reporting of allocation concealment. Failing to blind participants, which can be difficult in online intervention studies, can lead to the "digital placebo effect" (Torous and Firth, 2016). One possible way of mediating this effect in future studies is to create a sham or static online program for control groups, therefore, reducing the risk of the digital placebo effect. As mentioned, individualised interventions are often the most effective, however RCT designs are inadequate in assessing the individualised dimension of interventions, therefore future studies should focus on conducting single case experimental designs in order to measure this (Carr, Moore and Anderson, 2014; Carr *et al.*, 2015).

2.5.5 Implications for aims of thesis

In this review, there is evidence from two trials supporting the use of online therapy for CYP with tic disorders. One of the trials found that videoconferencing therapy could be as effective as face-to-face therapy for CYP with tics. Both studies included a quantitative rating of acceptability whilst other studies in this review included satisfaction ratings for both children and parents. One aim of the process evaluation of the ORBIT trial includes gathering and analysing data from the online platform to gage participant usability and satisfaction of the intervention. The evidence from this review suggests online interventions generally have high acceptability and satisfaction ratings, however where the process evaluation goes further, will be to qualitatively analyse the implementation quality and mechanisms with which online interventions work and for whom precisely. However, this review is somewhat limited in its applicability to ORBIT, as very few of the included studies can be generalised to a tic disorder

population as a whole due to the heterogeneity of the conditions targeted, types of therapies delivered, and the low mean age of participants in the included trials.

2.5.6 ***Conclusions***

Technological advances and mobile device popularity have huge potential to improve outcomes in CYP with NDDs and comorbid psychological problems. Overall, this review suggests online interventions can be beneficial in improving symptoms in this population, however, due to the small number of RCTs yielded and several methodological limitations in the included studies mean findings must be considered with caution. There need to be more studies with larger sample sizes assessing the effectiveness of online interventions for CYP. Furthermore, a qualitative evaluation of the intervention is encouraged in future work in order to provide bespoke online interventions for youth populations.

Chapter 3: Protocol for the Process Evaluation of Online Remote Behavioural Intervention for Tics (ORBIT)

Khan, K., Hollis, C., Hall, C.L., Davies, E.B., Mataix-Cols, D., Andrén, P., Murphy, T., Brown, B.J., Murray, E. and Glazebrook, C. (2020). Protocol for the Process Evaluation of the Online Remote Behavioural Intervention for Tics (ORBIT) randomized controlled trial for children and young people. *Trials*, 21(1). https://doi.org/10.1186/s13063-019-3974-3

3.1 Abstract

Background: Process evaluations are an important component in the interpretation and understanding of outcomes in trials. The 'Online Remote Behavioural Intervention for Tics' (ORBIT) study is a randomised controlled trial evaluating the effectiveness of an internet delivered behavioural intervention compared to an internet delivered education program aimed at children and young people with tics. A process evaluation was undertaken alongside the main trial to determine precisely how the behavioural intervention worked and ascertain whether, and if so, how, the intervention could be successfully implemented in standard clinical practice. This protocol describes the rationale, aims, and methodology of the ORBIT process evaluation.

Methods: The process evaluation used a mixed-methods design following the UK Medical Research Council's 2015 guidelines, comprising of both quantitative and qualitative data collection. This included: analysing data usage of participants in the intervention arm; purposively sampled, semi-structured interviews of parents and children, therapists, and referring clinicians of the ORBIT trial, as well as analysis of qualitative comments input into the online therapy platform by participants at the end of treatment. Qualitative data was analysed thematically in a framework approach. Quantitative and qualitative data was integrated in a triangulation approach,

to provide an understanding of how the intervention worked, and what resources are needed for effective implementation, uptake and use in routine clinical care.

Discussion: This process evaluation explored the experiences of participants, therapists, and referring clinicians of a complex online intervention. By contextualising trial efficacy results, this helped to understand how and if the intervention worked and what may be required to sustain the implementation of the treatment long-term. The findings also aid in our understanding of factors that can affect the success of complex interventions. This will enable future researchers developing online behavioural interventions for children and young people with mental health and neurological disorders to gain invaluable information from this process evaluation.

3.2 **Introduction**

There is growing interest within healthcare as to how advances in technology can be used in developing effective treatments for people with psychiatric and neurological disorders (Fairburn and Patel, 2017). Although CYP (i.e. individuals up to the age of 18) make up a large proportion of the population with psychiatric and neurological conditions (Kessler *et al.*, 2005; McGorry and Jorm, 2007), there is limited access to evidence-based treatments aimed at reducing symptoms in this population. Access to services for CYP is the lowest amongst all demographics (Gibb, Fergusson and Horwood, 2010) with only 25% of CYP receiving appropriate treatments (Sanci, Lewis and Patton, 2010). Behavioural treatments, in particular, are desirable and highly recommended by healthcare professionals as a first line treatment in reducing symptoms in CYP due to the limited side effects relative to pharmacotherapy (Cuenca *et al.*, 2015). However, these treatments are often difficult to access and CYP may avoid face-to-face therapy due to stigmatisation (Gega, Marks and Mataix-Cols, 2004). Due to their affinity for technology, a promising development that may benefit CYP are online interventions or DHIs. As discussed in The effectiveness of online interventions delivered to children and young people with neurodevelopmental disorders: a systematic review and meta-analysis, RCTs have shown that DHIs can be effective in treating psychological and neurological symptoms for CYP (Rice *et al.*, 2014; Ricketts *et al.*, 2016; Conaughton, Donovan and March, 2017; Khan *et al.*, 2019) but they can also be ineffective (Fletcher-Watson *et al.*, 2016; Whitehouse *et al.*, 2017). Hence, before any new DHI is introduced, clinicians, patients and commissioners need robust research to determine efficacy. However, data on efficacy alone is insufficient to inform effective implementation and uptake in routine health care. Data are also required on acceptability, uptake, and use of the intervention, including any

apparent impact of the digital divide on health inequalities, as well as on the resources and activities required to achieve effective implementation.

Little is known about how, and for whom in particular, DHIs work and what makes them effective in one context and not another and the barriers to effective implementation (Hawe, Shiell and Riley, 2004; Oakley *et al.*, 2006). The UK's MRC has developed specific guidelines for conducting process evaluations of complex interventions. As mentioned (see 1.4.3), process evaluations must assess intervention implementation by evaluating the quality (fidelity), dose, reach, adaptations, as well as analysing the causal mechanisms, and to identify any contextual factors (Moore *et al.*, 2015). Process evaluations can therefore aid interpretation and understanding of trial outcomes as well as informing future refinements of the intervention under study.

Grant *et al.* (2012) have identified the importance of outlining process evaluation methodology *a priori* and consider the publication of process evaluation protocols as 'best practice' in order to improve trial quality. Despite the increasing popularity in conducting process evaluations of complex interventions (Oakley *et al.*, 2006; Moore *et al.*, 2014) and the aforementioned importance of publishing protocols*,* explicit guidelines for publishing process evaluation protocols are limited (Grant *et al.*, 2013). Using previously published process evaluations of complex interventions protocols as a guide (Mann *et al.*, 2016; Jong *et al.*, 2018), here an outline of the methodology and a description of the planned process evaluation of ORBIT is given.

3.3 **The ORBIT intervention**

The ORBIT trial and its intervention have been described in detail previously as part of the main trial protocol (Hall *et al.*, 2019) (03/01/2019; version 3.0) and a summary is given here: 1.4.

Overall, the ORBIT trial aims to evaluate the clinical effectiveness of an online behavioural treatment for CYP aged 9-17 years with tics compared to online tic-related education in reducing tics, as measured by the YGTSS TTSS. Furthermore, the trial aims to evaluate the cost-effectiveness of the online treatment and to estimate the longer-term impact on patient outcomes and health service costs.

3.4 Process evaluation aims and objectives

The aims of the ORBIT process evaluation were to understand the causes of the observed behaviour change data obtained from the RCT, and in particular, to explore the fidelity of intervention delivery, acceptability of the intervention, reasons for observed variation in uptake and use, and consider the resources and implementation processes required.

Specific objectives were:

1. To assess the fidelity, reach, and dose of intervention delivery.
2. To explore whether any of the intervention features were tailored for individual needs enabling potential recommendations for adaptations.
3. To explore the intervention from the perspective of children, parents, therapists, and clinicians in order to gain a deeper understanding of potential mechanisms underlying participant behaviour change whilst probing for any unexpected consequences.
4. To evaluate any factors external to ORBIT that may have affected delivery (i.e. the environment and its characteristics) or whether its mechanisms of impact worked as intended.
5. To consider the resources and implementation processes required for effective implementation, uptake and use of the intervention.

The design of this process evaluation was guided by MRC directives on the process evaluation of complex interventions (Moore *et al.*, 2015). The MRC outline three essential components in understanding how outcomes are achieved: implementation, mechanisms of impact, and context. The application of these guidelines in the context of ORBIT was as follows:

> **Implementation**: an exploration as to how delivery of the intervention was achieved by examining quality (fidelity) and quantity (dose) of what was implemented. The structures and processes through which ORBIT was delivered as intended, any adaptations made, and establishing the extent to which the intervention reached its intended audience (reach).
>
> **Mechanisms of impact**: an examination of the causal mechanisms through which ORBIT produced change by understanding how participants interacted with the intervention. This also allows for an identification of any unexpected pathways and consequences.
>
> **Context**: an exploration of any factors external to ORBIT, which may have influenced its implementation (e.g. comorbidities, home life for the family, school life for the child, system factors in health services). MRC guidelines outline that a process evaluation should address how context affects implementation and outcomes (e.g. tic severity change). They further suggest that when investigating impacts of context on outcomes, it is helpful to relate contextual variations to *a priori* hypothesised causal mechanisms, or those emerging from qualitative analysis, in order to generate insights into context-mechanism-outcome patterns. Thus, in order to explore context this process evaluation was as flexible as possible with regards to data analysis.

MRC guidance on the development and evaluation of complex interventions notes that identifying and developing a theoretical understanding of the likely process of change is a key early task for developing a complex intervention or evaluating one that has already been developed. MRC guidelines stipulate an important component of a process evaluation is to outline the processes of the intervention and the outcomes it aims to achieve by means of a logic model. The logic model for the study is shown in Figure 8.

Problem	**Delivery mechanisms**	**Intervention (what is to be implemented and how delivery achieved)**	**Mechanisms of impact**	**Intended outcomes**	**Impact**
Growing demand for behavioural therapy as a first line treatment Lack of specialised care for children and young people with tics	Exposure and Response Prevention Education on tics and comorbidities Parent resources Therapist contact	Therapist reinforcement Follow-up sessions Therapist support Knowledge about tics and management 10 modules at weekly intervals	How children, parents, and therapists feel about ORBIT Motivation levels Treatment credibility Unanticipated consequences Mediators	Reduced tics Reduced co-morbid psychological symptomology of psychiatric condition Increased parental and children and young people's awareness and knowledge Improved function (e.g.	Improved provision of care for children and young people Increase in behavioural therapy as a first line treatment Health economic aspects

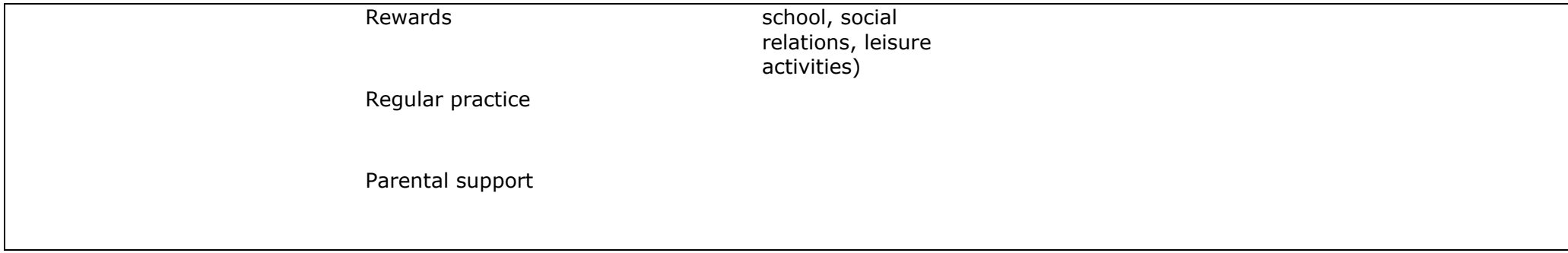

Figure 8. Logic model for the ORBIT intervention

3.5 **Overall design**

The overall design of the ORBIT process evaluation was a mixed-methods study using purposively sampled qualitative data together with quantitative data from the trial. This involved semi-structured interviews with children, parents, therapists, and clinicians as well as analysis of online feedback from participants together with data from the online platform, such as total therapist time, number of chapters viewed, and number of logins.

The schedule of the ORBIT process evaluation procedures is displayed in Figure 9. In Appendix C a populated Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) checklist is provided (Chan *et al.*, 2015).

Ethical approval for the process evaluation was obtained from North West - Greater Manchester Central Research Ethics Committee as part of the ORBIT trial (REC: 18/NW/0079).

	STUDY PERIOD							
	Screening	**Baseline**	**Post-randomisation**					
TIMEPOINT	**0**	**0**	t_1	t_2	t_3	t_4	t_5	t_6
ENROLMENT:								
Eligibility screen	X	X						
Informed consent/assent		X						
Primary outcome measure (YGTSS TTSS)		X			X	X	X	X
Randomisation		X						
INTERVENTIONS:								
ERP (intervention)			♦—	—	—	—♦		
Psychoeducation (control)			♦—	—	—	—♦		
PROCESS EVALUATION:								
Qualitative feedback from online platform					X			
Quantitative data from online platform					X			
Invited for interview					X			
Interview with parent/child					X			

Figure 9. Schedule of ORBIT and process evaluation procedures

Note: t_1 – mid-treatment (three-weeks); t_2 – mid-treatment (five-weeks); t_3 – primary end point (three-months); t_4 – six-months; t_5 – 12-months; t_6 – 18-months; YGTSS – Yale Global Tic Severity Scale; TTSS – Total Tic Severity Score; ERP – exposure and response prevention

3.6 Qualitative data collection

Qualitative data was collected by interviewing participants using a semi-structured interview guide in the intervention group only (both CYP and

parents, either separately or as a dyad), therapists and referring clinicians. Interviews with therapists and supervisors involved in ORBIT were conducted early in the trial and near the end of recruitment in order to gain an understanding of their experience at different time points. All interviews were conducted either by telephone or by videoconferencing (WebEx or Skype) or, where possible, face-to-face. Given that there are concerns by some qualitative researchers that telephone interviews do not allow the same rapport between interviewer and interviewee and, consequently, may limit the depth and quality of collected data (Novick, 2008), videoconferencing was the first-choice for conducting interviews. In addition, at the end of treatment participants were asked within the online platform questions including what the most important thing they have learnt from treatment was, how the treatment has helped, if the treatment caused any difficulties to participants, and any other comments they may wish to add.

Qualitative data followed the COREQ (COnsolidated criteria for REporting Qualitative research) (Tong, Sainsbury and Craig, 2007) guidelines and a checklist is provided in Appendix D.

3.6.1 Semi-structured interviews

In line with previous literature (Young *et al.*, 2008; Partridge *et al.*, 2016), four semi-structured interview schedules were developed (see Appendix E for all four interview schedules). In a semi-structured interview, the interview schedule is guided by relevant topics, but the order in which they are asked vary allowing a degree of flexibility (Potter and Hepburn, 2005). There are certain considerations that must be undertaken when developing interview schedules such as these. For instance, they must not lead participants towards a particular response; they must be open-ended; and they must be easily understandable by participants in terms of wording and

structure (Howitt, 2019). The nature of semi-structured interviews also allows for follow-up questions or prompts in order to gain a deeper understanding into a particular comment verbalised by participants (Howitt, 2019). At the end of all interviews, participants were given the opportunity to ask any further questions and were given the main researchers email address if they had any follow-up thoughts that did not arise within the interviews.

3.7 Sampling and recruitment for interviews

3.7.1 Children and parents

The child and parent interview schedules were drafted and underwent revision from the main researcher and three academics (CG, CLH, and EBD). Questions included: (a) how they found out about the ORBIT trial; (b) why they took part; (c) their initial expectations; (d) their views of the content, structure, and the different chapters of the online program; (e) what impact the therapy had, if any, on their tics; (f) what they found most and least helpful; (g) barriers to participation; (h) how they felt about communicating with their therapist; (i) if they would alter anything about the program; (j) their recommendations for improvement of the interventions and their overall experience of participating in the trial.

The revised drafts were sent to two dyads of the Patient and Public Involvement (PPI) group — including two children with tics — for feedback and were revised accordingly. The PPI input was invaluable, as it ensured the questions were understood by children as young as nine years.

All interviews were carried out with CYP and parents of CYP following completion of the intervention at the three-month (primary end-point) follow-up assessment in the main trial. Recruitment for the interviews began in August 2018 through the following methods:

- Following completion of the primary end-point, the researcher conducting the follow-up assessment asked participants if they were willing to be contacted about taking part in an interview. If the participant agreed, the researcher informed the process evaluation researcher (KK) who made contact with the family.
- Researchers at both QMC and GOSH arranged a convenient date, time, and method for interview to participants who agreed following their primary end-point follow-up assessment.
- A proportion of the participants were contacted by telephone following their primary end-point assessment by the main researcher of the process evaluation.

Participants were only contacted if they gave explicit written consent to participate in an interview for the ORBIT trial and, for a child under 16; assent was obtained with parental consent (see Appendix F for assent and consent forms). Participants were purposively sampled with the intention of collecting data from a diverse cohort to obtain varying views on the intervention. This included ensuring perspectives from a range of ages; gender, ethnicity, and level of interaction with the intervention were voiced. It was anticipated that this sampling strategy would result in sufficient heterogeneity to provide examples of both relatively poor and relatively good adoption, delivery, and maintenance, and would allow for an identification of the barriers and facilitators to implementation and to generate hypotheses about factors that may be associated with differing outcomes for CYP in the intervention arm.

The target for participant interviews was CYP (n=>20) and parents of CYP (n=>20). This ensured that data reached a level of saturation (Dworkin, 2012) and enabled a diversity of views.

3.7.2 ***Therapists***

The therapist interview schedules were drafted and underwent revision from the main researcher and the same three academics, as well as input from a therapist (TM) and a clinical researcher (PA) with specific expertise in the field. Therapist questions included: (a) their role on the ORBIT trial; (b) how they found out about ORBIT and why they got involved; (c) what specific skills they felt a therapist needed for the program; (d) any training needs identified; (e) how they managed ORBIT around other commitments; (f) their experiences of receiving/giving supervision sessions; (g) if the therapy is being delivered as planned; (h) their experiences of interacting with participants; (i) their views on the two trial arms; (j) and their recommendations for future use.

Therapists were initially interviewed individually early into the trial (halfway through the study) and then a proportion were interviewed again near the end of the trial. This allowed for a range of experiences at different time-points to investigate trial progression. The target for therapist interviews was n=>5, of which two were supervisors. There were two therapists at the Nottingham study site and two at the London study site with one supervisor at each site. The therapists were educated to graduate level and were not required to have previous experience in treating tic disorders but were trained on the platform and its contents and received regular expert supervision. Therapists received five days training in CBIT during the trial.

3.7.3 ***Clinicians***

Clinicians refer to any healthcare professional (usually a doctor) who were responsible for referring participants to the ORBIT trial. Whilst they were not explicitly involved in the ORBIT trial, the main purpose of interviewing them was to gain their views on potential implementation in routine care. The clinician interview schedules were drafted and underwent revision from

the same team as above and were guided by normalisation process theory (NPT) (May *et al.*, 2009; Murray *et al.*, 2010). NPT attempts to identify factors that promote and inhibit the routine incorporation of complex interventions into routine practice. It also attempts to explain how such interventions work, looking not only at early implementation, but beyond it whereby an intervention becomes so embedded into routine practice that it is normalised (Murray *et al.*, 2010). As the purpose of the clinician interviews were to explore their views about the feasibility of integrating the intervention into everyday practice, including any potential barriers to or facilitators of this, NPT framework approach seemed the most appropriate. The clinician interview schedule questions aimed at eliciting information on how they got involved in the ORBIT trial and why, their experience of recruiting for the trial including factors that affected recruitment, and how the NHS could incorporate the intervention into everyday practice. Clinicians were purposively selected from the PIC sites involved in recruiting for ORBIT and the target for clinician interviews was n>5.

3.7.4 Ethical considerations

All four interview schedules were submitted to North West - Greater Manchester Central Research Ethics Committee as a substantial amendment to the ORBIT trial (REC: 18/NW/0079) on 28/06/2018. On 16/07/2018, the committee responded (see Appendix G for full letter) that:

> The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation. The Sub-Committee reviewed the amendment, and no ethical issues were raised.

In the interviews conducted by WebEx or face-to-face, KK paid careful attention to participants' body language and general demeanour, as well as asking how they were feeling at various time points. Where it was not possible to view the participants' (i.e. telephone interviews), they were asked how they were feeling and KK paid attention to their tone of voice for any signs of distress. Furthermore, it was explained to all participants before the interviews began that they did not have to answer any questions they were uncomfortable with, that they could stop the interview at any point with no explanation needed, and that all their responses were completely anonymous. Participants' emotional state were explored further as part of the debrief.

Standard Operating Procedures (SOP) were in place in the event of any safeguarding issues arising. It stated that:

> All potential safeguarding issues should be immediately reported to the study Principal Investigator and the Trial Manager. Such issues may include (but are not limited to), disclosure of being abused, self-harm and suicidal ideation. This should be reported even if the child/young person has told you in confidence.

Therefore, the procedure was in place if any children were to disclose safeguarding issues.

Formal written consent was not required for the semi-structured interviews, as participants were only contacted if they initialled point number six on the consent form at the baseline assessment. Point 6 stated: 'I understand that I/my child may be asked to take part in research interviews, which will be recorded and anonymous direct quotes from these interviews may be used in study reports.' Verbal consent was obtained at the beginning of all interviews.

3.8 Quantitative data collection

Online data was collected and recorded from participants throughout the trial. This included the following measures: total therapist time; therapist time specific to each therapist; therapist time specific to each child and parent; total number of characters submitted by child and parent (as part of communication messages via the online system); total number of logins for child and parent; average time between each login (in days) for child and parent; average pages visited per login for child and parent; and the five most frequently visited pages per child and parent. This data was amalgamated and entered into a centralised online database whereby the main researcher extracted this data for analysis as part of the process evaluation.

3.8.1 *Trial data*

As part of the quantitative measures for the process evaluation, data was also extracted and analysed regarding change in YGTSS TTSS from baseline to primary end-point, which was used to inform change in tic severity. As mentioned, this is a key component of the MRC guidance on process evaluations. Demographic data, overall improvement as measured on the Clinical Global Impressions Scale-Improvement (CGI-I) (Guy and National Institute of Mental, 1976), depressive symptoms at baseline and primary end-point as measured on The Mood and Feelings Questionnaire (MFQ; Child completed version) (Angold *et al.*, 1995), and anxiety symptoms at baseline and primary end-point as measured on the Spence Children's Anxiety Scale (SCAS) (Spence, 1998) was also analysed. These data were used to measure context and the mechanisms of impact. The target sample size for all quantitative data was N => 110.

Table 9 presents a summary of the explanatory data sources that was used to inform each component of the process evaluation.

Table 9. Process evaluation components, areas of research, explanatory data and outcomes

Process Evaluation components	**Research questions**	**Explanatory data**	**Outcomes**
Implementation (What is implemented and how?)	➢ Fidelity of implementation ➢ Dose of intervention delivered ➢ Adaptations ➢ Reach	➢ Therapist contact/time (N => 110) ➢ Intervention adherence (N => 110) ➢ Usage metrics (N => 110) ➢ Clinician (n > 5), children and parent (n => 20), therapist (n => 5) interviews	➢ Engagement and satisfaction with intervention
Mechanisms of impact (How does it produce change?)	➢ Mediators and moderators ➢ Unexpected pathways and consequences	➢ Usage metrics ➢ Therapist contacts ➢ Clinician, children and parent, therapist interviews	➢ YGTSS TTTS change

Context (How do factors external to the intervention affect implementation and change?)	➢ Factors related to improvement in YGTSS TTSS, fidelity of delivery	➢ Demographic data ➢ Clinician, children and parent, therapist interviews ➢ Comorbidities ➢ Baseline severity of tics	➢ YGTSS TTTS change ➢ Engagement with intervention

Note: YGTSS – Yale Global Tic Severity Scale; TTSS – Total Tic Severity Score

3.9 **Data analysis**

Qualitative data was exported and analysed in QSR International's NVivo 12 Software (Ltd., 2018) and quantitative data was exported and analysed in SPSS (version 27.0) (Corp., 2017). Process evaluation data were analysed autonomously of the main outcome data of the ORBIT trial to avoid biasing of findings.

3.10 **Qualitative data analysis**

All interviews were recorded either by the WebEx videoconferencing application or by Dictaphone and then transcribed verbatim. Transcripts were checked for accuracy against the recordings with any corrections made as appropriate. Prior to the transcripts being imported into QSR NVivo 12, any reference to places, clinicians, therapists, and/or family members that may reveal participants' identity were redacted, and all participants' names were anonymised. The interviewer (KK) took notes during all interviews.

As the process evaluation is a combination of exploration and description, thematic analysis was used to identify, analyse, and report patterns within the transcribed interviews. Thematic analysis is widely used within the field of psychology and is considered the most flexible qualitative analytical process (Braun and Clarke, 2013). More broadly, the framework method (Ritchie and Spencer, 1994) of analysis was employed, as it is most commonly used for the thematic analysis of semi-structured interviews (Gale *et al.*, 2013). Moreover, Ritchie and Spencer (1994) outline four types of research questions that they believe framework analysis can helpfully address: 1) Contextual - identifying the form and nature of what exists (e.g. what is the nature of people's experience?); 2) Diagnostic - examining the reasons for, or causes of, what exists (e.g. why are services or programmes not being used?); 3) Evaluative - appraising the

effectiveness of what exists (e.g. what affects the successful delivery of programmes or services?); and 4) Strategic - identifying new theories, policies, plans or actions (e.g. how can systems be improved?). As the process evaluation covers all of these questions, it is felt that this is the appropriate methodology to use.

Ritchie and Spencer (1994) and, more recently, Gale *et al.* (2013) suggest the following key stages of framework analysis: (i) familiarisation; (ii) coding; (iii) developing a working analytical framework; (iv) applying the analytical framework; (v) charting data into the framework matrix; (vi) interpretation. During the familiarisation stage, the main researcher immersed himself in the data by listening and/or watching back the interviews, reading the first 10 transcriptions, and studying observational notes whilst listing key ideas and recurring themes. After familiarisation, the main researcher carefully read the transcript line by line and applied an appropriate paraphrase or label (a 'code') that described their interpretation of the passage. At this stage, coding can be 'open' or pre-defined depending on whether the study is more inductive or deductive. As this process evaluation was based on theoretical assumptions, a more deductive approach was taken to coding of transcripts, however, open coding was also used to ensure important aspects of the data were not missed. After coding the transcripts, codes were grouped together into categories, which were then clearly defined. This formed the working analytical framework. The working analytical framework was then applied by indexing subsequent transcripts using the existing categories and codes. The use of NVivo 12 was particularly helpful at this stage, as it sped up this time-consuming process and ensured that the data was easily retrievable. A spreadsheet was then used to generate a matrix with the data 'charted' into the matrix. This involved summarising the data by category from each

transcript. The final stage involved interpreting the data by characterising the data, generating typologies, and exploring relationships between the data.

A subset of transcripts was double coded by two independent coders (CLH and EBD) to identify emergent patterns and themes relating to participants', therapists, and clinicians' experiences of the ORBIT trial. Charted data was annotated independently with discussions taking place on these findings, which allowed for a refinement and amendment of data in an iterative process. Once confidence in the congruity and meaningfulness of interpretation was established between researchers, the remaining interviews were reviewed to establish whether understanding had reached acceptability. This ensured the qualitative data was valid and reliable (Golafshani, 2003).

The large amount of data collected for the process evaluation encouraged the use of computer assisted qualitative data analysis software (CAQDAS). One CAQDAS package, QSR NVivo 12, is fully integrated with framework analysis and this was used to categorise data and document any themes and sub-themes. Online feedback given by participants at the end of therapy was analysed using quantitative content analysis (Hsieh and Shannon, 2005). Quantitative content analysis involves assigning data a meaningful 'code' and then frequency counting the use of these 'codes' within the data. This data was mainly used for the fidelity part of the process evaluation, as the main questions asked at the end of treatment involved seeking open-ended responses about satisfaction and acceptability.

3.10.1 Reflexivity

One of the ways in which qualitative researchers must establish rigour and quality in their work is through clearly describing the contextual

relationships (e.g. race, socioeconomic status, age, culture etc.) between the participants and themselves (Dodgson, 2019). Moreover, it is important for the researcher to recognise how their role in the data collection and analysis process is influenced by their own experiences and perceptions, and in turn how this is likely to have influenced the data and findings obtained (Howitt, 2019). This is generally achieved through reporting the main characteristics of the lead researcher. Accordingly, KK is a male postgraduate student born in England but of South Asian heritage. He has an MSc in Psychological Research Methods. He is in his mid-thirties and has had no previous experience of working with tics and TS, however he has a background working in various psychiatric institutions, including a child and adolescent mental health services (CAMHS) unit. The researcher has always lived in areas of the country with diverse ethnic groups and has lived in working class as well as middle class neighbourhoods. This has enabled him to gain valuable "code-switching" skills whereby he is able to shift his communication skills from one setting and context to another. The researcher is not a parent, and this may have affected his interpretation of the role of the parents within the ORBIT trial as well as their approach to caring for a child with tics and other complex comorbidities. He had no prior relationship with any of the participants in the interviews except for the therapists in the study who he knew on personal level and all participants were told about what the research aimed to achieve prior to all interviews. Finally, he was aware of the need not to bias interpretation. As such, the researcher adopted a reflexive approach to qualitative data collection and analysis and discussed their reflections alongside the relevant study findings.

3.11 **Quantitative data analysis**

Quantitative data from the online platform was subject to descriptive statistical analysis with total numbers and percentages and mean with standard deviation (SD) or median (range), if not normally distributed, being presented. This provided information on intervention delivery, including the implementation of different components and fidelity. Data was tested for normality using the Kolmogorov–Smirnov test. Correlations between variables were examined using bivariate Spearman correlations. Independent samples chi-squared and *t* tests were calculated to explore any significant differences within the intervention group. For data not normally distributed, non-parametric alternatives were used (i.e. Kruskal–Wallis H and Mann–Whitney U tests). Regressions were calculated, if prior statistical assumptions were met, to identify predictors, mediators, and moderators of engagement with various independent variables. All quantitative data were subject to a significance level of $p<0.05$. The results of all these analyses including underlying statistical assumptions are presented within the results sections of the relevant studies.

3.12 **Mixed methods analysis**

Qualitative and quantitative data were analysed separately and then mixed during analysis in a methodological approach known as triangulation (O'Cathain, Murphy and Nicholl, 2010). Both qualitative and quantitative data were given equal importance, as both sets of data were central to addressing the research questions posited by the process evaluation. In Appendix H a Good Reporting of A Mixed Methods Study (GRAMMS) (O'Cathain, Murphy and Nicholl, 2008) checklist is provided.

Coding of qualitative data and preliminary qualitative analysis were conducted synchronously with the analysis of descriptive statistics of participants' online data. Thus, the descriptive data aided in the refinement

and amendment of questions central to qualitative data collection. In other words, key themes emerged from the quantitative data, which were then further explored or clarified from qualitative data, and vice versa. The main researcher integrated and compared outcomes from the various data sets guided by triangulation protocol. The aim of this was to create a matrix of converging data sets to assess outcomes where there was agreement, dissonance, and where themes or outcomes emerged in one dataset but not another. Once the matrix of outcome synthesis from the various datasets was finalised, it was used to emphasise the mechanisms of impact, intervention implementation, and context and, more broadly, explain the outcomes of the trial.

3.13 Integration of findings

The process evaluation data was analysed prior to knowing the main ORBIT trial results with the two analyses being independent of each other. The ORBIT trial team were unaware of the findings of the process evaluation until the primary outcomes from the main trial were analysed. Once both trial and process evaluation analyses were complete, combined qualitative and quantitative data aided in the development of hypotheses about the potential successful implementation in one context over another and how and why some components were delivered successfully, and others were not. Furthermore, the analysis of different components aided in the identification of causal mechanisms and how and why individual intervention components were more effective than others were. Following quantitative analysis of ORBIT outcome data, qualitative data from the process evaluation was used to help explain findings from the trial (i.e. mechanisms of impact). Additional analyses were then conducted to test hypotheses emanating from integration of process evaluation data with trial outcomes, drawing together the findings to understand why the

intervention worked (or not), context, and implications for further dissemination to improve provision of care for CYP with tics.

3.14 **Discussion**

This protocol outlines the rationale, design and methodology for the planned mixed methods process evaluation of ORBIT, a complex online intervention for CYP with tics. The process evaluation was designed to explore the implementation of the online intervention and provide a holistic view of trial outcomes. By explicitly outlining the process evaluation methodology, guided by MRC framework of complex intervention trials, this protocol adds to the literature of process evaluation protocols using a mixed-methods design. In doing so, this improves the integrity of this process evaluation and, as mentioned, there is growing emphasis on the importance of publishing process evaluation protocols in advance to improve overall trial quality and reporting (Grant *et al.*, 2012).

The combined qualitative and quantitative process evaluation data support the homogenous interpretation of the main outcome data from the ORBIT trial. By providing an illumination of how and why the intervention was effective or not, the process evaluation helped to elucidate a holistic view of ORBIT. Moreover, understanding the mechanisms of impact and any contextual factors, this data augmented the dissemination plan and may support the long-term implementation of the intervention. The process evaluation also offers insight into digital interventions and may inform future development of such health technologies.

3.14.1 ***Strengths and limitations***

Conducting the process evaluation contributes to explaining the overall findings of the main RCT: the factors underlying positive and negative effects of different aspects of the intervention. For example, where there were certain negative outcomes from using ORBIT, the process evaluation

was an invaluable resource in elucidating whether the intervention was inherently inadequate, if there was a failure of implementation, and if this was related to participants (e.g. lack of motivation) or contextual factors (e.g. pre-existing beliefs of online therapy or certain characteristics). This will help to improve the intervention progressively and make recommendations once implemented into routine healthcare.

In contrast, if there were positive outcomes from using ORBIT, the process evaluation helped to identify the core components that made the intervention a success. For example, where it was determined that an essential component for promoting participants' adherence to the intervention was the use of parental support and therapist encouragement, these findings were crucial to the development and implementation of future digital programs aimed at CYP with tics.

By collecting data from a range of relevant stakeholders (e.g. parents, children, therapists, and clinicians) and combining quantitative and qualitative data, this evaluation gained a holistic understanding of the mechanisms underlying the impact of the intervention. Furthermore, the proposed sample size for qualitative data was adequate to capture a comprehensive overview of perspectives, generating rich data and analytical depth. The main limitation in terms of future implementation was that the environment/context was heavily influenced by this study being an RCT. It would arguably have been more appropriate to conduct a parallel implementation study, however lack of resources prohibited this. For instance, the component of reach may not have been generalisable outside of the RCT. Thus, going forward if ORBIT was implemented in routine clinical practice, then a parallel implementation study would be most suitable to assess the quality of what is being delivered.

Chapter 4: Part One – Intervention implementation and contextual factors influencing children's level of engagement

Khan K., Hollis C., Hall C.L., Murray E., Davies E.B., Andrén P., Mataix-Cols D., Murphy T., Glazebrook C. (2021). Fidelity of Delivery and Contextual Factors Influencing Children's Level of Engagement: Process Evaluation of the Online Remote Behavioral Intervention for Tics Trial. *Journal of Medical Internet Research*;23(6):e25470. doi: 10.2196/25470

4.1 Abstract

Background: The Online Remote Behavioural Intervention for Tics (ORBIT) study was a multicentre randomised controlled trial of a complex intervention that consisted of an online behavioural intervention for children and young people (CYP) with tic disorders. In this first part of a two-stage process evaluation, a mixed-methods study was conducted exploring reach, dose, adaptations, and fidelity of the intervention and contextual factors influencing engagement with the intervention.

Objective: This study aims to explore the fidelity of delivery, intervention implementation and the contextual factors underpinning the ORBIT intervention.

Methods: Baseline study data and intervention usage metrics from participants in the intervention arm were used as quantitative implementation data (N = 112). The experiences of being in the intervention were explored by semi-structured interviews with children (n = 20) and parent (n = 20) participants, therapists (n = 4), and referring clinicians (n = 6). A principal components analysis was used to create a comprehensive, composite measure of CYP's engagement with the intervention. Engagement factor scores reflected relative uptake as

assessed by a range of usage indices including chapters accessed, number of pages visited and number of logins.

Results: The intervention was implemented with high fidelity, and participants deemed the intervention acceptable and satisfactory. Engagement and adherence were high with child participants completing an average of 7.5/10 chapters and 99/112 (88.4%) participants completed a minimum of the first four chapters: the pre-defined threshold for effective dose. Compared to the total population of children with tic disorders, the sample tended to have more educated parents and live in more economically advantaged areas, but socioeconomic factors were not related to engagement factor scores. Factors associated with higher engagement factor scores included participants enrolled at the London site vs. the Nottingham site (p = .011), self-referred vs. clinic-referred (p = .041), higher parental engagement as evidenced by number of parental chapters completed (ρ = 0.73, n = 111, p<.001) and more therapist time for parent (ρ = 0.46, n = 111, p<.001). A multiple linear regression indicated that parents' chapter completion (β = .69, t_{110} = 10.18, p<.001) and therapist time for parent (β = .19, t_{110} = 2.95, p = .004) were the only significant independent predictors of engagement factor scores.

Conclusions: Overall, the intervention had high fidelity of delivery and was evaluated positively by participants, although reach may have been constrained by the nature of the randomised controlled trial. Parental engagement and therapist time for parent were strong predictors of intervention implementation which has important implications for the design and implementation of digital therapeutic interventions into Child and Adolescent Mental Health Services.

4.2 Introduction

This chapter presents part one of the process evaluation of ORBIT. The aim of this study was to conduct the first part of a two-stage process evaluation of ORBIT as outlined in the study protocol (see Chapter 3). Part one focuses on intervention implementation by exploring the fidelity of delivery experienced by participants using usage statistics, reach, and the acceptability of the intervention. It also investigates contextual factors associated with the observed variation in uptake and usage by examining the components specified in MRC guidelines (Moore *et al.*, 2015) (see Table 9 for process evaluation components, areas of research, and outcome data).

As discussed previously (see 1.3), despite the benefits and evidence-based effectiveness of behavioural therapies for tic disorders (Piacentini *et al.*, 2010; McGuire *et al.*, 2014; Hollis *et al.*, 2016; Whittington *et al.*, 2016), there is great difficulty in patients accessing behavioural treatments due to a shortage of trained therapists (Novotny, Valis and Klimova, 2018). One promising development in increasing accessibility to behavioural treatments is the use of DHIs (Hollis *et al.*, 2017). There is preliminary evidence that DHIs are efficacious for CYP with tic disorders in pilot RCTs (Himle *et al.*, 2012; Ricketts *et al.*, 2016; Andrén *et al.*, 2019). A study that has assessed DHIs for tic disorders is the ORBIT trial, which has been described in detail previously (see 1.4). Figure 10 briefly describes the

ORBIT trial for context to the next two sections of this thesis.

Design: A 10-week, two-armed, parallel group, single blind, randomized controlled trial (RCT) with an embedded process evaluation.

Aim: To evaluate the effectiveness of an online, remote, therapist-supported and parent-guided behavioural intervention for tics, initially developed and piloted in Sweden called BIP TIC.

Intervention group: 112 children and young people received 10 modules (called 'chapters') of behavioural therapy following the principles of Exposure and Response Prevention (ERP) via a secure online platform, with access to a therapist, delivered over a period of 10-12 weeks.

Control group: 112 children and young people received 10 chapters of psychoeducation via a secure online platform, with access to a therapist, delivered over a period of 10-12 weeks.

Primary outcome: Total Tic Severity Score (TTSS) on the Yale Global Tic Severity Scale (YGTSS) at 3-months post randomization.

Therapist role: Both children and parents had regular contact with a therapist during the 10-12 weeks via messages that were sent within the treatment platform (resembling an email) or telephone if required. The therapist was also able to directly comment on exercises that the participant had been working on, and give specific feedback to motivate participants. All participant contact with the therapist was asynchronous.

Parent role: One or both of the child's parents received a separate login to the online treatment where they could access their own chapters. The parent chapters contained information regarding parent coping strategies, how to support their child in working with BIP TIC and functional analysis relating to tics. They also had access to the assigned therapist.

Figure 10. Brief description of the Online Remote Behavioural Intervention for Tics (ORBIT) trial

4.2.1 Process evaluation

The population impact of any given intervention depends on both its effectiveness and its reach, defined as the proportion of the target population who access the intervention (Glasgow, Vogt and Boles, 1999). Although RCTs are the "gold standard" method for determining efficacy, additional data are needed before a decision as to whether an intervention should be adopted into mainstream healthcare can be reached. These

additional data include understanding the reach of the intervention, and the extent to which the data from an RCT, where the delivery of the intervention is often tightly controlled and monitored, can be extrapolated to use in routine healthcare. It has been argued that studies addressing questions about reach and effectiveness in routine care are needed (Glasgow, Lichtenstein and Marcus, 2003; Murray *et al.*, 2016). However, like all research, such studies are expensive, and a process evaluation conducted alongside an RCT is an efficient method of maximising the information yielded by the trial. As described previously (see 1.4.3) the MRC has developed specific guidelines for conducting process evaluations of complex interventions (Moore *et al.*, 2015). The MRC outline three essential components for evaluating complex interventions: implementation, mechanisms of impact, and context. The focus of this chapter is on implementation and context.

4.2.2 Intervention implementation

Individual studies use various terms for implementation fidelity. These terms include adherence, treatment fidelity, treatment integrity, program integrity, and implementation quality (Montgomery *et al.*, 2013). However, the specific concept of implementation fidelity has been defined and described in detail in the MRC guidelines on process evaluations of complex interventions (Moore *et al.*, 2015), which is the definition this study followed. Implementation can refer to how an intervention will be delivered within routine clinical practice, having shown efficacy in an outcome evaluation. However, this chapter is concerned with another aspect of implementation: the extent to which the delivery of an intervention is achieved within the context of an RCT and the structures and processes through which an intervention is delivered as intended (i.e. fidelity) (Moore *et al.*, 2015). In short, implementation fidelity refers to the degree to

which an intervention was implemented according to design or protocol (also known as 'intervention implementation'). If an intervention is designed according to well established theoretical and empirical underpinnings, including identifying essential ingredients and their subsequent relationship to the intended outcome, implementation fidelity is seen as crucial (Bragstad *et al.*, 2019). There are multiple benefits to a trial which includes a rigorous assessment of implementation fidelity. These include improving the validity of intervention outcomes (Hulscher, Laurant and Grol, 2003; Carroll *et al.*, 2007), enabling replicability (Montgomery *et al.*, 2013), and it can also aid in the understanding as to why an intervention succeeded or failed (Hasson, 2010). For example, a study may erroneously determine that the lack of impact of an intervention was caused by particular elements of the program itself if no process measures were evaluated (i.e. a type III error) (Dobson and Cook, 1980). Therefore, it is essential that an RCT which includes a process evaluation should contain a rigorous analysis of implementation fidelity.

For complex interventions like DHIs, an important component of implementation fidelity is the degree to which participants engage with the intervention, and use it as intended. Effective engagement requires participants to register with the programme, and then continue to use it and apply the recommended behavioural techniques over time. Non-use of DHIs is a well-recognised challenge (e.g. Eysenbach's Law of Attrition (Eysenbach, 2005)), and can be considered in two parts: initial uptake (e.g. registration/onboarding) and ongoing adherence or engagement. Carroll *et al.* (2007), outline the importance of evaluating what they term 'participant responsiveness' when assessing implementation. Essentially, this refers to how participants and those who deliver an intervention respond to and engage with the program. For example, if participants view

an intervention as being of no significance to them, then their lack of engagement and adherence may be a major cause of its failure or low reach, and thus implementation fidelity will be lower.

In order to evaluate intervention implementation, MRC guidelines for process evaluations suggest researchers assess: i) reach – the extent to which a target audience comes into contact with the intervention; ii) dose – how much intervention is delivered and received; iii) fidelity – the quality of what was delivered; iv) adaptations – any modifications made to an intervention in order to achieve better contextual fit. The intended target audience for ORBIT was CYP with tic disorders; however, there were pertinent questions that could be asked, such as whether there were socioeconomic biases in who was reached. In terms of dosage, the ORBIT protocol (Hall *et al.*, 2019) states the intervention should consist of 10 individual intervention chapters following a suggested frequency and total duration of 10-12 weeks. There were four core chapters (chapters 1-4), and this was deemed the minimum requirement for treatment completion. There were six additional chapters offering reinforcement, further practise, and relapse prevention. For DHIs, the fidelity of delivery of the intervention is assured by the online delivery platform. However, the intervention that is experienced by the user is highly dependent on the extent to which they engage with the intervention and use it as intended. Hence in this process evaluation, the focus is on usage and the proportion of participants receiving the pre-defined "minimum effective dose" of four or more chapters. Finally, understanding adaptations to the intended intervention involves exploring whether these improve its contextual fit or compromise its functioning (Hawe, Shiell and Riley, 2004), or whether they represent innovation, or intervention drift (Bumbarger and Perkins, 2008). Participants were able to make modifications to various components of the

intervention, such as the "tic stopwatch" which was used to self-time the length of tic control.

4.3 Methods

4.3.1 Study design

This study followed MRC guidelines (Moore *et al.*, 2015) for the process evaluation of complex interventions and used a mixed-methods, longitudinal design to explore the implementation fidelity of an online intervention for CYP with tics (Hall *et al.*, 2019) and the contextual factors that influenced level of engagement. Protocol for the Process Evaluation of Online Remote Behavioural Intervention for Tics (ORBIT) describes the methodology of this study in detail, however, here an overview of the methodology, including the study specific outcome measures is given for context.

4.3.2 Participants

The sample included in the quantitative phase of the process evaluation consisted of key information from all participants (N = 112) from the intervention arm of the RCT. The sample included in the qualitative component of the process evaluation consisted of interviews with child and parent participants (target n=>20), interviews with all therapists delivering the intervention or supervising the therapists, and interviews with referring clinicians (target n>5).

4.3.3 Quantitative data collection

Quantitative process data were collected simultaneously along with enrolment, intervention delivery, and outcome data collection in the main RCT.

4.3.3.1 Demographic and clinical data

Demographic and clinical information was recorded from a baseline demographics questionnaire. These data included the child's age, residence

(full postcode), gender, ethnicity, parental education level and occupation, all current suspected or confirmed diagnoses and interventions, and medication use.

4.3.3.2 Index of Multiple Deprivation

Index of Multiple Deprivation (IMD) is a relative measure of deprivation across seven different domains: income deprivation; employment deprivation; education, skills and training deprivation; health deprivation and disability; crime; barriers to housing and services, and living environment deprivation (*The English Indices of Deprivation 2019*, 2019). Based on the six-digit postcode, a rank of deprivation associated with participants' area of residence was calculated (https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019) from 32844 small areas or neighbourhoods in England, with higher ranks indicating greater deprivation. Ranks were re-coded into quintiles with 1 being most deprived and 5 being least deprived.

4.3.3.3 Yale Global Tic Severity Scale

The primary outcome measure used in the ORBIT intervention was the Total Tic Severity Score (TTSS) as measured by the Yale Global Tic Severity Scale (YGTSS). The YGTSS is a valid and reliable, clinician-rated scale (Leckman *et al.*, 1989), which scores the severity of motor and vocal tics separately by an evaluation of the number, frequency, intensity, complexity, and interference of tics. Each domain is scored on a 0-5 scale. Two tic severity scores are given: total motor (0-25) and total vocal (0-25), which when combined give the TTSS (0-50).

4.3.3.4 Mood and Feelings Questionnaire

The Mood and Feelings Questionnaire (MFQ) (Costello and Angold, 1988) is a 33-item measure evaluating depressive symptoms rated on a 3-point scale: 0 is "not true"; 1 is "sometimes" and 2 is "true". Total scores range

from 0 to 66 with higher scores reflecting more severe depression. A cut-off score of ≥29 is generally used to suggest clinically significant depression (Burleson Daviss *et al.*, 2006).

4.3.3.5 Usage metrics

Online usage data was collected and recorded from participants throughout the trial. This included the following measures: number of chapters completed per child and per parent; total therapists' time per child and per parent; individual therapist's telephone time with participants; volume of written communication (total number of characters) submitted by child and parent via the online system; total number of logins for child and for parent; average time between each login (in days) for child and for parent; and average pages visited per login for child and for parent.

4.3.3.6 Satisfaction and treatment credibility

At the 3-week post-randomisation point of treatment, all participants were asked to rate treatment credibility. Two questions were asked: one relating to how well suited the participant felt the intervention was for helping CYP to manage their tics and the other question was about how much better they expected to feel as a result of the intervention. The responses were on a Likert-scale of 0 to 4 for each question with higher scores indicating higher treatment credibility. At the primary end-point, all participants were asked to rate their satisfaction with the intervention. Eight satisfaction questions were asked with responses rated on 0 to 4 scales meaning the overall satisfaction score was out of 32.

4.3.4 Qualitative data collection

Interviews with therapists involved in the ORBIT trial were conducted early in the study and near the end of recruitment in order to gain an understanding of their experience at different time points. Interviews with referring clinicians were conducted at the end of recruitment. Interviews

with CYP and parents were conducted following completion of the intervention at the 3-month follow-up assessment (primary end-point) in the main RCT in order to minimise the risk of bias in outcomes. Recruitment for the interviews began in August 2018 and ended in October 2019.

All interviews were conducted either face-to-face, by telephone, or via videoconferencing (WebEx or Skype). Younger children were interviewed together with their parents, while older children were interviewed separately. Participants were purposively sampled so that a diverse range of views on the intervention were voiced. This included ensuring perspectives were heard from participants with a range of ages, gender, ethnicity, and level of interaction with the intervention. The overall sample enabled a diversity of views of the intervention and ensured that data reached a level of saturation. In addition to the interviews, at the end of treatment, all participants were asked to give their overall feedback on the intervention to which they could provide open-ended responses. Table 10 demonstrates how the various data sources contribute to different components of implementation fidelity.

Table 10. Implementation fidelity components and data sources

	Reach	Dose	Fidelity	Adaptations	Context
Quantitative data sources					
Demographic and clinical data	✓				✓
Usage metrics		✓			
Treatment credibility and satisfaction			✓		
Qualitative data sources					
Child interviews		✓	✓	✓	✓
Parent interviews		✓	✓		✓
Therapist and clinician interviews	✓		✓	✓	✓
End of treatment feedback questionnaire			✓		

4.3.5 Data analysis

The quantitative data set were presented with total numbers and percentages and mean with SD or median (range), if not normally distributed. Data were tested for normality using the Kolmogorov–Smirnov test. A principal components analysis was run to determine a composite measure of level of engagement. Correlations between variables were examined using bivariate Spearman correlations, and a *t*-test was calculated to explore any significant differences between groups with chi-square tests to explore for differences between categorical variables. A multiple linear regression was calculated to identify predictors of engagement with independent variables. All statistical analyses used a significance level of $p<0.05$ and were conducted using IBM SPSS Statistics 27.

All interviews were recorded either by videoconferencing software or by Dictaphone and were then transcribed verbatim. Transcripts were checked for accuracy against the recordings with any corrections made as appropriate and anonymised for confidentiality purposes. As the process evaluation was a combination of exploration and description, the Framework Method (Ritchie and Spencer, 1994) of analysis was used to identify, analyse, and report patterns within the transcribed interviews. Moreover, the steps outlined by Gale *et al.* (2013) were systematically followed to create an overall framework matrix using categories of engagement and contextual factors. Consistency of analysis was ensured throughout by the use of a codebook and through frequent meetings between researchers. Researcher bias was minimised through regular cross-checking of data and outcomes by members of the research team.

The software package QSR NVivo 12 was used to analyse the interview data. In addition, the end of treatment feedback questionnaire was exported to an Excel spreadsheet and quantitative content analysis (Hsieh and Shannon, 2005) was performed. Overall, the findings from the qualitative analysis were linked to relevant quantitative adherence outcomes and contextual factors to assess which potential variables may have influenced implementation fidelity and in what way, in an approach termed 'triangulation' (O'Cathain, Murphy and Nicholl, 2010).

4.3.6 Ethical considerations

Ethical approval for the process evaluation was obtained from North West - Greater Manchester Central Research Ethics Committee as part of the ORBIT trial (REC: 18/NW/0079). All child and parent participants provided written informed consent and all interview participants provided oral consent for audio-recording.

4.4 Results

4.4.1 Overview of qualitative sample and framework analysis findings

From the intervention group, 38 children and their parents were contacted to participate in semi-structured interviews. Eighteen of these did not respond or declined to participate. Overall, semi-structured interviews were conducted with children (n = 20) and parents (n = 20), therapists (n = 4) and clinicians (n = 6). The average age of child interviewees was 12 years (range 9-16 years) with 16 (80%) of the sample being male and four (20%) females. The majority of the sample was white (n = 18, 90%). The mean TTSS was 28.8 (*SD* = 7.2) with a range of 13-45 for child interviewees. All 20 of the interviews with the parents were with the CYP's mother with all 20 having completed at least further education. One of the therapist interviewees was a therapist's supervisor and half of the clinicians were consultant psychiatrists (n = 3, 50%). See Table 11 for demographic characteristics of all participants, therapists, and clinicians who took part in the interviews.

The framework analysis of the resulting 50 transcripts resulted in 12 categories: 'motivation for participating', 'initial response to ORBIT', 'ORBIT program content', 'mechanisms of impact', 'intervention outcomes', 'intervention characteristics that enabled implementation', 'trial related enablers to implementation', 'trial related barriers to implementation', 'intervention characteristics that supported tic reduction', 'intervention characteristics that hindered engagement', 'participant contextual factors', and 'family contextual factors'. Across all categories, there were a total of 59 themes. The qualitative findings are presented, as much as possible, in participants' own words.

Appendix I shows the full list of framework categories and themes.

Table 11. Demographic characteristics of all interview participants (n = 50)

Child participants

ID	Gender	Age (years)	Ethnicity	Study centre	Method of interview	Time (hh:mm:ss)
C1	Male	12	White	Nottingham	WebEx	00:22:14
C4	Male	11	White	GOSH	Telephone	00:32:24
C5	Male	10	White	GOSH	WebEx	00:31:16
C7	Male	10	White	Nottingham	Telephone	00:26:27
C10	Male	10	White	GOSH	Telephone	00:20:20
C12	Male	11	White	Nottingham	Telephone	00:13:14
C13	Male	11	White	GOSH	Telephone	00:15:45
C14	Male	13	White	Nottingham	Telephone	00:32:34
C16	Male	10	White	Nottingham	WebEx	00:15:13
C18	Female	14	White	GOSH	WebEx	00:25:15
C19	Male	16	White	Nottingham	WebEx	00:14:58
C20	Male	12	White	Nottingham	Skype	00:27:00
C21	Female	15	White	Nottingham	WebEx	00:27:24
C22	Female	15	Chinese	GOSH	Telephone	00:22:10
C23	Female	10	White	Nottingham	Telephone	00:18:20
C24	Male	14	White	Nottingham	Telephone	00:21:20
C25	Male	15	British African	Nottingham	WebEx	00:23:09
C26	Male	9	White	Nottingham	WebEx	00:09:11

C27	Male	13	White	Nottingham	Telephone	00:15:19
C28	Male	10	White	GOSH	Telephone	00:17:50

Parents

ID	Relationship to child	Education level	Ethnicity	Study centre	Method of interview	Time (hh:mm:ss)
P1	Mother	Completed further education	White	Nottingham	WebEx	00:28:25
P5	Mother	Completed further education	White	GOSH	Telephone	00:28:08
P6	Mother	Completed university/higher education	White	GOSH	WebEx	00:29:00
P8	Mother	Completed further education	White	Nottingham	Telephone	00:36:56
P11	Mother	Completed university/higher education	White	GOSH	Telephone	00:39:35
P13	Mother	Completed post-graduate taught degree	White	Nottingham	Telephone	00:23:00
P15	Mother	Completed further education	White	GOSH	Telephone	00:24:50
P16	Mother	Completed university/higher education	White	Nottingham	Telephone	00:10:08
P18	Mother	Completed university/higher education	White	Nottingham	WebEx	00:27:10
P20	Mother	Completed university/higher education	White	GOSH	WebEx	00:35:05
P21	Mother	Completed post-graduate taught degree	White	Nottingham	WebEx	00:17:31
P22	Mother	Completed university/higher education	White	Nottingham	Skype	00:22:12
P23	Mother	Completed university/higher education	White	Nottingham	WebEx	00:22:09
P24	Mother	Completed university/higher education	White	GOSH	Telephone	00:26:07
P25	Mother	Completed university/higher education	White	Nottingham	Telephone	00:27:00
P26	Mother	Completed further education	White	Nottingham	Telephone	00:18:20
P27	Mother	Completed post-graduate taught degree	British African	Nottingham	WebEx	00:43:48
P28	Mother	Completed further education	White	Nottingham	WebEx	00:22:00

P29	Mother	Completed university/higher education	White	Nottingham	Telephone	00:24:37
P30	Mother	Completed further education	White	GOSH	Telephone	00:15:36

Therapists

ID	Supervisor/Supervisee	Method of interview	Time (hh:mm:ss)
Therapist 1	Supervisee	Face-to-face	01:12:56
Therapist 2	Supervisee	Face-to-face	01:03:32
Therapist 3	Supervisee	Telephone	00:31:32
Therapist 4	Supervisor	Skype	00:19:12

Clinicians

ID	Occupation	Method of interview	Time (hh:mm:ss)
Clinician 1	Psychiatrist	Telephone	00:24:49
Clinician 2	Psychiatrist	Telephone	00:30:15
Clinician 3	Research Nurse	Telephone	00:26:26
Clinician 4	Psychiatrist	Telephone	00:19:15
Clinician 5	Research Nurse	Telephone	00:30:02
Clinician 6	Research Nurse	Telephone	00:11:09

4.4.2 Reach

Participants were eligible for the study if they were aged 9–17 years, with a suspected or confirmed tic disorder, competent to provide written, informed consent (parental consent for a child aged <16 years) and had broadband internet access and regular use of a computer, with mobile phone text messaging facilities. Patients were excluded from the study if they had received any form of structured behavioural intervention for tics within the preceding 12-months, had a change of medication for tics (i.e. stop/start) within the previous two months, any diagnoses of alcohol/substance dependence, psychosis, suicidality, or anorexia nervosa or moderate/severe intellectual disability, were an immediate risk to self or others, and/or parent or child was not able to speak, or read and write English.

Four hundred and forty-five families expressed an interest in taking part in the study either through self-referral via *Tourettes Action* charity website (n = 251) or via clinic referral (n = 194); however, 47 were subsequently uncontactable and 90 were ineligible to take part for reasons such as having had behavioural therapy in the last 12 months or due to start behavioural therapy, living outside of England, or being an immediate risk to self/others. Of the 308 potentially eligible CYP, 84 families (27.3%) declined to take part due to the child not wanting to participate, family not wanting to attend the baseline appointment, having insufficient time or no specific reason given. Thus, 112/224 CYP (90 male, 22 female) with an average age of 12.2 years (range 9-17; Table 12) were randomised to the intervention arm of the ORBIT trial and were included in the process evaluation. The sample was predominantly white (n = 96, 85.7%) and

well-educated with just over half (n = 60, 53.5%) of the participants mothers having completed university/higher education.

The median IMD rank was 19318 with a range of 147 to 32668 (out of 32844). Of the 112 participants, 8 (7.1%) were in the most deprived quintile (1), 31 (27.7%) in quintile 2, 18 (16%) in quintile 3, 26 (23.3%) in quintile 4, and 29 (25.6%) were in the least deprived quintile (5). Although the reach of the intervention was not limited geographically, for the purposes of the research participants did have to attend a baseline screening assessment at either the Nottingham study site (n = 57, 50.9%) or the London study site (n = 55, 49.1%) depending on personal preference and/or location of residence. All participants were based in England with 63 (56.3%) participants living in towns, 30 (26.7%) in cities, and 19 (17%) living in villages.

In terms of clinical characteristics, the intervention reached a moderately severe symptomatic sample with a mean TTSS of 28.4 (*SD* = 7.7) out of a maximum of 50, with a range of 12-50. The majority of participants (n = 98, 87.5%) were not on any medication for their tics and just under half of the overall intervention sample had no diagnosed or suspected comorbidities (n = 51, 45.5%). Of those who did have a comorbid diagnosis, the most common was anxiety disorder (n = 34, 30.4%) followed by attention-deficit/hyperactivity disorder (ADHD; n = 26, 23.2%). An assessment of depressive symptoms by the MFQ showed a mean score of 16.3 (*SD* = 11.3) out of 66 with 14 (12.5%) participants scoring above the cut-off (≥29) suggesting clinically significant depression (Burleson Daviss *et al.*, 2006).

Table 12. Demographic and clinical characteristics of participants in the ORBIT trial intervention group (N = 112)

	Intervention group
Mean age, years (range)	12.2 (9-17)

Gender, n (%)	
Male	90 (80.4)
Female	22 (19.6)
Study site, n (%)	
Nottingham	57 (50.9)
London	55 (49.1)
Ethnicity, n (%)	
White	96 (85.7)
Asian	7 (6.2)
Mixed race	3 (2.7)
Other	6 (5.4)
Supporter, n (%)	
Mother	93 (83.0)
Father	16 (14.3)
Other	3 (2.7)
Highest level of education (Mother), n (%)	
Did not complete compulsory education	3 (2.7)
Completed compulsory secondary education	16 (14.3)
Completed further education	33 (29.5)
Completed university/higher education	43 (38.4)
Completed postgraduate taught degree	11 (9.7)
Completed doctorate/medical degree	6 (5.4)
Highest level of education (Father), n (%)	
Did not complete compulsory education	2 (1.8)
Completed compulsory secondary education	29 (25.9)
Completed further education	35 (31.2)
Completed university/higher education	29 (25.9)
Completed postgraduate taught degree	10 (8.9)
Completed doctorate/medical degree	7 (6.3)
Method of referral, n (%)	
Self	69 (61.6)
Clinic	43 (38.4)
IMD rank, median (range)	19318 (147-32668)
No tic medication, n (%)	98 (87.5)
On tic medication, n (%)	14 (12.5)
Comorbidities, n (%)	61 (54.5)

No comorbidities, n (%)	51 (45.5)
TTSS baseline score, mean (SD)	28.4 (7.7)
MFQ, mean (SD)	16.3 (11.3)

Note: IMD – Index of Multiple Deprivation; TTSS – Total Tic Severity Score; MFQ – Mood and Feelings Questionnaire.

It was not possible to interview people who had not taken part in the study so the qualitative data threw little light on reach; however, one clinician identified that some families were worried about the level of commitment involved and associated travel to one of the study sites under the category 'Initial response to ORBIT' and theme *clinician perceptions of and contribution to recruitment* (see Appendix I for full list of framework categories and themes in the analytical framework and Appendix J for interpretation of qualitative framework data):

> "So children quite often with autism…other kind of family reasons where I think they were just worried about the level of that kind of commitment to…an intervention to be able to kind of travel to Nottingham or London for the initial assessment" (Clinician 3, Psychiatrist).

Another clinician highlighted the lack of access to children with intellectual disabilities:

> "So say for example they've got severe intellectual inabilities so they're non-verbal you know so clearly they're not gonna be able to access the trials and things. I mean even somebody with a mild…intellectual disability to be honest if it was on the low end of the mild so kind of like between 50 to 60 in the IQ kind of thing…you would struggle to, you know, to access it" (Clinician 1, Psychiatrist).

Finally, one of the clinicians struggled to gain her colleagues' interest in the intervention despite numerous attempts:

> "So but the interesting thing is to get clinicians interested in it and thinking about the children because we have a big Trust with three areas and I have sent it out over and over and over and over again and I think the uptake has been really low from the other…professionals" (Clinician 2, Psychiatrist).

4.4.3 Dose

Child participants completed an average of 7.5 (*SD* = 2.7; Table 13) and their parents completed an average of 7.6 (*SD* = 2.8; Table 14) out of 10 chapters of the intervention indicating high engagement. Only 13 (11.6%) child participants and 17 (15.2%; see Figure 11) parents failed to meet the criteria for treatment completion (i.e. minimum of first four chapters completed as per protocol) with a total of 99 (88.4%) child participants and 95 (84.8%) parents completing their treatment, meaning that adherence to the intervention was high. Indeed, 46 (41%) CYP and 52 (46.4%) parents completed all 10 chapters of the intervention and only one child participant failed to complete any chapters. Participants were given 10 weeks of supported therapeutic input in order to complete their treatment chapters. In some circumstances, such as holidays or particularly busy periods, one or two weeks were added on to supplement this time. Although the majority of families (n = 73, 65%) finished their therapy within 10 weeks, 39 (35%) required extra time to complete treatment. Child participants logged onto the online treatment platform an average of 19.8 (*SD* = 10.9) times throughout the 10-12 weeks with an average of 4.2 (*SD* = 2.6) days between logins. In terms of total interactions with their assigned therapist, child participants required their therapist's online assistance for an average of 59 minutes 14 seconds (*SD* = 00:29:08) over

the course of treatment, which results in around 6 minutes per child per week. Whereas parents interacted online with their assigned therapist an average of 1 hour 23 minutes 55 seconds (*SD* = 00:42:45), which results in around 8 minutes per parent per week. Of 112 CYP, only 2 (1.8%) were contacted by telephone by their assigned therapist. Of 112 parents, 49 (43.7%) were contacted by telephone by their assigned therapist.

Table 13. Usage data for child participants in the ORBIT trial intervention group (N = 112)

	Median (Range)	**Mean (SD)**
Chapters completed	8 (0-10)	7.5 (2.7)
Total therapist time, hh:mm:ss	00:53:57 (00:07:27 - 03:11:08)	00:59:14 (00:29:08)
Telephone time with therapist, hh:mm:ss	00:00:00 (00:00:00-00:18:44)	00:00:10 (00:01:46)
Number of logins	19 (3-57)	19.8 (10.9)
Number of days between logins	3 (1-16)	4.2 (2.6)
Number of pages visited per login	15 (7-38)	16.9 (5.8)
Total number of characters submitted	2507 (238-8749)	2784 (1608)

Table 14. Usage data for parents in the ORBIT trial intervention group (N = 112)

	Median (Range)	**Mean (SD)**
Chapters completed	9 (1-10)	7.6 (2.8)
Total therapist time, hh:mm:ss	01:15:33 (00:22:01 - 04:48:19)	01:23:55 (00:42:45)
Telephone time with therapist, hh:mm:ss	00:00:00 (00:00:00-00:49:00)	00:04:06 (00:07:41)
Number of logins	18 (3-50)	20.4 (11.4)
Number of days between logins	4 (0-19)	4.2 (2.7)

Number of pages visited per login	17 (9-36)	17.4 (5.2)
Total number of characters submitted	6533 (346-29631)	7286 (5093)

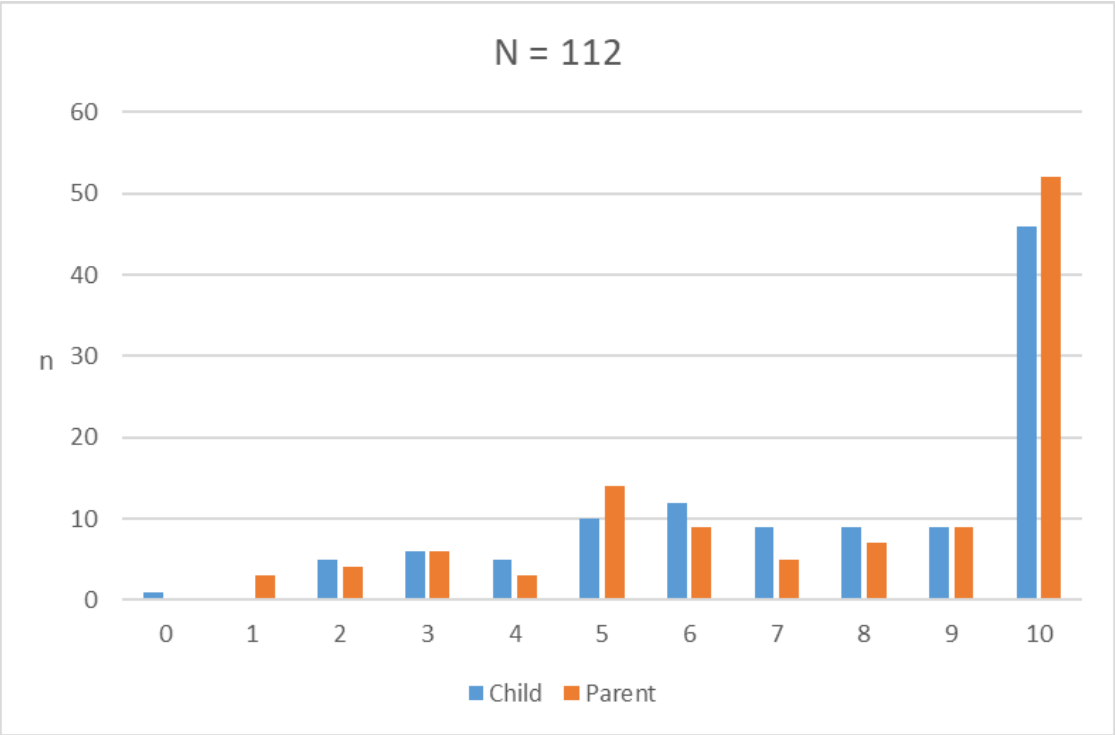

Figure 11. Total number of chapters child and parent participants completed (N = 112)

Interview data relating to participants' *perceptions of ORBIT organisation* (category: 'ORBIT program content') covered the implementation component of dose. Although the majority of participants felt that the intervention was just the right length, some CYP wished to have a longer period of time in which to access their therapist:

> "I just liked doing the whole bit of ORBIT and chatting to my therapist but I think it was too short. Cause I could only chat to my therapist for 10 weeks, but then we had a full year logging on to ORBIT but we could not chat to our therapist which I found a bit annoying" (Child 20, 12 years old).

One child felt that the intervention could have been condensed to make it shorter:

> "9 weeks with 12 chapters. Make the chapters shorter. Some of them are like 13 pages like you have to do the questions. Like those pages questions" (Child 26, 9 years old).

On the whole, parents agreed with their child that the dose received was just right with one parent claiming if it was longer it would have affected engagement in a negative way:

> "Just the right length. I think if it'd been any longer he'd have got he wouldn't have engaged as much" (Parent 26, Mother).

4.4.4 Fidelity

At the 3-week point of post-randomisation, participants were asked to rate treatment credibility. Treatment credibility was rated highly by child participants with a mean score of 6.4 (*SD* = 1.5) out of 8. Furthermore, at the primary end-point, participants were asked to rate their overall satisfaction with the intervention. Child participants were highly satisfied with the intervention with a mean score of 24.8 (*SD* = 5.2) out of a total of 32. At the end of treatment, participants were asked to give their feedback on the intervention within the online platform and they were able to give open-ended responses. Only 67 (59.8%) child participants provided this feedback. From the quantitative content analysis conducted, four categories were generated relating to implementation fidelity, namely, 'limitations of ORBIT' (n = 51), which captured how participants felt that overall ORBIT was helpful however was limited by certain factors; 'ORBIT as a suitable treatment' (n = 49), which suggested that participants felt that the online delivery of treatment for tic disorders was suitable; 'problems with using ORBIT' (n = 20), which captured those participants

who stated that they felt was ORBIT not helpful to them or was associated with negative factors; and 'feeling supported' (n = 19), where participants mentioned that they felt supported in a way they had never been before (e.g. by their therapist). The main code relating to 'limitations of ORBIT' centred on *improvement required* (n = 33). This code captured anything related to the intervention being unhelpful or inappropriate. Examples included repetitiveness of treatment, the treatment being too short or too long, unhelpful aspects, and suggested improvements. Two child participants reported technical issues with the ORBIT platform, which related to intermittent problems with connectivity. Despite this, many participants felt the intervention was acceptable as a treatment with the largest number of participants being coded at *positive experience of ORBIT* (n = 42), which was part of the category 'ORBIT as a suitable treatment' and related to being pleased to have taken part and finding it enjoyable whilst recommending the treatment to other CYP with tic disorders.

See Appendix K for full list of content analysis tables with number of participants who reported various codes and see Appendix L for full interpretation of content analysis data.

Although satisfaction was rated highly, some participants felt that the role of the therapist was somewhat misleading. This was captured by the theme *expectations of role of the therapist* (category: 'Initial response to ORBIT'). Some felt that a therapist was not needed for the delivery of the intervention:

> "Like that just I don't like emailing so I think I felt a bit awkward cause I didn't really know how to write back but I felt most of the comments were quite generic…I don't know just I'd say something and [therapist] be like 'oh well done'…but I don't think [therapist]

necessarily has to be there. I think you could have done it on your own" (Child 21, 15 years old).

Some parents agreed with the sentiment that they could have completed the therapy without the assistance of a therapist:

> "I probably could have done without the therapist because I would want a therapist to advise me about [child's name] tics I didn't need advising about using the therapy, does that make sense?" (Parent 25, Mother).

The term 'therapist' itself was felt to be somewhat misjudged as a label and many participants viewed the therapist more of a 'motivator':

> "I don't know that the therapist was of any use. We didn't utilise the therapist I don't think. It was more sort of it felt like they were cheering you on…they are more like a motivator than a therapist I think. I kind of maybe expected a little too much from the ORBIT study" (Parent 30, Mother).

The therapists themselves concurred with this and perhaps they should not have been called a 'therapist' within the ORBIT study:

> "I think part of it would come down to whether we would want to use the word 'therapist' within ORBIT because there's a lot of semantics and meaning about that word and I'm not sure off the top of my head if therapist or…what's the lay meaning of therapist basically? Does that mean psychotherapist, does that mean someone who's got a doctorate, who knows? So, everyone could…participants come into that with their own meaning and it also assumes that I…they've got expectations about what a therapist is, it assumes that I'm the expert and I really felt like I wasn't in this. My supervisors were experts" (Therapist 1).

At the end of the interviews, participants were asked if they had any recommendations in order to improve the intervention and the overriding majority felt that a mobile application was needed in future iterations of the intervention. This was captured by the theme *ORBIT recommendations* (category: 'ORBIT program content'):

> "I mainly focused on…wanting to beat my score and like I couldn't actually put that on when I was like…I couldn't actually put it online when I was…just like in lesson or when I was like doing it…watching TV, just like do the stop clock on my phone. So I think like if they had an app or something" (Child 27, 13 years old).

Some of the older CYP felt that the content and presentation of the intervention was not directed at them and felt there could be two separate versions in future iterations of ORBIT (i.e. one for teenagers and one for young children):

> "The layout and stuff was very much directed to younger kids…and I think if there was like a separate version of ORBIT that was for more like teenagers and stuff…and…the videos were a bit more…accustomed to young children. I think if there was just a bit there that was more directed to teenagers I think it would be better in that way" (Child 14, 13 years old).

4.4.5 Adaptations

Regarding adaptations, the intervention did not appear to evolve in any way from the original plans. There appeared to be consistency in the way the intervention was delivered and received. Interviews with therapists confirmed how consistency was maintained in delivery. For example, they created a list of standardised responses to common queries (theme: *Strategies to support therapists*):

> "We had standardised documents, of like a collection of standardised responses so any time we'd come across something unique or difficult or not immediately obvious to answer, after sort of emailing around and reviewing potential answers we'd obviously say how to come up with an answer to send to the participant and once I'd done so, I'd add a section into the collection of responses and add it in. So basically, we had something we could look at and call upon when we see someone and go 'look, we're not sure how to answer that, let me check this document' and then you can see if there was anything similar, or it's been answered before umm, that was very useful…" (Therapist 2).

Parts of the intervention were designed to be adapted by the user and tailored to their needs and preferences, such as the 'tic stopwatch' and 'tic ladder' (hierarchy of exposure exercises). For instance, on the 'tic stopwatch' participants could modify the difficulty levels of the given exercises, such as the 'focussing on tic signals' task could be altered depending on how difficult the participant found it. The 'tic ladder' could also be modified so that participants could add their own places to the hierarchy depending on where they tic the most frequently. This was captured by the theme *Adaptations*:

> "I had to answer questions in the chapters and when I finished it I could go back and change it and I could change my ladder when I do my tics and where I do my tics most often and my tic list of what I have. I liked the idea that I could change it. And it helped me" (Child 20, 12 years old).

Another participant adapted the intervention to make it easier to complete by altering some of the activities to make them more user friendly:

> "We…changed some of the activities that like…so one of them was like…doing trying to suppress your tics whilst focussing only on your tics. But I really wasn't able to do that one at all really so we did that while I was watching TV or like being on my phone. So we changed some bits" (Child 22, 15 years old).

4.4.6 Contextual factors influencing intervention implementation

As discussed previously, engagement with the intervention is seen as crucial in determining the effective implementation of the intervention. In order to establish a measure of intervention implementation that captured both the breadth and depth of participants' usage, a principal components analysis with varimax (orthogonal) rotation was conducted on the 7 items relating to the dose of intervention received. The analysis suggested a two-factor model. The strongest factor accounted for 47% of the variance (Eigenvalue 3.3) (see Table 15) and seemed to capture strength of engagement with the intervention. Factor scores ranged from -2.65 to 2.26 with a mean of 0.001 (*SD* = 0.99) and these scores were used as the engagement measure.

Table 15. Summary of principal components analysis for child's usage data for the ORBIT intervention (n = 111)

	Factor Loadings	
Item	**Factor 1 - Engagement**	**Factor 2 – Sporadic use**
Number of logins	.90	
Chapters completed	.79	
Total therapist time for child	.76	
Total number of characters submitted	.74	
Number of days between logins	-.63	.54
Number of pages visited per login	-.41	.80
Telephone time with therapist	-.44	-.46
Eigenvalue	**3.3**	**1.5**
% of variance	**47**	**21**

The data met assumptions of independence and linearity and did not deviate substantially from normality therefore parametric tests were conducted. A 2-tailed *t*-test found that participants who were enrolled at the London site (M = 0.25, SD = 0.90) scored significantly higher on engagement compared to those enrolled at the Nottingham site (M = -0.22, SD = 1.03), $t(109) = -2.58$, $p = .011$. Moreover, those who were self-referred (M = 0.16, SD = 0.94) scored higher on engagement than those who were referred through clinics (M = -0.24, SD = 1.04), $t(109) = -2.06$, $p = .041$. Spearman's rho correlations were run to determine the association between engagement and various contextual factors. CYP's engagement factor score was strongly correlated with parents' chapter completion ($\rho = 0.73$, n = 111, $p<.001$) and moderately correlated with therapist time for parent ($\rho = 0.46$, n = 111, $p<.001$). There were no significant relationships between CYP's engagement factor score and age, parental education, IMD, TTSS at baseline, or MFQ baseline score. There were also no statistically significant relationships between child's gender, comorbidities, or use of tic medication and CYP's engagement.

A multiple linear regression was conducted with CYP's engagement factor score as the dependent variable, and site, child's age, child's gender, IMD, TTSS at baseline, method of referral, parental education, and therapist time for parent, and parents' chapter completion as the independent variables. The results of the simultaneous regression indicated that collectively the independent variables had a significant amount of variance on the CYPs engagement factor score, $F(10,100) = 20.84$, $p<.001$, $R^2 = .64$. There was no evidence of multi-collinearity, with all tolerances above 50%, and all variance inflation factors below 2. Only parents' chapter completion ($\beta = .69$, $t(110) = 10.18$, $p<.001$) and therapist time for parent ($\beta = .19$, $t(110) = 2.96$, $p = .004$) were significant independent predictors

in the model. Results of the multiple linear regression analysis are shown in Table 16.

Table 16. Regression Analysis for predictors of child engagement (n = 111)

Variable	B	SE	β	t	p	95% CI
(Constant)	-3.05	0.56		-5.46	<.001	[-4.15, -1.94]
Site	0.18	0.12	0.09	1.48	0.143	[-0.06, 0.41]
Age	0.01	0.03	0.02	0.34	0.734	[-0.05, 0.07]
Gender	-0.07	0.15	-0.03	-0.46	0.647	[-.036, 0.22]
Index of multiple deprivation	0.02	0.02	0.05	0.81	0.421	[-0.03, 0.06]
TTSS at baseline	0.01	0.01	0.07	1.20	0.233	[-0.01, 0.02]
Method of referral	0.04	0.12	0.02	0.33	0.741	[-0.21, 0.29]
Mother level of education	-0.01	0.05	-0.01	-0.18	0.855	[-0.12, 0.10]
Father level of education	0.01	0.05	0.02	0.22	0.826	[-0.09, 0.11]
Total therapist time for parent	0.07	0.00	0.19	2.96	0.004	[0.00, 0.00]
Parents' chapter completion	0.25	0.02	0.69	10.18	<.001	[0.20, 0.30]

Note: Overall regression model: R^2 = .64, F(10,100) = 20.84, p<.001; dependent variable = child engagement factor score.

Under the framework category 'participant contextual factors', the theme of *parental persuasiveness* was generated. Many of the parents interviewed outlined that they were often the main motivating force behind their child's level of engagement by reminding their child to practise the learnt techniques:

> "If he's got a really bad tic and I'll say to him you know, [child's name] use your tic timer in your head, try and see how long you can do he will then do it…but he doesn't really use the techniques himself without being reminded to…So I suppose that was a little bit of a disappointment" (Parent 15, Mother).

Some parents found motivating their child to engage very challenging:

> "Obviously for me trying to keep [child's name] engaged…on the computer and with the time aspect…you know that was the challenging part" (Parent 28, Mother)

This was even more challenging for those with children who have comorbidities:

> "I knew I'd have to help motivate him…cause he has ADHD…he's got easily distracted and…he hasn't got a great attention span but that was fine because I knew the importance of it so I was fully aware when I went into it" (Parent 8, Mother).

Some parents found it difficult to support their child due to hectic schedules, which was captured by the theme of *busy lives*:

> "It was a challenge as I said because I work 4 days a week…ideally it would have been better to do it after school when we had plenty of time. It was a bit sort of frantic at times…you know trying to fit cooking tea in and…try and fit it in before bedtime so from that point of view…as I said I knew that would be our biggest challenge was the time aspect…so yeah it was a challenge" (Parent 28, Mother).

Although under the theme *high motivation levels*, this found highly engaged CYP without their parents' persuasion:

> "[Child's name] was fully engaged and I think the whole thing made him feel quite special. I think the fact it was targeted. The fact it was all about tics and it was educational and he was seeing other kids with it. It was all positive" (Parent 6, Mother).

4.5 Discussion

This first part of a two-stage process evaluation used a mixed-methods approach to investigate the extent to which the ORBIT intervention was implemented as planned within the context of an RCT and to explore participants' experiences with the intervention and the contextual factors influencing children's engagement. In doing so, this made it possible to identify reasons for variation in uptake, usage, and engagement, to reflect on how implementation may ultimately give greater confidence in the outcomes, and to outline lessons for potential future implementation within routine care. Uptake of the intervention was high with nearly 90% of participants receiving the pre-defined minimum effective dose of first four chapters completed. The median uptake was eight chapters and only one child failed to access any chapters. Fidelity of delivery was also excellent with participants reporting high levels of satisfaction and acceptability.

The intended sample of CYP with a diagnosed tic disorder was reached, with 7.1% of families residing in the most deprived areas (IMD quintile 1) and over a quarter (25.6%) of the families residing in the least deprived areas (IMD quintile 5). As over half (53.5%) of the CYP's mothers had completed graduate-level education, against a UK average of 42% (Office for National Statistics, no date) it seems that more advantaged families may have been over-represented. It may have been that the requirement to have broadband internet access and regular use of a computer, with mobile phone text messaging facilities, in order to participate in the study may have differentially impacted on participants in the most deprived IMD quintile. This is a concern, as one of the aims of ORBIT was to increase access to evidence-based therapeutic interventions for CYP with tic disorders. Particularly as access to services is generally limited for those from lower economic backgrounds (Packness *et al.*, 2017). However, the

initial baseline visit with associated travel may have been a disincentive to more disadvantaged families: a limitation which would not be relevant if ORBIT was delivered entirely remotely in routine care rather than as part of an RCT. Moreover, there was no evidence that socioeconomic factors influenced CYP's engagement with ORBIT. Furthermore, child's age, severity of tics, well-being and comorbidities did not appear to influence child's level of engagement with the intervention providing further evidence that the intervention would have a wide reach within routine clinical care. However, due to the various factors relating to this RCT as opposed to routine care, caution should be taken when interpreting the results from this study concerning reach.

London study site, self-referral, and higher parental engagement were all associated with higher levels of engagement. The London site is a world-renowned centre of excellence for paediatric care which may have increased parents' motivation for treatment. However, the only independent predictors of child engagement in the multivariate analysis was level of parental engagement with intervention as measured by their chapter completion and by parent time with therapist. This is consistent with previous literature (Lyneham and Rapee, 2006; Cobham and Cobham, 2012; Thirlwall *et al.*, 2013; Pennant *et al.*, 2015) which found that parental involvement was particularly key for younger CYP to assist with their engagement with therapeutic interventions, which in turn leads to better outcomes (Nock and Ferriter, 2005; Vernon *et al.*, 2012; Haine-Schlagel and Walsh, 2015). It has been shown in the literature that parental engagement may impact a provider's ability to implement parent- and family-focused evidence-based treatment with fidelity (Haine-Schlagel and Walsh, 2015). Therefore, it is crucial to understand the role of parental support for the implementation of DHIs for children, as without attention to

the key processes of child and family engagement, efforts to improve the effectiveness and efficiency of the treatment are less likely to succeed. Furthermore, it will be crucial to assess whether parental support also predicts intervention efficacy and the mechanisms through which its impact is achieved.

An interesting finding is the usage and interactions with the therapist within this study. Therapists interacted online with their assigned child participants an average of about six minutes per child per week, which is lower than the 24 minutes average time per week participants interacted with their therapist in the Swedish pilot trial of BIP (Andrén *et al.*, 2019). However, in the UK study therapists were encouraged to use pre-prepared scripts to respond to participants. Their responsibilities involved reinforcing the ORBIT treatment material with the aim of spending around six minutes a week responding to each child which was in the therapist guidance given by supervisors. Detailed analysis of the content of therapists' interactions is outside the remit of this study, as that is to be conducted in a future study, but it is apparent from qualitative interviews that many participants felt that the term 'therapist' was somewhat misleading. Some participants felt that 'therapist' had connotations of a clinically trained individual delivering an intervention. This may have limited their reliance on the therapist. Therefore, in any implementation of this intervention within routine healthcare, it would be sensible to alter the title to 'coach', 'guide', or 'mentor' as this better reflects the role of the therapist.

4.5.1 Strengths and limitations

To the best of current knowledge, this study is one of the first studies to have conducted an in-depth mixed-methods process evaluation of a complex intervention aimed at CYP with TS and CTDs. A number of important findings emerged from the process data which helped to

characterise the implementation of the intervention within an RCT and provide lessons for potential future implementation within routine care. Furthermore, a principal components analysis of participants' usage data provided an objective, reliable, and comprehensive measure of engagement with which to explore the role of contextual factors.

However, this study has some limitations. Firstly, there was the issue of potential recruitment bias. It may have been that the more motivated families self-referred to the trial and that recruitment from clinics was skewed towards punctual, frequent attenders, in contrast to patients with multiple missed appointments. This may have limited the power of this process evaluation to detect socioeconomic biases in engagement. Secondly, the information on uptake, although comprehensive, cannot fully capture the quality and quantity of adherence to ORBIT. For example, indices such as chapter completion, number of pages visited, and number of logins may not fully capture factors such as level of attention or adherence to practice exercises. Finally, and perhaps most crucially of all, a major limitation was that it was not possible to interview those who had not taken part in the RCT or to reach those who had withdrawn early from the study. Their perspective is obviously vital to fully understanding factors influencing engagement with DHIs.

4.5.2 Conclusions

In conclusion, the intervention had high fidelity of delivery and was evaluated positively by CYP, although some participants suggested some minor improvements and reach may have been constrained by the nature of the RCT. Parental engagement was a strong, independent predictor of intervention implementation, which has important implications for the design and implementation of digital therapeutic interventions into Child and Adolescent Mental Health Services.

Chapter 5: Part Two – Mechanisms of impact and factors influencing effectiveness

5.1 Abstract

Background: Tic disorders are a highly debilitating neurodevelopmental disorder (NDD). Although behavioural interventions have shown effectiveness, access is limited. Digital interventions have shown efficacy across a range of NDDs, however uptake into clinical practice has been suboptimal. One potential factor impeding implementation may be the lack of research and understanding into the mechanisms of digital interventions' impact. In this second part of a two-stage process evaluation of the ORBIT intervention, a mixed-methods study was conducted exploring the impact of ORBIT, the mechanisms of impact, and the factors influencing effectiveness.

Objective: This study aims to explore the overall impact of ORBIT, contextual factors that influenced impact, and any mediators or moderators.

Methods: Baseline and primary end-point (3-months post treatment) study data from participants in the intervention arm were used as quantitative data (N = 112). The experiences and perceptions of the intervention were explored by semi-structured interviews with children (n = 20) and parent (n = 20) participants, therapists (n = 4), and referring clinicians (n = 6). An engagement measure was used as the mediator and moderator variable against other potential variables, including depression change, anxiety change, parental support, and age. Outcomes were assessed by the TTSS score (including a TTSS change score) on the YGTSS and CGI-I.

Results: Overall, the ORBIT intervention elicited a reduction in TTSS score from baseline (*M* = 27.92, *SD* = 7.17) to primary end-point (*M* = 23.87, *SD* = 8.18), which is a reduction of around four points with a Cohen's *d* effect size of 0.5 and was statistically significant ($p<0.001$). Of 101 participants in the intervention group, 36 (36%) had their condition rated as being very much or much improved on the CGI-I. Only TTSS at baseline ($\rho = -.26$, $p<.001$) was statistically significantly correlated with TTSS change. Child engagement factor score ($\rho = -23$, $p = .02$) and parental chapter completion ($\rho = -.25$, $p = .01$) were statistically significantly negatively correlated with CGI-I. Results from a regression model indicated that only parental chapter completion ($\beta = -.10$, $t(100) = -2.41$, $p = .018$) was a significant contextual predictor in the model. There were no statistically significant mediators or moderators. From the qualitative findings, CYP and parents appreciated working together on the intervention, however they identified certain limitations with the online nature of therapy including lack of an immediate response from their therapist and poor Internet connection.

Conclusions: ORBIT is an effective and acceptable intervention for CYP with tic disorders and engaging parents seems to be a key factor in successful outcomes. With no significant mediators or moderators of outcomes, there is no particular subgroup that is more or less likely to find this treatment beneficial suggesting ORBIT can be implemented to a wide demographic of patients.

5.2 Introduction

As discussed previously (see 1.3.4), tic disorders are a highly debilitating condition that are more common in CYP than in adults (Knight *et al.*, 2012). Although behavioural therapy is effective and avoids the unpleasant side-effects associated with medication, access is limited. Digital interventions have been shown to be effective for a range of NDDs, including tic disorders, in RCTs and offer enormous potential in widening access to behavioural treatments (Khan *et al.*, 2019). However, despite an expanding body of evidence to support the acceptability and effectiveness of online therapy, uptake of DHIs into clinical practice has been extremely disappointing. For instance, there is ample evidence to suggest that digital CBT is effective in treating anxiety and depression (Karyotaki *et al.*, 2017; Andrews *et al.*, 2010), however this has not been widely implemented within clinical practice (Bennion *et al.*, 2017). Various systematic reviews have suggested reasons for a lack of implementation of effective DHIs into clinical settings. These include high costs, poor IT skills amongst staff members, negative attitudes toward DHIs, and general opposition to change (Granja *et al.*, 2018; Vis *et al.*, 2018; Ross *et al.*, 2016). Thus, at an individual level, DHIs must be user friendly and adaptable to the needs of the target population and the staff who engage with them in order for effective implementation (Aref-Adib *et al.*, 2019).

One potential factor impeding implementation may be the lack of research into the mechanisms of impact of DHIs. For instance, in the systematic review conducted within this thesis (see: Chapter 2), only one of the ten trials carried out a separate subgroup analysis of impact. In a RCT evaluating a serious game for children with ADHD, Bul *et al.* (2018) carried out a separate moderator analysis to identify which subgroups benefitted the most from the intervention. They found that girls in general and boys

with both a lower score on hyperactivity/impulsivity symptoms and a higher score on conduct disorder symptoms benefitted most from the serious games, especially on planning/organising skills. The researchers found no moderating effect of age, IQ, medication use, game experience and ADHD diagnosis.

The field of DHIs delivered to CYP with tic disorders is relatively new and therefore efforts are more focused on evaluating overall impact on outcomes instead of identifying moderating variables that are linked to those outcomes. However, there have been moderator analyses of face-to-face tic disorder interventions. One study by Sukhodolsky *et al.* (2017) examined moderators of treatment response to face-to-face behavioural therapy in children and adults with tic disorders. They found that the presence of tic medication significantly moderated impact. For participants receiving 10 weeks of behavioural therapy, medication status did not impact on effectiveness. In contrast, participants in the psychoeducation and supportive therapy group who were receiving medication showed significantly greater tic reduction than participants not on medication. Tic phenomenology, age, gender, family functioning, treatment expectancy, and comorbidities did not moderate response to treatment. A more recent study which examined moderators of treatment outcome after adolescents with CTD received either individual or group therapy found that higher levels of anxiety and a higher premonitory urge to tic favoured treatment in groups, whereas increased hypersensitivity and higher depression symptomology favoured individual treatment (Nissen, Parner and Thomsen, 2019).

As mentioned in the protocol (see Chapter 3), this thesis followed the MRC's guidelines for conducting a planned, mixed-methods, two-part process evaluation of the ORBIT intervention to explore: (i) the fidelity of

delivery and the contextual factors influencing engagement with the intervention; (ii) the impact of the intervention and mediators, contextual factors, and moderators of impact. In part one of the process evaluation (see Chapter 4), it was found that fidelity of delivery was high with child participants completing an average of 7.5 out of 10 chapters and 88.4% receiving the minimum effective dose of the first four chapters. Factor analysis was used to develop a comprehensive measure of child engagement. Parental engagement (i.e. parents' chapter completion and therapist time for parent) was the significant independent predictor of child engagement in a regression analysis. The first part of the process evaluation has important implications for the design and wider implementation of DHIs into clinical settings, as it suggests that an online intervention delivered to CYP with tic disorders can be implemented with high fidelity whilst emphasising the importance of engaging the parent. In addition to evaluating fidelity and effectiveness, it is crucial to successful implementation that we understand in what circumstances a behavioural intervention for tics can be effective and what factors enhance or constrain the impact of the intervention.

Overall, part two of the process evaluation used qualitative and quantitative data to explore the impact of ORBIT, contextual factors influencing effectiveness and factors moderating and mediating the relationship between implementation of the intervention (child engagement) and the impact of the intervention on tic severity and clinical improvement. This will provide insight into how and why outcomes occurred under given circumstances and what mechanisms underlie these impacts in order to facilitate the implementation of the ORBIT DHI into clinical settings. To the best of current knowledge, this study is the first to

examine potential mediators and moderators of an online intervention delivered to CYP with tic disorders.

5.3 Methods

5.3.1 Study design

This study used a mixed-methods, longitudinal design to explore the impact and mechanisms of impact of an online intervention for CYP with tics called ORBIT. This study used quantitative analyses to explore contextual factors, mediators and moderators of impact and qualitative analyses to illuminate those relationships in more depth.

5.3.2 Participants

Participants were CYP randomised to receive the online ERP intervention (N = 112) and their parents. Inclusion criteria was CYP aged 9–17 years, with a suspected or confirmed tic disorder, competent to provide written, informed consent (parental consent for a child aged <16 years), broadband internet access and regular use of a computer, and mobile phone text messaging facilities (Hall *et al.*, 2019). From this sample, CYP (n = 20), and their parents (n = 20) participated in semi-structured interviews. Therapists (n = 4) and referring clinicians (n = 6) were also invited and agreed to participate in semi-structured interviews. See Table 11 for demographic characteristics of all interview participants.

5.3.3 Measures

5.3.3.1 Outcomes

The primary outcome for assessing impact was the tic severity change score as measured on the TTSS at post intervention (3-month follow-up) minus baseline TTSS. Possible change scores ranged from 40 (maximum deterioration) to -50 (maximum improvement). The secondary outcome measure used was the Clinical Global Impressions-Improvement Scale

(CGI-I). Both outcomes were completed by the same trained and reliable assessors blind to the intervention status.

The YGTSS has been described in detail previously (see: 4.3.3.3) and the CGI-I is described below.

5.3.3.2 Clinical Global Impressions Scale (CGI)

The CGI (Guy and National Institute of Mental, 1976) provides an overall clinician-determined summary measure that takes into account all available information, including knowledge of the patient's history, psychosocial circumstances, symptoms, behaviour, and the impact of the symptoms on the patient's ability to function. The CGI comprises two companion one-item measures evaluating the following: (a) severity of psychopathology from 1 to 7 and (b) change from the initiation of treatment on a similar seven-point scale. For the purpose of this study, only the CGI-Improvement (CGI-I) was used as an outcome. The CGI-I consists of one item: "Compared to the patient's condition at admission to the project [prior to the intervention], this patient's condition is: 1=very much improved since the initiation of treatment; 2=much improved; 3=minimally improved; 4=no change from baseline (the initiation of treatment); 5=minimally worse; 6=much worse; 7=very much worse since the initiation of treatment." The questionnaire has established validity and reliability (Busner and Targum, 2007).

5.3.3.3 Child engagement factor score

In order to establish a comprehensive measure of child's level of engagement with the intervention, a principal components analysis with varimax (orthogonal) rotation was conducted on the 7 items relating to the dose of intervention received: number of logins, chapters completed, total therapist time for child, total number of characters submitted, number of days between logins, number of pages visited per login, and telephone

time with therapist. This measure has been described in more detail elsewhere in this thesis (see: 4.4.6).

5.3.3.4 Contextual, mediator and moderator variables

Based on previous research on behavioural therapy for tic disorders (Sukhodolsky *et al.*, 2017; Nissen, Parner and Thomsen, 2019), theoretical assumptions, as well as recommendations about the domains that should be included when conducting moderator analysis in paediatric RCTs (Burns, Hoagwood and Mrazek, 1999), the following four potential mediator variables were selected: depression change (as measured on the MFQ), anxiety change (as measured on the SCAS), treatment satisfaction (Likert scale: overall satisfaction 0-32), and treatment credibility (Likert scale: how well suited and how much better do you expect to be from treatment 0-8). The following seven potential moderator variables were selected: medication use, comorbidity, parental support (number of chapters completed), baseline tic severity (as measured on the YGTSS), age, deprivation (as measured on the IMD), and mother's level of education. Contextual variables were selected based on findings from part one of the process evaluation and outcomes from the exploratory correlational analyses.

The majority of these measures have been described in detail elsewhere in this thesis. Only the SCAS has not been defined in detail and therefore is described below for context to this study.

5.3.3.5 Spence Child Anxiety Scale (SCAS)

The SCAS (Spence, 1998) is a highly validated child self-report measure that evaluates symptoms relating to separation anxiety, social phobia, OCD, pain, agoraphobia, generalised anxiety and fears of physical injury. The child is asked to rate on a 4-point scale: 0='never'; 1='sometimes'; 2='often'; or 3='always' to indicate how often each of the items occurs. In

total, 38 anxiety items are scored yielding a maximum possible score of 114.

5.3.4 Data collection

The data collection is described in detail in the process evaluation protocol (see 3.6 and 3.8). In brief, the combined qualitative and quantitative data collection period was between August 2018 and January 2020. Demographic data including child's age, residence, gender, ethnicity, parental level of education, all current diagnoses, and medication use were collected at baseline (pre-randomisation) and clinical data including TTSS, MFQ, and SCAS were collected at baseline and at the primary end-point (3-month follow-up). The CGI-I was collected at primary end-point only. Semi-structured interviews with CYP and parents were conducted following completion of the intervention at the primary end-point. Interviews with therapists were conducted early in the study and near the end of recruitment in order to gain an understanding of their experience at different time points. Interviews with referring clinicians were conducted at the end of recruitment.

All interviews were conducted either face-to-face, by telephone, or via videoconferencing (WebEx or Skype). Younger children were interviewed together with their parents, while older children were interviewed separately. Participants were purposively sampled to represent views from participants with a range of ages, gender, ethnicity, and level of interaction with the intervention.

5.3.5 Statistical analysis

Data were tested for normality using the Kolmogorov–Smirnov test. A repeated measures ANOVA was initially run to determine whether the intervention had an effect on tic severity. Effect size of the intervention was calculated using Cohen's *d* (Cohen, 1988). Spearman correlations were

used to analyse relationships between the outcome variables (TTSS change and CGI-I) and all contextual, mediator, and moderator variables. This was to establish whether a relationship between the variables exists prior to the next stage of analysis.

Mediator analyses were conducted using the bootstrapping indirect effects method using the PROCESS macro in SPSS (Hayes, 2009). PROCESS is an innovative macro for SPSS based on a regression approach focusing on mediation models and indirect effect testing via bootstrapping. The procedure of bootstrapping creates a large sample (e.g. 5000) from the original data through a sampling with replacement approach. It constructs a confidence interval of 95% around the indirect effect, and the interval must not contain a zero to assume a significant indirect effect. It is used to test hypotheses about the contingent nature of the mechanisms by which an independent variable utilises its influence on a dependent variable (Hayes, 2013). Alternative methods were considered, however previous research found bootstrapping to be among the most powerful methods to detect mediation (Preacher, Hayes and Preacher, 2008; Hayes, 2009, 2013). Mediator analyses were conducted on nonsignificant correlations because the lack of an overall effect does not exclude the possibility of mediated effects (MacKinnon, Krull and Lockwood, 2000).

Contextual variables were examined in a multiple linear regression model. Moderators were examined using regression models. Each potential moderator variable was considered in turn. To formally assess the statistical significance of any observed effect moderation, a multiple linear regression model was fitted with inclusion of an interaction term between child engagement factor score and the moderator variable.

Each variable was centred prior to its inclusion in the mediator and moderator models; continuous variables were centred at their respective

means, while binary variables were recoded as -0.5 and 0.5 (rather than 0 or 1). Centring refers to the subtraction of the overall mean from each observation. Therefore, each variable is ''zeroed'' at its own mean. Centring the data aids interpretation of mediator and moderator analyses and diminishes the effects of multicollinearity (Kraemer and Blasey, 2004).

Given the exploratory nature of the mediator and moderator analyses, we did not correct for multiple comparisons. All data used a significance level of $p<0.05$. All statistical analyses in this study were conducted using IBM SPSS Statistics 27.

The qualitative data set was subjected to the Framework Method of analysis and, in particular, the steps outlined by Gale *et al.* (2013). The software package QSR NVivo 12 was used to analyse this data. Overall, the findings from the qualitative analysis were linked to relevant quantitative measures and contextual factors to assess which potential mediators and moderators may have impacted upon the mechanisms through which change occurred in an approach termed 'triangulation'.

5.3.6 Ethical considerations

Ethical approval for the process evaluation was obtained from North West - Greater Manchester Central Research Ethics Committee as part of the ORBIT trial (REC: 18/NW/0079). All child and parent participants provided written informed consent and all interview participants provided oral consent for audio-recording.

5.4 Results

5.4.1 Characteristics of participants

A total of 112 CYP (mean age 12.2 years; range 9-17 years; males n = 90 (80%)) were randomised to the intervention arm of the ORBIT trial and were included in the subsequent contextual, mediator and moderator

analyses. Clinically, the sample was moderately severe with a mean TTSS of 28.4 (*SD* = 7.7) out of a maximum of 50, with a range of 12-50. The majority of participants (98, 87%) were not on any medication for their tics. See Table 12 for full demographic and clinical characteristics of participants in the ORBIT intervention group.

5.4.2 Overall impact

5.4.2.1 Primary outcome

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean TTSS score statistically significantly differed between baseline and primary end-point ($F(1, 100) = 39.71$, $p<0.001$). The ORBIT intervention elicited a reduction in TTSS score from baseline ($M = 27.92$, $SD = 7.17$) to primary end-point ($M = 23.87$, $SD = 8.18$), which was statistically significant ($p<0.001$). Cohen's *d* for the pre-post change in TTSS was 0.5 indicating a moderate effect. Figure 12 presents the estimated marginal means of the TTSS from baseline to primary end-point with 95% CI.

The mean TTSS change score was -4.05 (*SD* = 6.46) with a range of -36 to 10.

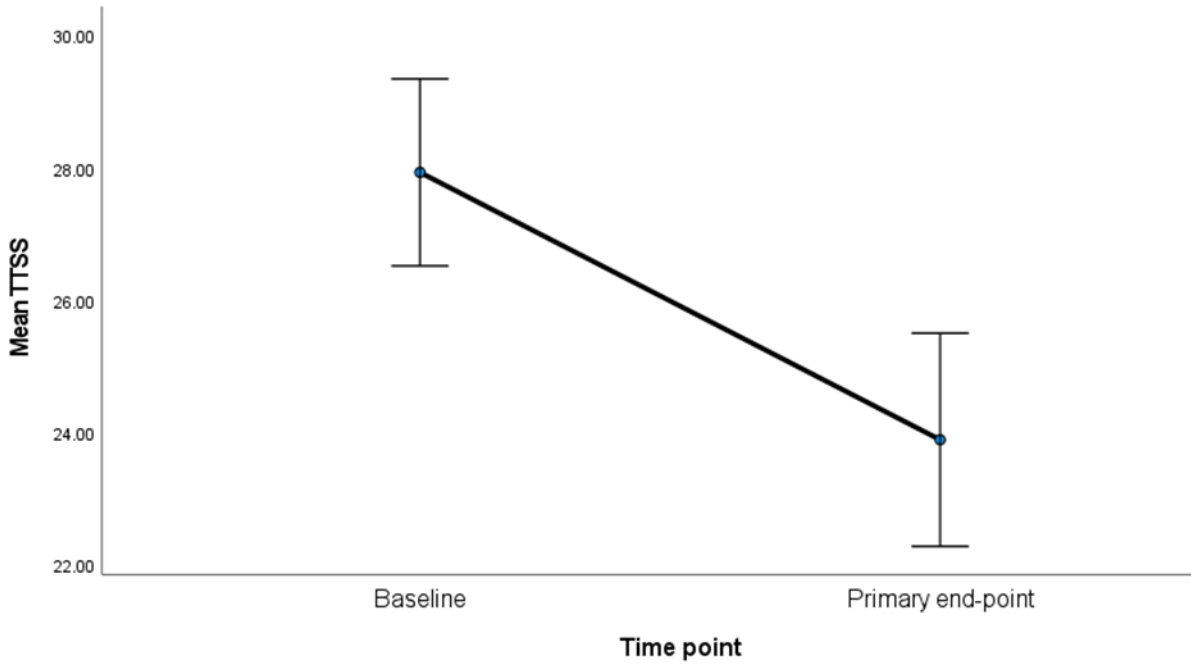

Figure 12. Estimated marginal means in Total Tic Severity Score from baseline to primary end-point with 95% CI

5.4.2.2 Secondary outcome

Of 101 participants in the intervention group, 36 (36%) had their condition rated as being very much or much improved on the CGI-I (Figure 13). Thirty-seven (37%) were rated as minimally improved, 18 (18%) were rated as having no change in their condition, and 10 (9%) were rated as being minimally worse. No participants were rated as being much or very much worse in their condition since the initiation of treatment.

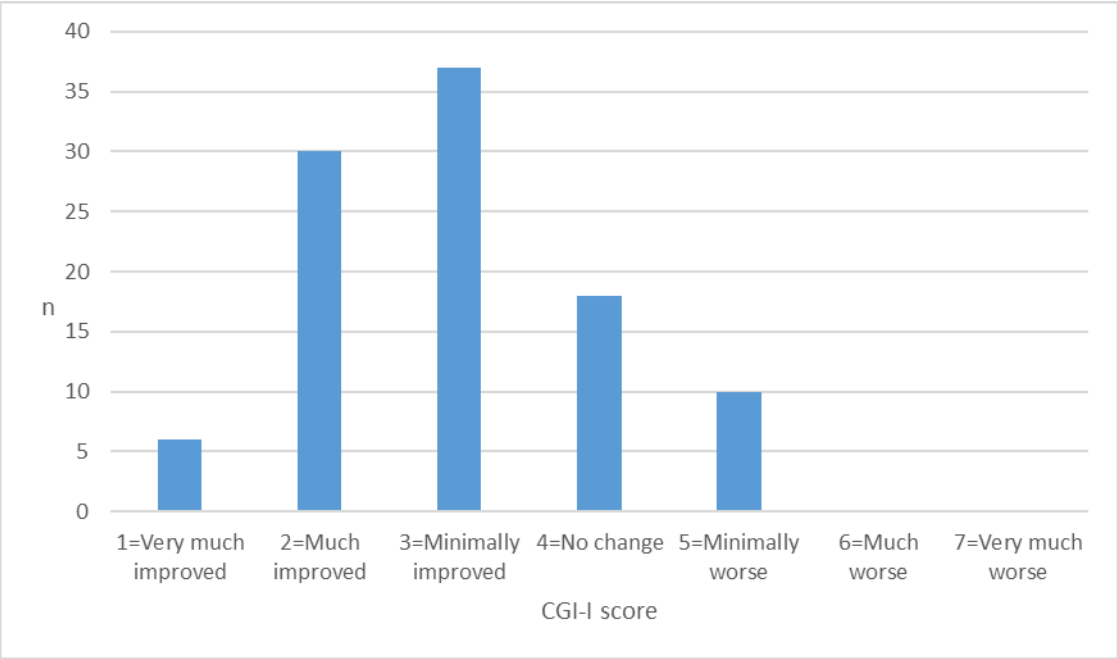

Figure 13. Clinical Global Impressions Scale-Improvement score at primary end-point

5.4.3 Correlations

Spearman's rank correlations were used to analyse associations between all contextual, mediator and moderator variables and the primary (TTSS change) and secondary (CGI-I) outcomes. Only TTSS at baseline (ρ = -.26, p<.001) was statistically significantly correlated with TTSS change so that higher scores at baseline were associated with a greater decrease in tic severity at primary end-point. Child engagement factor score (ρ = -23, p = .02) and parental chapter completion (ρ = -.25, p = .01) were statistically significantly negatively correlated with CGI-I, suggesting that CYP with high levels of engagement with the intervention and CYP with parents who were more involved showed better overall clinical improvement at primary end-point.

Table 17 shows intercorrelations between TTSS change score, CGI-I, and contextual, mediator and moderator variables.

Table 17. Intercorrelations between primary and secondary outcomes and contextual, mediator and moderator variables

Variable	2	3	4	5	6	7	8	9	10	11	12	13	14
1. TTSS change	.51**	-.05	.11	.07	-.05	-.08	.09	.05	.01	-.26**	.13	-.04	-.02
2. CGI-I	—	-.23*	.04	.02	-.12	-.06	.05	-.25	-.25*	.05	.03	.00	.13
3. Child engagement factor score		—	-.01	.08	.47**	.31**	.04	-.19*	.73**	.08	-.14	.18	-.01
4. MFQ at baseline			—	.63**	-.25*	.05	-.15	.02	-.12	.30**	.06	.03	.03
5. SCAS at baseline				—	.04	.11	-.07	.24*	-.07	.26**	.02	.06	-.04
6. Treatment satisfaction					—	.56**	.08	-.21	.23*	-.13	-.19	.08	-.21
7. Treatment credibility						—	.12	-.14	.24*	.01	-.34**	.24*	.05
8. Medication status							—	.03	.00	-.04	.02	.00	-.08
9. Comorbidity status								—	-.13	.10	-.14	.04	-.20*
10. Parent completed chapters									—	-.01	-.22*	.16	-.02
11. TTSS at baseline										—	-.02	-.16	-.06
12. Age											—	-.08	-.07
13. IMD												—	.21*
14. Mother level of education													—

Note: TTSS – Total Tic Severity Score; CGI-I – Clinical Global Impressions-Improvement Scale; MFQ – Mood and Feelings Questionnaire; SCAS – Spence Child Anxiety Scale; IMD – Index of Multiple Deprivation. **p<.001; *p<.05

5.4.4 Contextual factors influencing impact

Following on from the correlational analysis, it was explored whether parental engagement was an independent contextual predictor of overall clinical improvement. A multiple linear regression was conducted with CGI-I as the dependent variable, and parental chapter completion, IMD, and mother level of education as the independent variables. There was no evidence of multicollinearity, with all tolerances above 50%, and all variance inflation factors below 2. The results of the simultaneous regression indicated that collectively the independent variables had a statistically significant amount of variance on CGI-I, $F(3,97) = 3.14$, $p = .029$, $R^2 = .09$. Parental chapter completion ($\beta = -.10$, $t(100) = -2.41$, $p = .018$) was the only significant independent predictor in the model.

Repeating the analysis with TTSS change as the dependent variable found no independent predictors of change in tic severity.

5.4.5 Mediators

Simple mediation analyses found that the relationship between child's level of engagement (child engagement factor score) and either tic severity change (TTSS change) or CGI-I was not mediated by: (i) depression change (MFQ change); (ii) anxiety change (SCAS change); (iii) treatment satisfaction; (iv) treatment credibility.

The mediator analyses did detect some statistically significant pathways between variables. There was a positive and significant direct effect pathway between child engagement factor score and treatment satisfaction ($b = 1.12$, $t(82) = 4.24$, $p<.001$). There was also a positive and significant direct effect pathway between child engagement factor score and treatment credibility ($b = .23$, $t(91) = 3.29$, $p<.001$).

The direct effect between child engagement factor score and CGI-I after controlling for treatment credibility was statistically significant (b = -.30, t(90) = -2.37, p = .02) with a statistically significant total effect (b = -.27, t(91) = -2.26, p = .03), however, there was not a statistically significant indirect effect of the model as the 95% CI included zero [-.07, .16] therefore the relationship between child engagement factor score and CGI-I was not mediated by treatment credibility.

5.4.6 Moderators

A moderator analysis was conducted to assess whether medication use, comorbidity, parental chapter completion, TTSS at baseline, age, deprivation (IMD), or mother's level of education moderated the relationship between child's level of engagement (child engagement factor score) and either of the outcome variables: TTSS change or CGI-I. No variables were found to moderate the relationship between child engagement factor score and outcome on either TTSS change or CGI-I.

Results from the moderator analyses are presented in Table 18, including the interaction terms with each potential moderator variable.

Table 18. Moderator analyses (n = 101)

Variable	**TTSS change**		**CGI-I**	
	F	*p*	*F*	*p*
Medication use	.01	.93	.19	.65
Comorbidity	.36	.54	.05	.81
Parental chapter completion	.38	.53	.01	.91
TTSS at baseline	1.66	.20	1.87	.17
Age	.64	.42	.33	.56
IMD	.06	.80	.06	.79
Mother's level of education	.56	.45	.06	.80

Note: TTSS – Total Tic Severity Score; CGI-I – Clinical Global Impressions-Improvement Scale; IMD – Index of Multiple Deprivation.
*Interaction term – child engagement factor score X moderator variable.

5.4.7 Framework categories

From the analysis of the qualitative data, four categories were generated relating to participants perceptions of impact of the ORBIT intervention: 'Mechanisms of impact', 'Intervention outcomes', 'Intervention characteristics that supported tic reduction', and 'ORBIT program content' (see Appendix I for full analytic framework categories and themes).

5.4.7.1 Mechanisms of impact

A potential factor in explaining the mechanisms of impact was the extent to which participants engaged with the intervention in a meaningful way. When participants began to notice an effect from engaging with the intervention this only strengthened their engagement levels, which may have led to more positive outcomes. This was captured by the theme *features of online therapy to support tic reduction* (Quote 1; see Table 19 for full list of quotes). Conversely, some participants felt that the nature of online therapy had certain barriers which may have impeded its impact with some CYP saying they would have preferred face-to-face therapy. This was captured by the theme *limitations of online therapy* (Quote 2). This theme also captured the frustration that some felt from not receiving an immediate response from their assigned therapist (Quote 3). One parent spoke about how their Internet connection was substandard and found it quite frustrating whenever the ORBIT program would not work (Quote 4).

Level of parental engagement was a contextual factor that was significantly associated with clinical improvement. Qualitative analysis also highlighted the importance of the extent to which CYP received support from their parents in completing the treatment. In particular, CYP appreciated being able to complete the therapeutic activities and chapters with their family members. This was captured by the theme *working together* (Quote 5).

Parents also seemed to appreciate this time spent working together as a team, which may have led to more positive outcomes (Quote 6). One parent explained how the added complication of comorbid ADHD meant that she had to arrange a suitable time and place for when her child was feeling relaxed in order to complete the chapters (Quote 7). Although the *working together* theme was largely related to the parent and child relationship, some parents did appreciate having therapist support. They particularly seemed to appreciate having an expert on hand if they required their assistance on anything that they were unsure about (Quote 8). Finally, one of the clinicians suggested that parental support seems to be the key factor in effective treatments (Quote 9).

5.4.7.2 Intervention outcomes

From this category, various themes were gathered which outlined the impact that the ORBIT intervention had on CYP and parents. The theme *improvement in tics* showed how participants felt that the ORBIT intervention had allowed the severity and frequency of their tics to dissipate (Quote 10). For one child participant in particular, the ORBIT intervention did not have an impact on the overall severity and frequency of their tics, however it did allow them to better understand their premonitory urges (referred to as 'tic signals' in ORBIT; Quote 11).

From the theme *Expectations vs. reality*, some parents thought that the ORBIT intervention would be more effective than it had been and were somewhat disappointed by the outcome (Quote 12). Finally, from the theme *Improved self-esteem and confidence*, some parents also noticed how there was an improvement in their child's psychological symptoms as a result of the ORBIT intervention (Quote 13).

5.4.7.3 Intervention characteristics that supported tic reduction

One theme under this category (*visualisation of progress*) captured how child participants were motivated by the ability to visualise how the treatment worked (Quote 14). This visualisation also enabled child participants to see how, and which tics in particular were increasing or decreasing in severity or frequency.

Another theme (*use of rewards*) showed how participants were motivated to complete the practises within ERP to gain rewards (Quote 15). One parent explained how during the middle of treatment their child began to disengage with the intervention and thus introduced the reward system which reignited their motivation levels (Quote 16).

5.4.7.4 ORBIT program content

In terms of what is known in the literature as 'essential ingredients', these were captured by the theme *useful and enjoyable program resources*. This theme captured how participants found certain components of the intervention to be the most impactful. Most CYP found the 'tic stopwatch' and 'tic ladder' to be the most useful to them (Quote 17). Others were attracted to the videos and animations, which some found to be engaging and an effective alternative to large quantities of text presenting key information (Quote 18). Parents also stated that they liked the videos, as it reassured them of the way they delivered the therapeutic techniques to their child (Quote 19).

Finally, under the theme *lack of fit between content and child*, some older participants found the content and presentation of some of the materials in the intervention to be childlike and aimed more towards younger children (Quote 20). One of the therapists agreed with this sentiment, however felt that due to the large age range involved in ORBIT, they had to cater to all participants (Quote 21).

Table 19. Qualitative quotes from semi-structured interviews

Quote number	Verbatim quote	Framework category	Theme
1	"I thought the therapy would help and I was hoping that it would help if I put some effort in and practise in. But I did not know how it was going to help like I didn't know that there was going to be tic stopwatches in there, videos, and chapters in there" (Child 20, 12 years old).	Mechanisms of impact	Features of online therapy to support tic reduction
2	"I guess with face-to-face, it's easier to connect with my therapist. It's easier to work through something with them. It's easier to make sure I understood the ORBIT stuff so yeah I would have probably have preferred face-to-face" (Child 18, 14 years old).		Limitations of online therapy
3	"You don't get an instant response from the therapist. Obviously they don't work after 5 or 6 o'clock at night…but sometimes they're in every three days or so. So if he didn't get a response the next day, there wasn't an immediate answer to his questions, which again for kids, they want something a little more immediate. And in the same, when you're having a particularly rough		Limitations of online therapy

	time, you'd email, you know, make a comment and because the therapist only works three days a week, you didn't get a response straight away…and that can be a bit frustrating" (Parent 5, Mother).		
4	"Well our internet connection is not great so it kept cutting out or freezing now and again. That was annoying" (Parent 18, Mother).		Limitations of online therapy
5	"I did the chapters with my mum and with my brothers and the tic stopwatch I had my mum or my brothers looking for my tics if I did the tic or not. And like I said that like made it harder for me if I wanted them to or just cheered me on" (Child 20, 12 years old).		Working together
6	"I think…I do this is just from judging from our perspective I do think [child's name] needed to have me guide him if you like on it. So this is what we're going to do and we're going to sit down and I explained to him I've already watched those bits I need to do but you need to watch this section and if you got any questions you can ask me. I think it was nice. I think [child's name] we		Working together

	kind of felt like a team working together on this" (Parent 11, Mother).		
7	"There was sometimes when he was tired and he didn't particularly want to do it but I think because we did it together it then become oh actually I've got the computer out we go on the nice sofa and sit together. So I tried to make it at times when he was reasonably relaxed and receptive because I know what he's like...in terms of prevarication with ADHD. So most of the time it ended up being a nice time that we ended up spending together doing something that was just the two of us" (Parent 21, Mother).		Working together
8	"I don't think I could have done it without [name of therapist]…being there. Because…you know therapy…if I just had access to videos its similar to watching YouTube you know. There are plenty of therapists out there on YouTube but knowing the right questions to ask and where you're struggling and the support behind it, that they know about tics, it does help" (Parent 27, Mother).		Working together

9	"My experience of the cognitive behavioural therapy tended to be you know probably 13 plus that they would have to have fairly committed parents who I think there needs to be a fair bit of encouragement in all these things" (Clinician 6, Psychiatrist).		Working together
10	"Yeah I think it has helped. It's helped me with supressing my tics. Like stopping me ticcing and also like it's stopped me like how much I actually tic" (Child 27, 13 years old).	Intervention outcomes	Improvement in tics
11	"I think it would have had an impact if I didn't struggle so much with noticing my tic signals. Because you know I can't even remember not ticcing so if I did have any tic signals they're just how I feel normally so I didn't pick up on them. And because I didn't pick up on them I really struggled to know when my tics are coming. I mean because I didn't know my tics were coming I couldn't stop them. So I think it helped me realise more that there is a tic signal and I think with particularly strong tics" (Child 21, 15 years old).		Improvement in tics

12	"I thought we'd have an 80-90% reduction…but yeah I was expecting it to be a lot more than it was so I think I was expecting him to be just a little calmer and a little nicer around the house. But it didn't really work quite that well" (Parent 5, Mother).		Expectations vs. reality
13	"It's affected his self-esteem positively. It's affected his outlook on himself…you know sort of being more positive about what he's got. And I think things like that are essential and…so even now that they haven't been limited and I think with his age they'll start to increase" (Parent 8, Mother).		Improved self-esteem and confidence
14	"It was like a circle, a vicious circle, where it was like urge, tics, it goes away, urge, tic, go away ['tic cycle']. And that helps you visualise what goes on and there was another one that was like, the urge, then tic, resist, urge, tic, resist. That helped you visualise what you needed to do" (Child 4, 11 years old).	Intervention characteristics that supported tic reduction	Visualisation of progress
15	"I liked the…reward thing because it was like a constant practicing you'll get a reward so it was like the motivation to do the practice"		Use of rewards

	(Child 27, 13 years old).		
16	"We did get into a bit of a lull midway through which is when we implemented the rewards which was…he's a saver…he likes pocket money so we kind of factored the rewards into his pocket money and…that gave him a bit more impetuous because we did hit a bit of lull…I don't know maybe midway through? Maybe just afterwards and implemented and we had all the rewards stuff and knew about it but in the beginning he was so focused on it and so into it that we didn't need to do it. So we implemented that side of it later" (Parent 6, Mother).		Use of rewards
17	"I think the one where we had to make a list of all the tics [tic ladder]. I engaged quite well with that one I think. I think it was a nice method like getting all the tics and putting them in an organised list" (Child 27, 13 years old).	ORBIT program content	Useful and enjoyable program resources
18	"I liked the videos because I didn't have to read it. And they were telling you it" (Child 16, 10 years old).		Useful and enjoyable program resources

19	"I really enjoyed the videos like when you see the therapist delivering the therapy in the sessions because to me it just kind of shows…because I'm very visual, I like to see things and you know be reassured that actually what I'm doing is right" (Parent 25, Mother).		Useful and enjoyable program resources
20	"Some of it was really a bit young for me because I am on the older end of the test study but…some of it was good to like go over the basics. Some of the like tasks like dragging facts into boxes were maybe a bit young for my age" (Child 22, 15 years old).		Lack of fit between content and child
21	"I think the older children tend to get less out of it, because obviously we've got quite a wide age range from 9 to 17, so inevitably the older children, I've got quite a lot of feedback that they felt it was a bit too young for them, so there's that" (Therapist 3).		Lack of fit between content and child

5.5 Discussion

This study found the ORBIT intervention was associated with significantly reduced tic severity as measured by the TTSS with 36% of CYP rated as having very much improved or much improved clinical outcomes at 3-months follow-up on CGI-I. With the main ORBIT trial results indicating

that the adjusted (for baseline and site) TTSS was reduced by 2.29 points with an effect size of -0.31 in favour of the therapist supported intervention compared to supported psychoeducation at primary end-point (Hollis et al., in press), it can be concluded that the ORBIT intervention had a positive impact on CYP. This study also aimed to identify factors that mediated or moderated the relationship between child's level of engagement with the intervention and overall impact, and any contextual factors that influenced impact. By identifying these factors, this would allow for a clearer understanding of how, why, for whom, and under what conditions ORBIT was likely to be effective in reducing tic severity and improving overall condition. Only tic severity at recruitment was associated with reduction of tic severity post-intervention. Higher levels of child engagement and higher parental engagement with ORBIT were associated with higher levels of overall clinical improvement but only parental engagement was independently associated with CGI-I scores. No mediators or moderators were identified for either reduction in tic severity or clinical improvement. The lack of mediators and moderators for the relationship between usage and impact of the intervention perhaps reflects ORBIT's high level of overall uptake, although there may be influential factors which were not assessed in this study. The impact was relatively modest compared to face-to-face therapy which again may have limited the scope to identify mediators and moderators. For instance, a review of tic treatments in children and adolescents identified two superiority trials of face-to-face behavioural therapy (HRT/CBIT) for tics (N = 133) with evidence of a medium effect size in improving tics in favour of behavioural therapy (HRT/CBIT) when compared to waitlist/supportive psychotherapy (pooled *ES* = 0.64) (Whittington *et al.*, 2016), which is about twice the magnitude of ORBIT.

5.5.1 Parental engagement

The finding that higher levels of child engagement with the intervention led to better overall improvement at primary end-point is consistent with the literature. Bennett and Glasgow (2009) found that level of usage across a diverse range of DHIs was a significant predictor of positive outcomes. Additionally, the association between parental engagement and positive outcomes is also consistent with previous research. Given that level of parental engagement with the intervention was the only significant predictor of child engagement in the first part of the process evaluation (see 4.4.6), it is not surprising this was also a significant contextual factor for positive outcomes. Moreover, CYP who were interviewed in the qualitative component of the current study emphasised that parental support was key for their levels of engagement, which further reinforces the importance of the parental role within the ORBIT intervention. In a review of parental engagement in child mental health face-to-face treatments, Haine-Schlagel and Walsh (2015) found that higher levels of parental engagement led to more positive outcomes, especially in the domain of functioning and impairment. Another study assessing an intervention for young children with autism and their parents, the researchers found that increases in synchronous parental engagement with the intervention led to increases in their child's use of eye contact, directed positive affect, and verbal initiations (Vernon *et al.*, 2012). Furthermore, in a recent systematic review of digital behaviour change interventions for children with chronic health conditions, the researchers found that the majority of what they classed as "promising interventions" had higher parental involvement (Brigden *et al.*, 2020).

5.5.2 The role of the therapist

From the qualitative analyses, a strong theme which occurred was the participants' negative perceptions of the role of the therapist. Some participants felt frustrated with the lack of an immediate response to their queries and, when they did eventually receive a reply, found the content of the messages to be somewhat generic. As was shown in part one of the process evaluation, many participants also felt that the term 'therapist' was misleading, and they expected a clinically trained individual who was directly delivering the intervention (see 4.4.4). However, many participants did appreciate having someone that understood tics and someone to answer any questions that they may have had. From various systematic reviews, the findings suggest that guided DHIs are more efficacious than unguided interventions (Richards and Richardson, 2012; Baumeister *et al.*, 2014), however, it may be that if ORBIT is implemented on a wider scale, it would be prudent to ensure that participants have clear expectations of the therapist role. Since therapists working on the ORBIT trial received five days training in CBIT, it may be that their role could be expanded to reflect that expertise, particularly in respect of mentoring parents.

5.5.3 Mediators and moderators

In terms of the mechanisms through which ORBIT produced impact — by analysing possible mediators and moderators — the quantitative analyses did not find any significant variables. The absence of significant findings in the mediator and moderator analyses in this study has a somewhat different implication than in other types of statistical analyses. The results across various subgroups and contextual factors suggests that treatment efficacy was not significantly affected by sociodemographic or clinical characteristics measured in this sample. Therefore, the findings from this study suggest that ORBIT is appropriate for a wide demographic of CYP

with tic disorders, regardless of parental education or deprivation, age, baseline tic severity, medication use, anxiety or depression levels, or comorbidities. Whilst the lack of statistically significant findings may be unsatisfactory from a scientific standpoint, it is encouraging for clinical practice, suggesting that healthcare specialists can confidently recommend the ORBIT intervention to families irrespective of sociodemographic or clinical traits.

The previous studies to assess potential moderators of behavioural therapy for people with tic disorders did find some significant moderators. In the study carried out by Sukhodolsky *et al.* (2017), they found that for participants in the behavioural therapy group, medication made no difference to outcome but for participants in the psychoeducation and supportive therapy group those who were on medication improved more than those who were not. However, similar to the present study, they found that comorbidities, tic severity and age did not moderate treatment efficacy. In a more recent study, researchers found that anxiety, a higher premonitory urge to tic, hypersensitivity and higher depression symptomology moderated treatment outcome for adolescents who received a therapeutic intervention (Nissen, Parner and Thomsen, 2019). There may be some potential explanations as to why these differences were found. Firstly, both the behavioural interventions in Sukhodolsky *et al's* (2017) and Nissen, Parner and Thomsen's (2019) studies were delivered face-to-face rather than remotely. Furthermore, the sample size in Sukhodolsky *et al's* (2017) study was considerably larger than in the present study (N = 248 vs. N = 112), thus creating substantially greater statistical power. It is known within the literature that large sample sizes and substantial power are necessary to be able to detect mediator and moderator effects (MacKinnon *et al.*, 2002; MacKinnon, Fairchild and Fritz, 2007).

Perhaps it is simply the case that the broader population of CYP with NDDs or psychiatric disorders is appropriately homogenous to preclude any significant mediators or moderators for effective treatment. For example, moderator analyses of the effect of behavioural treatments in children with autism taking risperidone did not find a significant moderator (Farmer *et al.*, 2012), whilst another moderator analysis conducted in children with autism and severe disruptive behaviour treated with risperidone yielded few significant moderators (Arnold *et al.*, 2010). Moreover, in a search carried out by Compton *et al.* (2014) of paediatric anxiety disorders published between 1980 and 2010 that included either predictor or moderator analyses, they found that of 98 RCTs, only five (5.1%) found significant results with regards to moderator analyses. Typically, there were a few consistencies across studies, including small sample sizes (e.g. <100) being the norm. It should be noted that failure to detect significant findings does not prove that none exist, however nonsignificant outcomes in mediator and moderator analyses are inherently interesting in that they suggest certain treatments can be effective for a wide range of populations and demographics. It is clear that more research with large sample sizes is needed to illuminate these assumptions.

5.5.4 Strengths and limitations

The present study marks a comprehensive assessment of the contextual factors, mediators and moderators of an online behavioural therapy delivered to CYP with tic disorders and, to the best of current knowledge, is the first study to do so. A particular strength is that this study used a mixed-methods approach to data analysis, which enabled it to capture a more holistic and richer depth of the mechanisms through which ORBIT achieved its impact. Furthermore, the absence of statistically significant mediators and moderators is encouraging to the extent that it suggests

that this evidence-based therapy can be delivered online to a diverse range of CYP with tic disorders. This is encouraging from a clinical perspective — especially in light of the Covid-19 pandemic — as there is a move away from more traditional forms of therapy (i.e. face-to-face) to digitally based approaches.

Current findings should be interpreted in light of several limitations. First, the ORBIT study was designed to evaluate the main effects of treatment and mediators and moderators of impact were secondary. This, by definition, renders the mediator and moderator analyses as exploratory and should be considered within a hypothesis-generating context. The study also had a major data analytic challenge for these types of analyses, including a relatively small sample size and subsequent lack of power. However, as mentioned, this seems to be inherent in all moderator analysis of RCTs. As a result of these limitations, it was not possible to exclude Type II errors (i.e. a false negative). It would also have been prudent to have included variables such as self-efficacy and motivation within the ORBIT trial so that these could have been investigated as potential mediators of impact. However, the ORBIT study was somewhat overloaded with outcome measures and thus the inclusion of these measures would have further burdened the trial staff.

5.5.5 Conclusions

Overall, this study found that the ORBIT intervention reduced tic severity in CYP with a Cohen's *d* effect size of 0.5 indicating a moderate effect and with 36% of CYP rated as having very much improved or much improved clinical outcomes at 3-months follow-up. Parental engagement was found to be a significant contextual predictor of overall improvement in condition, however, there was no evidence of mediators or moderators of outcomes to an online ERP intervention delivered to CYP with tic disorders. The

results of these analyses suggest that engaging parents is a key factor in successful outcomes and that whilst online therapy seems an effective alternative to face-to-face therapy for CYP with tic disorders, there is no particular subgroup that is more or less likely to find this treatment beneficial. This is a positive finding from a clinical perspective, as it suggests that ORBIT can be implemented within routine healthcare to a broad range of CYP with tic disorders. However, it is clear that more research needs to be carried out in this area with larger sample sizes and with a primary focus on the potential mediators and moderators of impact in order to fully understand the mechanisms through which online therapy has its desired effect.

Chapter 6: Overall Discussion

6.1 Introduction

This chapter brings the thesis to a conclusion by integrating the findings of each study and their contributions to the thesis as a whole. The aims of this thesis were to conduct a mixed-methods process evaluation of an ERP intervention for CYP with tics delivered online with therapist and parental support called ORBIT. Specific objectives were to assess the extent to which the intervention was implemented as part of a trial and the contextual factors that influenced child participants' level of engagement; and to evaluate the overall impact of ORBIT, the mechanisms through which ORBIT achieved its impact and the factors influencing its overall effectiveness. In doing so, this thesis aims to contribute to the wider understanding of how online behavioural therapies for CYP can improve outcomes, and, more broadly, the factors influencing CYP's engagement with DHIs and the potential resources needed in order to implement online ERP for CYP within routine clinical practice.

This chapter begins with a brief recap of the main findings from each study, followed by an evaluation of the findings in relation to each of the overall thesis aims. It then finishes by discussing the main strengths and limitations of the thesis and identify important implications for research and practice.

6.2 Main findings

6.2.1 The effectiveness of online interventions delivered to children and young people with neurodevelopmental disorders: a systematic review and meta-analysis

Access and treatment to behavioural therapies for CYP with chronic health conditions, such as NDDs (e.g. ASD, ADHD, and tic disorders) is currently very limited, however one method of increasing access is through the use of digital technology. Although there have been RCTs evaluating the

efficacy of such interventions for young people with NDDs, at the time of writing, there were no systematic reviews collating the overall evidence of their efficacy. Thus, a systematic review and meta-analysis was conducted to synthesise the evidence about the overall effectiveness of online interventions delivered to CYP with NDDs. The review identified 10 eligible studies which evaluated the effectiveness of online interventions delivered to CYP with NDDs — two of which targeted tic disorders. The review established that six of the ten trials found that online interventions were effective in reducing the severity of NDDs, or associated symptoms in participants. Both studies evaluating the effectiveness of internet delivered CBIT via videoconferencing for young people with tic disorders reduced tic symptomology in participants. A meta-analysis was conducted only on those studies which used valid and reliable outcome measurements of NDD severity and associated symptoms and found neither intervention nor control was favoured, with a high level of statistical heterogeneity detected from five studies.

The review also aimed to evaluate the main characteristics of effective online interventions. Some features were found within the effective interventions. For instance, the use of parental support was utilised in four of the six effective interventions. Of the four interventions which did not produce an effect, two of these did not use parental support. However, it was difficult to establish the main characteristics due to the high level of statistical heterogeneity detected. Overall, the findings suggested that online interventions can be effective in reducing symptoms in CYP with NDDs. However, the evidence was inconclusive due to the limited number of retrieved studies and small sample sizes in the included trials. The findings indicated there was a need for more research with larger sample sizes and in-depth evaluations of digital interventions aimed at CYP with

NDDs to understand how they work (or not), under what circumstances, and for whom in particular. However, the review was somewhat limited in its applicability to ORBIT, as very few of the included studies can be generalised to a tic disorder population as a whole. It may have been more prudent to conduct a review that broadened the criteria to include any evidence-based therapy delivered to children aged 9 and over (i.e., to include CBT). That would have allowed for more flexibility to include subgroup analyses for therapist supported therapies and made the findings more applicable to ORBIT.

6.2.2 Part One – Intervention implementation and contextual factors influencing children's level of engagement

This study was the first part of a two-stage process evaluation using MRC guidelines (Moore *et al.*, 2015) and explored the implementation of ORBIT by conducting a mixed-methods design exploring reach, dose, adaptations, and overall fidelity of the intervention and contextual factors influencing child's level of engagement with the intervention. The findings assessed the intervention as having high fidelity, and participants found ORBIT acceptable and satisfactory. Engagement and adherence were also excellent. Of the overall intervention sample (N = 112), over a quarter (25.6%) of the families resided in the least economically deprived areas (IMD quintile 5) and over half (53.5%) of the CYP's mothers had completed graduate-level education, which is higher than the UK average (42%) (Office for National Statistics, no date). Parental engagement was found to be the only contextual factor influencing child's level of engagement emphasising the important role parents have in digital interventions. Age, gender, level of deprivation, tic severity at baseline, and parental education were not related to child's level of engagement. From the qualitative data, child participants reiterated that their parents were the main motivating force behind their level of engagement and both parents and CYP spoke of

having differing expectations of their assigned therapist and felt they were more of a motivator than a therapist.

6.2.3 Part Two – Mechanisms of impact and factors influencing effectiveness

The second part of the mixed-methods process evaluation investigated the overall impact of ORBIT and if any factors mediated or moderated the relationship between children's level of engagement with the intervention and overall impact, and any contextual factors that influenced effectiveness. The ORBIT intervention elicited a significant reduction in tic symptomology from baseline to primary end-point (3-months post-treatment) by an average of around four points on the TTSS and 36% of CYP were rated as having their overall condition as very much or much improved on the CGI-I. Higher child engagement was associated with greater overall improvement at primary end-point and, similar to part 1 of the process evaluation, parental engagement was the only significant contextual factor influencing effectiveness. However, there were no statistically significant mediators or moderators of outcome. From the qualitative analysis, CYP further emphasised the important role of their parents and they appreciated being able to work together on ORBIT with their family members. Parents and CYP also spoke of certain limitations with the online nature of the platform including the delay between posting a question and therapist response. Overall, the findings suggest that engaging parents is a key factor in gaining successful outcomes and that, whilst ORBIT seems to be effective for CYP with tic disorders, there is no particular subgroup that is more or less likely to find the treatment beneficial. This is positive from a clinical perspective, as it suggests that ORBIT can be implemented successfully within routine healthcare to a broad range of CYP with tic disorders.

6.3 Contributions of findings to overall aims

6.3.1 Fidelity of intervention implementation and contextual factors

The first core component of this thesis aimed to assess the extent to which the delivery of ORBIT was achieved within the context of an RCT and the structures and processes through which it was delivered according to protocol (i.e. fidelity). The findings suggested that ORBIT achieved a high degree of fidelity in terms of uptake of the intervention (nearly 90% of participants receiving the pre-defined minimum effective dose of first four chapters completed), satisfaction and acceptability. This is in contradistinction to the current evidence, whereby online trials in particular may be susceptible to poor recruitment and engagement with the intervention (O'Connor *et al.*, 2016) as well as retention (Verheijden *et al.*, 2007; Khadjesari *et al.*, 2011). The findings suggest that contributory factors were having a world-renowned centre of excellence for paediatric care involved in the study (GOSH, London) and having engaged parents. Two main aspects of the findings contribute to these conclusions; firstly, London study site, those who were self-referred and higher parental engagement were all associated with higher levels of child engagement in the quantitative analysis; and secondly, the themes captured within the qualitative analysis.

Participants at the London study site and those who self-referred to ORBIT engaged at a significantly higher level compared to those enrolled at the Nottingham study site and those who were clinic referred, which was somewhat of an unexpected finding. Self-motivation is a requirement for self-help interventions such as ORBIT thus it could be argued that those who sought referral to this intervention for themselves would be more motivated to adhere to the treatment. Furthermore, the London study site is a world-renowned, clinic and, generally considered one of the leading

specialist tic centres in the UK, which may have potentially increased the family's trust in this prestigious service and felt it was a privilege to be in a study associated with GOSH. Participants may have increased expectancy of successful treatment delivery and therefore be more willing to engage with the intervention. This factor was also captured by the theme *trust in experts*, whereby participants stated that they were more motivated and more likely to engage and adhere to the intervention if it was delivered by those with tic expertise. This finding is in line with recent evidence. A qualitative study found that participants were more likely to engage and adhere to a home-based physical activity programme if a clinician had advocated it, as this was considered vital to reassure patients about the interventions' safety and efficacy, and to add credibility (Okwose *et al.*, 2020).

The most significant predictor of intervention implementation as found by the multiple linear regression within this study was parental engagement. Various studies and reviews (including the systematic review in this thesis) suggest that parental involvement was of particular importance to younger CYP and their engagement with therapeutic interventions and may also impact on a provider's ability to implement parent-focused evidence-based treatments with fidelity (Lyneham and Rapee, 2006; Cobham and Cobham, 2012; Thirlwall *et al.*, 2013; Haine-Schlagel and Walsh, 2015; Pennant *et al.*, 2015). The qualitative data further confirmed the importance of the parental role within ORBIT. Although some parents found motivating their child a challenging task for reasons such as having busy lives and the child's comorbid ADHD, they did emphasise how they were the main motivating force behind their child's level of engagement and adherence with the intervention. From the qualitative findings, a strong theme which occurred was the extent to which parents felt supported in a way they had

never felt previously and their main motivation for referring their child to the study was a lack of access to suitable resources within routine care. Therefore, it seems that ORBIT was a great opportunity for many to receive an evidence-based treatment for the first time and motivation to engage and reap the benefits of it would have been high from the outset. Engaging and supporting parents will arguably improve the sustainability of the intervention and outcomes.

From these findings, it suggests that the parental role was more crucial than the therapist role for effective implementation. Although many participants appreciated having therapist support as and when needed, CYP only interacted online with their assigned therapist an average of about six minutes per week and parents only interacted with the therapist an average of about eight minutes per week. This finding was contrary to expectation, as the Swedish pilot trial of BIP found that therapists interacted with their participants an average of 24 minutes per week (Andrén *et al.*, 2019). However, from the qualitative data, it seemed that many participants had a different expectation of the role of the therapist. They felt that the therapist would be a clinically qualified individual who would be actively delivering the treatment sessions. Perhaps it was the case that many participants began to interact with their therapist and when they discovered the nature of their role, they subsequently reduced their reliance on the therapist, which may reflect the importance of parental support to supplement this. This is an important finding, as it has implications for the implementation of this treatment in routine care. Firstly, it is important from an economic perspective, as if therapists' time is less intensive and their role is less clinically demanding, they could be employed on a part-time basis and they would require only limited training. Secondly, it would be sensible to alter the title of the therapist to avoid

high expectations of their role. It may be more effective to call them a 'mentor' or 'coach' or similar, which seems to capture the essence of their role. As research of online interventions suggests supported therapy is more effective than non-supported (Baumeister *et al.*, 2014), it would be sensible to have a therapist present in any wider implementation, however, the modifications suggested above would make their role more operational. Furthermore, the evidence for the effectiveness of ORBIT is based on the fact it is therapist supported. There is no empirical evidence for implementing ORBIT in routine care without the support of therapists.

Overall, the finding that ORBIT was implemented with high fidelity and the main contextual factors found from the first part of the process evaluation are important, as they improve the validity of intervention outcomes (Hulscher, Laurant and Grol, 2003; Carroll *et al.*, 2007), enable replicability (Montgomery *et al.*, 2013), and also aid in our understanding as to why ORBIT succeeded (Hasson, 2010).

6.3.2 Mechanisms of impact and contextual factors

Prior to the commencement of the process evaluation, a logic model (see Figure 8) was designed to demonstrate an understanding of the intervention's likely causal mechanisms. The findings from the second part of this process evaluation have provided evidence to support many of the proposed determinants as instrumental in outcomes, but not necessarily via the expected mechanisms. As was expected, though, parental support played a crucial role in successful outcomes.

The ORBIT intervention elicited a mean reduction in TTSS score from baseline to primary end-point of around four points with a Cohen's *d* effect size of 0.5, indicating a moderate effect. Analysis from the main trial paper (Hollis et al., in press) indicated a significant effect of TTSS in favour of the intervention (mean TTSS reduction of 4.5) compared to the control group

(mean TTSS reduction of 1.6) at primary end-point. The adjusted (for baseline and site) TTSS was reduced by 2.29 points with an effect size of -0.31 in favour of the therapist supported intervention compared to supported psychoeducation at primary end-point. The absolute tic reduction found in ORBIT is slightly less than previous studies of digital interventions for tic disorders (Himle *et al.*, 2012 (mean TTSS reduction of 6.4 points at follow-up); Ricketts *et al.*, 2016 (mean TTSS reduction of 7.25 points at follow-up); Andrén *et al.*, 2019 (mean TTSS reduction of 5.50 points at follow-up); Rachamim *et al.*, 2020 (mean TTSS reduction of 11.68 points at follow-up)). The effect size and tic reduction are comparable to previous studies assessing face-to-face therapeutic interventions for tic disorders (Cook and Blacher, 2007; Whittington *et al.*, 2016) but somewhat smaller than that found in Piacentini *et al.* (2010) RCT. However, it is difficult to make direct comparisons of therapeutic efficacy with previous trials of digital and face-to-face behavioural therapies given that participants in ORBIT had a high level of baseline tic severity (M = 28.4, SD = 7.7), fewer co-morbidity exclusions, a lower proportion of participants receiving tic medication (13%), and the range of therapeutic methods employed (see Table 5).

Facilitating engagement with the intervention appeared to be the fundamental mechanism through which ORBIT achieved positive outcomes. The findings suggest that the intervention achieved this through having engaged parents and characteristics of the intervention itself, such as the use of animations and videos and the use of the reward system, which led to more positive outcomes. Similar to part 1 of the process evaluation, parental role appeared to be the key factor, as it was shown to be the only predictor for influencing overall clinical improvement. This supports the existing literature regarding the crucial role parents have in positive

outcomes for CYP across a range of treatments for a variety of conditions (Vernon *et al.*, 2012; Haine-Schlagel and Walsh, 2015; Brigden *et al.*, 2020). In addition to the direct impact of tic disorders and associated conditions on CYP, these issues often have an equally distressing effect on their parents. A parent's perception of their child's vulnerabilities and the experience of a limited social/school life are both likely to have a significant negative impact on parental wellbeing and the wider family unit (Vernon *et al.*, 2012). For example, studies have shown that stress from caregiving, anxiety, lack of social support, and disrupted caregiver sleep have all played a role in how complex conditions relate to maternal depression (Boman, Lindahl and Björk, 2003; Manuel *et al.*, 2003; Meltzer and Mindell, 2006; Moore *et al.*, 2006). These factors, together with parents stating that this was their first attempt at any form of non-pharmacological treatment for their child, meant that parents may have felt they were the primary driver for their child's engagement with ORBIT. This was captured by the theme *parental persuasiveness* from the qualitative data. Moreover, parents bring a strong level of commitment, availability and personal expertise of their child that is an invaluable asset to trials (Vernon *et al.*, 2012). These traits, when combined with education in evidence-based treatments, have the potential to serve as a powerful therapeutic force in a child's intervention. As parents had their own chapters to work through, they appeared to gain more knowledge of their child's tics and were able to understand them better. This was evidenced from the qualitative theme *impact on parent*, whereby many parents spoke of empathising more with their child's condition, not commenting on their tics, and feeling better able to support them. Furthermore, both CYP and parents' accounts of their experiences frequently cited being able to work together as a team as one of the main drivers for how they conducted their time on ORBIT. It was clear from the interviews that ORBIT managed to facilitate a symbiotic

relationship between child and parent, which may have led to positive outcomes.

Participants' perceptions of their experiences of using ORBIT were almost universally positive, with accounts stating that the platform was easy to use and navigate with visually appealing and attractive animations and videos. Whilst design considerations of DHIs are one of many factors, the findings suggested that these may be especially important in initial stages of engagement to encourage continued use and adherence. Participants' perceptions of the presentation of information and usability of the intervention appeared far more substantial in these initial stages, which was evidenced from the qualitative interviews where participants stated that the early materials engaged them sufficiently to encourage continued use. These findings are consistent with existing literature with regards to how individuals make credibility judgements about online information (Liao and Fu, 2014) and cost-benefit analysis of behaviour (Horne and Weinman, 1999; Donkin and Glozier, 2012) to determine their projections of continuing. This was further evidenced by some parents stating that their child's engagement began to dissipate in the early to middle stages of treatment, whereby they felt the information presented was becoming somewhat repetitive. Some parents would then introduce the reward system in order to facilitate continued use. This seemed to be an effective strategy to engage their child and ensure that they would maintain their level of commitment with the practises involved in ERP. Whilst many of the younger children appreciated the graphics and animations, the older children felt they were somewhat "child-like". As ORBIT was delivered to a wide age range, in retrospect, it was difficult to cater to this demographic holistically and, as there was no association between age and effectiveness, it seems the presentation did not impact on outcomes.

In terms of what the literature calls 'essential ingredients', this thesis appeared to shed some light on what these may constitute. Specific features such as the video demonstrations of therapy, animations, the ability to visualise which tics in particular were increasing or decreasing in severity and frequency on the 'tic ladder', and the 'tic stopwatch' were all highlighted as especially engaging and enjoyable. Indeed, these interactive components were identified as key features of the intervention that seemed to be used most. This is consistent with evidence that interactive elements, including attractive audio-visual material to be amongst the most highly used features of DHIs as they tend to keep users' interest (Wantland *et al.*, 2004; Brouwer *et al.*, 2011). This would be especially important to younger children whose concentration levels would not be maintained with material that was simply presented in writing, for example. Although participants were mainly positive about the features of ORBIT, they did have some recommendations for future iterations of the intervention. Participants were unanimous in their feedback that an app would be a welcome addition in a future version of ORBIT. This would be time saving and more efficient, as it would have the benefit of participants being able to log their 'tic stopwatch' times remotely.

Overall, these findings contribute to our understanding of the way in which DHIs work and what is required to make their impact more successful. As some studies have shown that digital technology can be used to reduce symptoms in CYP with tic disorders, this thesis contributes to the wider knowledge of the underpinnings of their mechanisms of action.

6.4 Strengths and Limitations

This thesis marks a comprehensive evaluation of a digital intervention delivered to CYP with tic disorders. This understanding is important in order to fully understand the circumstances under which such interventions are

likely to be effective, for whom in particular, and in order to maximise its efficacy (Craig *et al.*, 2008). In addition to explaining intervention-specific processes, the findings also contribute to the currently limited knowledge regarding how CYP and their parents engage with digital interventions to manage complex symptoms. Furthermore, it provides evidence of the feasibility and utility of digital interventions amongst a youth population.

There are several strengths within the design of this process evaluation which was carried out concurrently with the ORBIT trial. A particular strength was that the methodology was based on a peer reviewed published protocol (Khan *et al.*, 2020), which is considered 'best practice' within process evaluation research. The sample involved in the semi-structured interviews and within the ORBIT intervention group were comparable in terms of age, gender, and baseline TTSS. As stipulated in MRC guidelines (Moore *et al.*, 2015), a mixed-methods approach was undertaken in the form of an integrative mixed-methods design. The use of two methodologies strengthened the validity of the study findings, as any weaknesses within one method were compensated by the strengths of the other method. Moreover, the qualitative data offered a more in-depth evaluation to participants, therapists, and referring clinicians' perceptions and experiences with ORBIT and was able to capture outcomes the quantitative dataset could not. Furthermore, the analysis of intervention usage data provided a detailed objective insight into the important features and underlying determinants central to its implementation and effectiveness. As recommended (Moore *et al.*, 2015), process evaluation data were analysed prior to the trial findings were known, thus avoiding biased interpretation of data.

Another major strength of this thesis is the use of an objective, comprehensive measure of child's level of engagement with the

intervention. By using a principal components analysis of dose of intervention received, this thesis was able to capture an innovative measure of engagement, which could be replicated in future designs of such studies. Several strategies were utilised to strengthen the validity of the qualitative analyses. Researcher bias which may have influenced the analyses was considered and described in a reflexive account (see 3.10.1). Furthermore, a multidimensional perspective was achieved by considering both CYP and parents' as well as therapists and referring clinicians' perceptions (Mason, 2006). A subset of the transcripts were also double coded and disagreements in coding were discussed which strengthens the validity and reliability of the qualitative data. A further strength of the qualitative data was the use of PPI in guiding the semi-structured interview questions.

Despite these strengths, this thesis and the subsequent findings should be interpreted with caution as a result of several limitations. Firstly, there is the issue of potential recruitment bias with the ORBIT trial, which is a threat to the external validity of findings. A large proportion of the intervention sample were self-referrers, and this sample may not be reflective of the characteristics of families with tic disorders as a whole. Those who volunteer their participation may be more willing and motivated to engage with treatment, which may have explained the high rates of engagement and adherence with the intervention. Accordingly, these families may demonstrate different behaviours and have different experiences than those less motivated to participate. It was also difficult to recruit participants to be interviewed who had either dropped out of the ORBIT trial early or were not deemed treatment completers and thus this data may have been skewed towards more positive experiences of the intervention. Furthermore, there are some limitations regarding the

generalisability of findings from the ORBIT sample. Whilst the sex distribution is typical for a tic disorder population, a large proportion of the sample was white, which may limit the generalisability of the findings with regards to ethnicity. Level of tic medication use, and comorbid OCD diagnoses were lower than in comparable studies conducted in the United States, which may limit generalisability to these populations. Finally, while the level of tic severity in ORBIT is higher than in comparable studies, the findings may not be generalisable to those young people with tics outside the severity range of this study population.

Limitations relating to the quantitative dataset must also be considered. This study was embedded within a trial, which limited the sampling frame. Although the ORBIT trial was one of the largest in online tic disorder research, for the purposes of the mediator and moderator analyses in particular the sample size was somewhat underpowered. Therefore, the lack of statistically significant findings within these analyses may have been due to the lack of power and should be considered as exploratory. In retrospect, it may have been prudent to include quantitative measures of self-esteem and sense of control of tics within the ORBIT trial, as this would have complemented the qualitative findings from this thesis and Cuenca *et al.* (2015) study. However, the process evaluation was constrained by being embedded within the trial. Finally, whilst process evaluations tend not to assess the control arm, in doing so it may have strengthened the generalisability of the overall findings contained within this thesis while giving a more holistic view of ORBIT.

6.5 Implications of thesis

6.5.1 Future research

The findings emanating from this thesis have wider implications for potential research in this area. Primarily, it would be important for any

future work to supplement the limitations highlighted above. Indeed, a more intensive effort to recruit participants who did not engage satisfactorily with digital interventions or dropped out early would be welcome. This would enable researchers to gain a more holistic understanding of the implementation and mechanisms of action and the findings would not be skewed towards more positive experiences. Moreover, by recruiting a sample large enough to detect mediator and moderator effects between child engagement and outcomes would allow for stronger theoretical conclusions to be drawn about predictors of impact. The findings from this thesis also identify questions that need to be answered. One of these relates to the processes through which self-esteem and confidence are reduced by digital interventions. Parent experiences of ORBIT emphasised how their child's self-esteem and confidence improved; however, this was not quantitatively captured. Moreover, a recent study of an online intervention for youth with tic disorders found a significant improvement in self-esteem (Rachamim *et al.*, 2020) suggesting that DHIs can have a positive impact on important outcomes. Future RCTs of complex interventions should consider the integration of quantitative process data from the outset which could then provide further insight. Whilst it was out of the remit of this thesis, future studies of DHIs that contain therapeutic support should also consider analysing the messages sent to and from participants to therapists. This would allow for a deeper understanding of these interactions.

More broadly, it would be valuable for future studies of complex interventions for CYP to include process evaluations. These should include objective usage metrics and also longitudinal qualitative data. Such research designs and analyses have been valuable for this thesis' findings: in being able to assess the quality and quantity of what was delivered;

identifying specific components of the intervention which appeared to be most effective; and in understanding the underlying mechanisms that seemed influential in determining users' experiences and perceptions of the intervention. Finally, and most crucially of all, future research should consider how this evidence-based online ERP intervention can be made deliverable in routine NHS care, thus giving more people access to much desired non-pharmacological treatments.

6.5.2 Implications for practice

Tic disorders and associated conditions are highly debilitating, which have a profound impact on both CYP and their parents. A range of tic related difficulties with academic work, and social and emotional well-being in CYP have been reported. For instance, in a qualitative study of young people with TS and their parents, participants reported that TS made school work more difficult and TS made it more difficult to manage their emotions in school (Wadman *et al.*, 2016). Tics are also related to significant isolation and withdrawal and children with tic disorders experience a lower quality of life (Eddy *et al.*, 2011; Kraft *et al.*, 2012; Wadman, Tischler and Jackson, 2013). Considering these tic-related impairments and implications for future life, knowledge of the best treatment options for tic disorders in CYP is clinically important. Children and their parents generally prefer behavioural therapy over medication due to the fewer associated adverse effects (Cuenca *et al.*, 2015), however the most widespread mode of treatment is pharmacotherapy (Whittington *et al.*, 2016). Although behavioural therapy for tics has demonstrated similar efficacy to pharmacotherapy (Whittington *et al.*, 2016) and is often recommended as a first line treatment (Roessner *et al.*, 2011; Hollis *et al.*, 2016) it is rarely available due to the shortage of trained therapists and limited number of specialist centres.

Therefore, the findings from this thesis have important implications for practice in a myriad of ways. It has shown how CYP engage with complex interventions; the importance of parental support and motivation; identified those who benefit the most from such interventions; and, more broadly, how DHIs can be designed and implemented in order to maximise their efficacy. Most importantly of all, the findings demonstrate that an online intervention is effective, can be delivered with high fidelity, and is highly acceptable to CYP with tic disorders and there is no subgroup who benefits the most. With evidence from the main ORBIT trial showing that the intervention is more efficacious than the control group and is cost-effective (Hollis et al., in press), this has important implications for how this intervention is delivered to patients within the UK. An online intervention that could be deployed to large numbers of patients at a relatively low cost is a much needed and seemingly acceptable means of providing patients with access to an evidence-based treatment. It could provide immediate access to ORBIT for those who otherwise would not have access due to long waiting lists or their geographical location, which could also potentially free up existing resources and services for those requiring more complex treatment and assessment. Thus, cutting costs and waiting times would be a two-fold benefit for the NHS and patients alike.

In addition, one of the barriers to reach identified was the associated travel to the baseline assessment. It would therefore be sensible to have an initial remote assessment. As the use of remote medical assessments is increasing due to the current Covid-19 pandemic, this flexible approach would allow even more people to benefit from this intervention. As already discussed, it is also recommended that the therapist's name should be altered to avoid high expectations of their role. Furthermore, they could be employed on a part-time basis and would require very little training, which

would cut costs even further. As the findings indicate, therapists should engage the parent as much as possible to achieve successful outcomes. Finally, it would be crucial to consider at what stage this intervention should be delivered to patients. From the qualitative analysis, referring clinicians suggested offering this treatment immediately after the patient has been diagnosed in order to "catch it early". This seems sensible from a clinical perspective as timely treatment will have long-lasting benefits for patients and findings from the impact study of this thesis indicated that ORBIT is effective for a wide range of patients.

6.6 Conclusions

This mixed-methods study is a comprehensive assessment of the processes underlying a complex online intervention delivered to CYP with tic disorders, using MRC guidelines as a framework (Moore *et al.*, 2015). The ORBIT intervention had high fidelity of delivery and was highly acceptable and satisfactory to CYP, although some participants suggested some minor improvements, such as an app to store their timings from the 'tic stopwatch' task. The reach of ORBIT may have been constrained by the nature of the RCT (i.e. baseline travel to one of the two study sites), however, this would not be an issue if delivered in routine healthcare. Engagement and adherence from both CYP and parents were excellent, whilst parental engagement was a strong, independent predictor of intervention implementation.

In terms of outcomes, the ORBIT intervention had a positive impact on participants as it reduced the severity of their tics and improved overall clinical condition. The mediator and moderator analyses suggested there were no subgroups who found the outcomes more or less positive, which indicates that ORBIT is appropriate and effective for a wide range of demographics. Parental engagement was found to be a significant

contextual factor influencing overall improvement in condition further emphasising the important role of parents in therapeutic interventions. However, further research with larger sample sizes is required to detect statistically significant mediators and moderators of impact to clarify the understanding of the complex interrelationships between the mechanisms of impact of the intervention.

Overall, ORBIT is an effective and acceptable means of delivering an evidence-based ERP treatment to CYP with tic disorders and supporting them in overcoming barriers to accessing this therapy. Whilst some CYP may require additional support from their parents to enhance their level of engagement with the intervention, there is substantial evidence that this online intervention is a promising means through which these debilitating and complex symptoms can be addressed.

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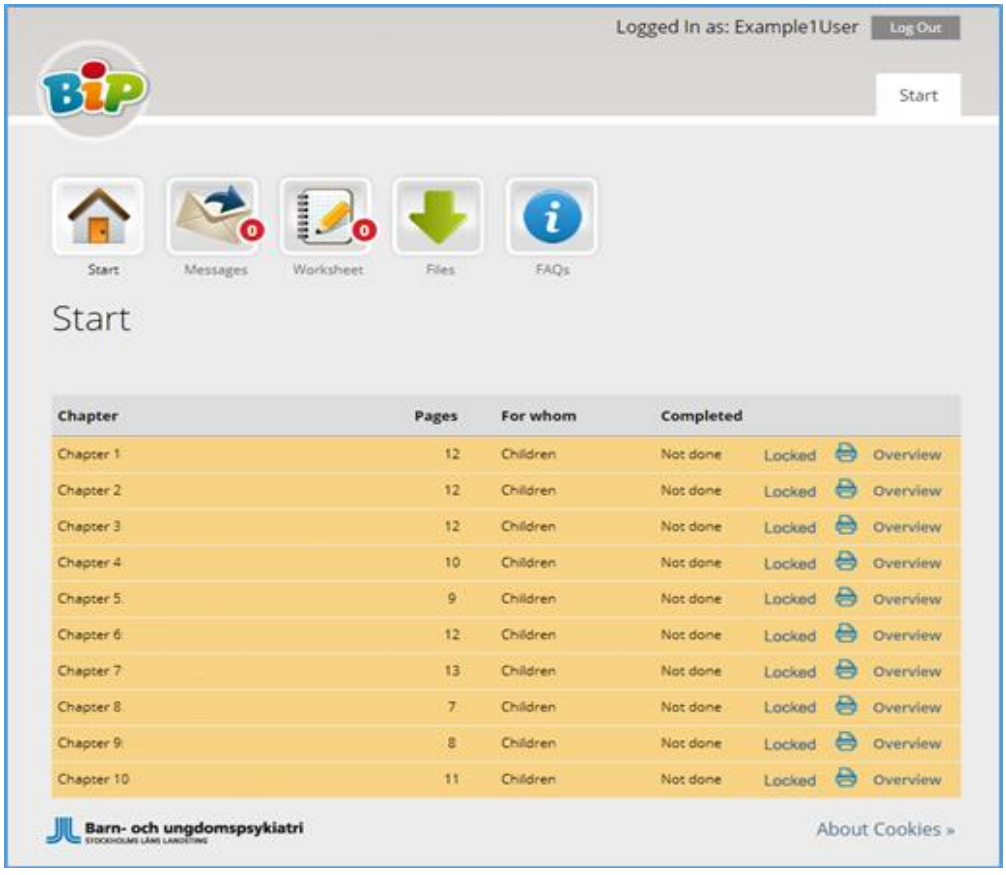
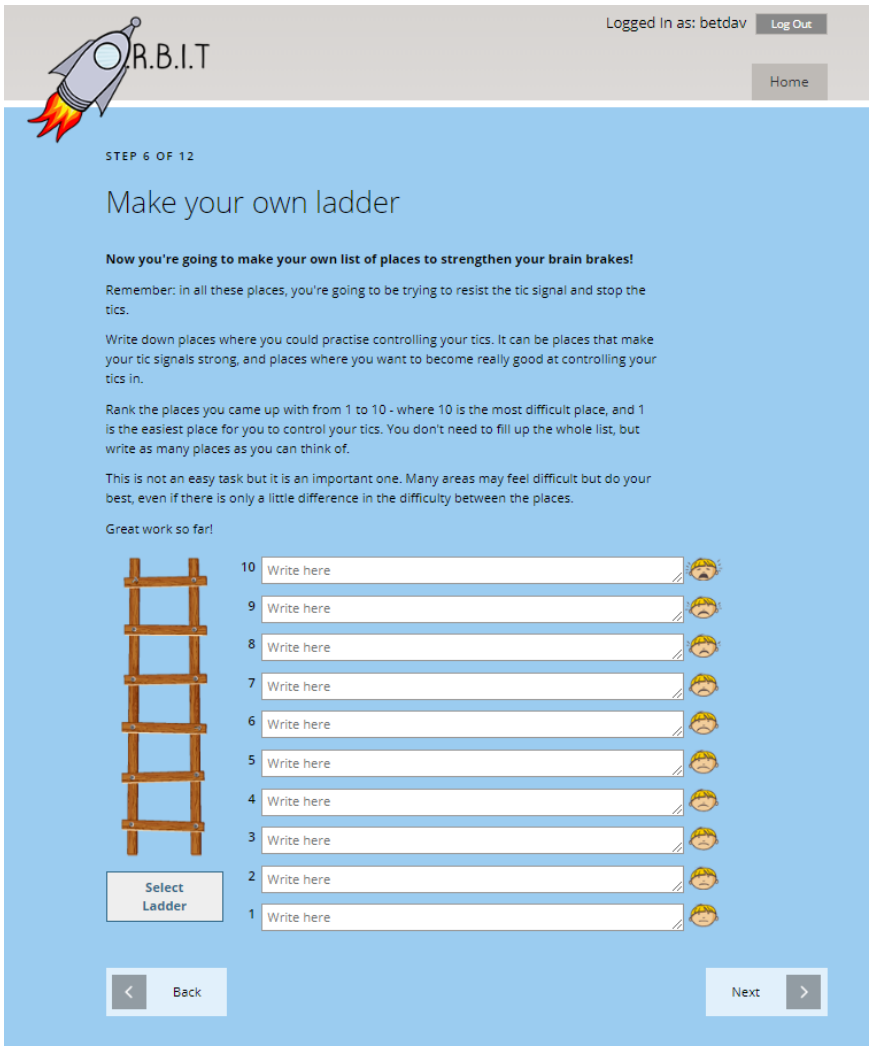
Appendix A Screenshots of ORBIT pages

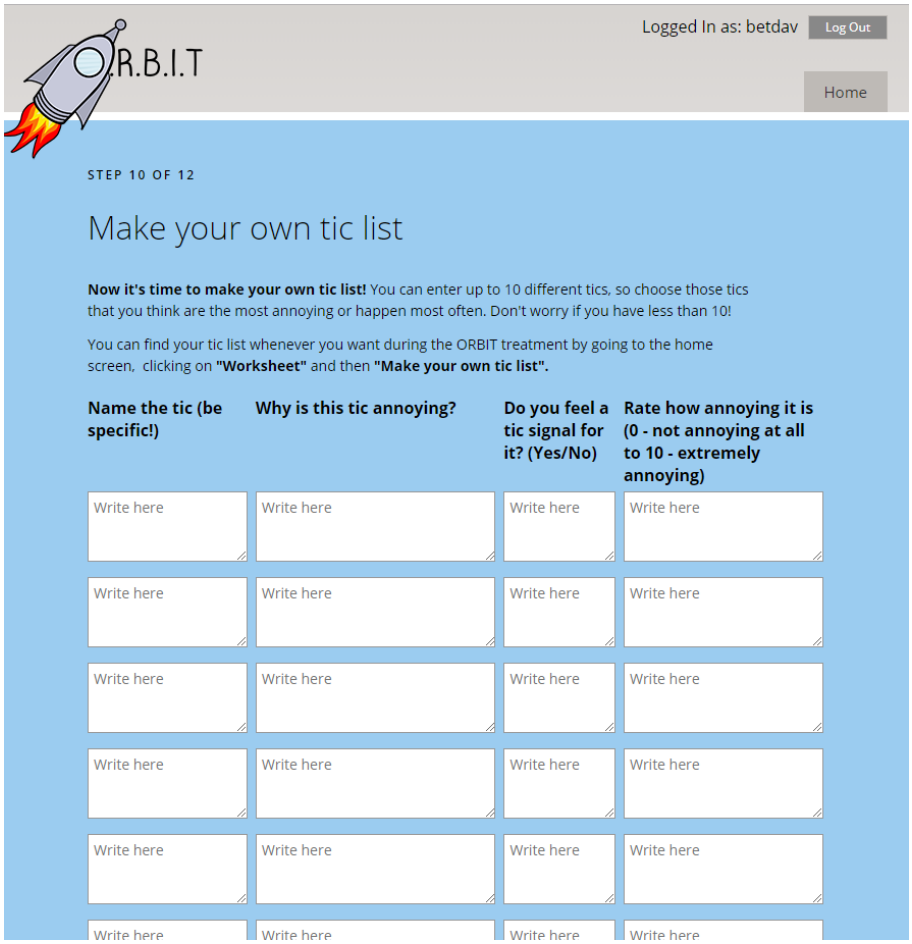
Log in screen



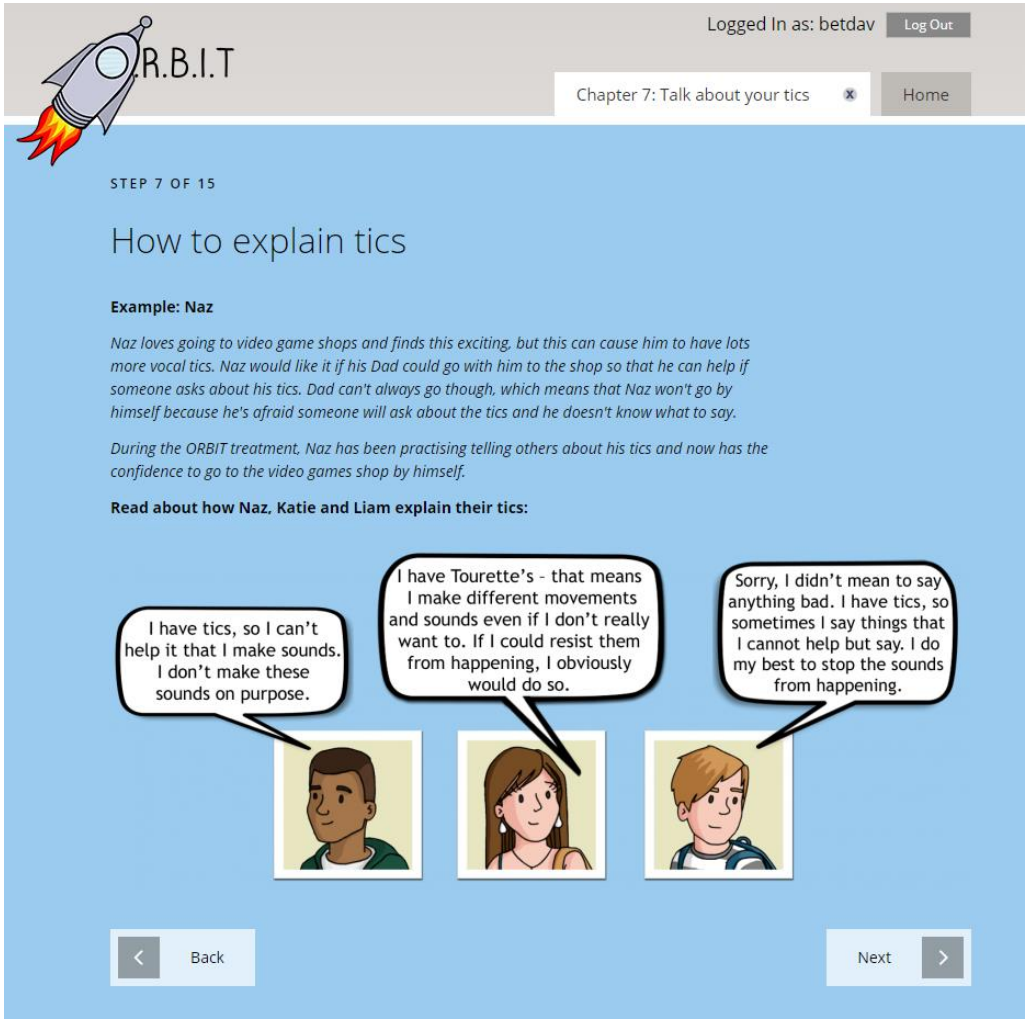
Home page


R.B.I.T
Logged In as: betdav
Log Out
Home
STEP 6 OF 12
Make your own ladder
Now you're going to make your own list of places to strengthen your brain brakes!
Remember: in all these places, you're going to be trying to resist the tic signal and stop the tics.
Write down places where you could practise controlling your tics. It can be places that make your tic signals strong, and places where you want to become really good at controlling your tics in.
Rank the places you came up with from 1 to 10 - where 10 is the most difficult place, and 1 is the easiest place for you to control your tics. You don't need to fill up the whole list, but write as many places as you can think of.
This is not an easy task but it is an important one. Many areas may feel difficult but do your best, even if there is only a little difference in the difficulty between the places.
Great work so far!
10 Write here
9 Write here
8 Write here
7 Write here
6 Write here
5 Write here
4 Write here
3 Write here
2 Write here
1 Write here
Select Ladder
Back
Next

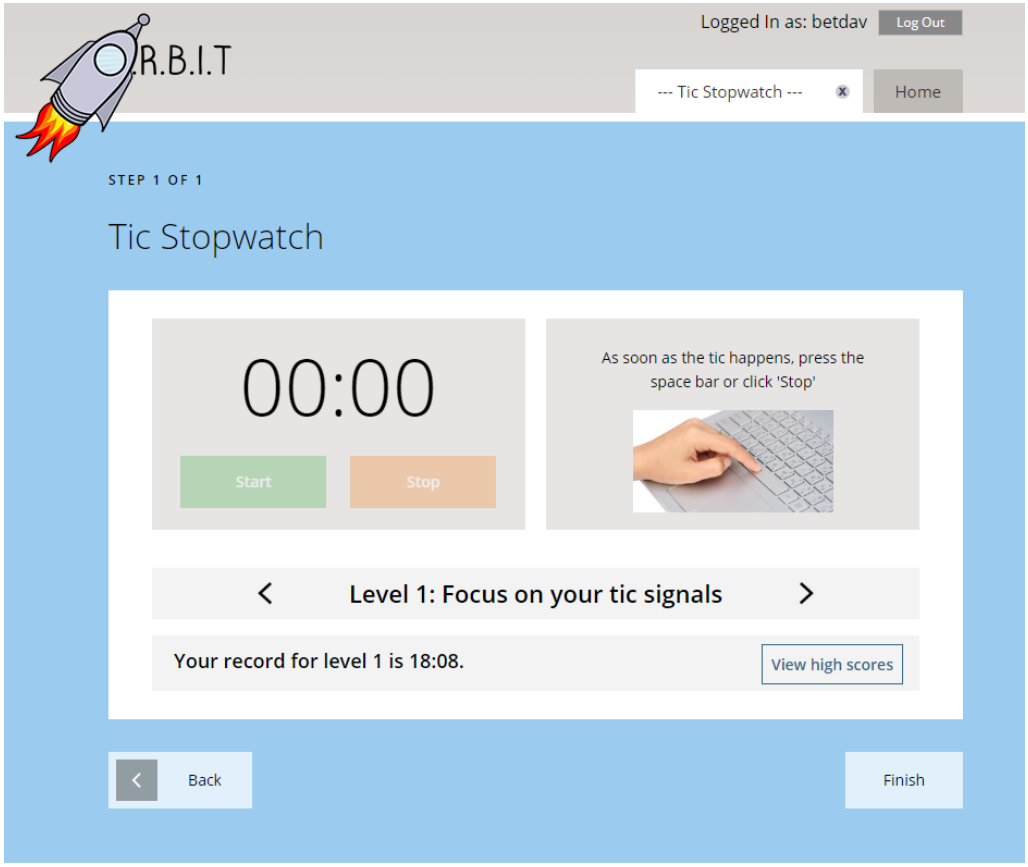
Tic ladder


R.B.I.T
Logged In as: betdav
Log Out
Home
STEP 10 OF 12
Make your own tic list
Now it's time to make your own tic list! You can enter up to 10 different tics, so choose those tics that you think are the most annoying or happen most often. Don't worry if you have less than 10!
You can find your tic list whenever you want during the ORBIT treatment by going to the home screen, clicking on "Worksheet" and then "Make your own tic list".
Name the tic (be specific!)
Why is this tic annoying?
Do you feel a tic signal for it? (Yes/No)
Rate how annoying it is (0 - not annoying at all to 10 - extremely annoying)
Write here

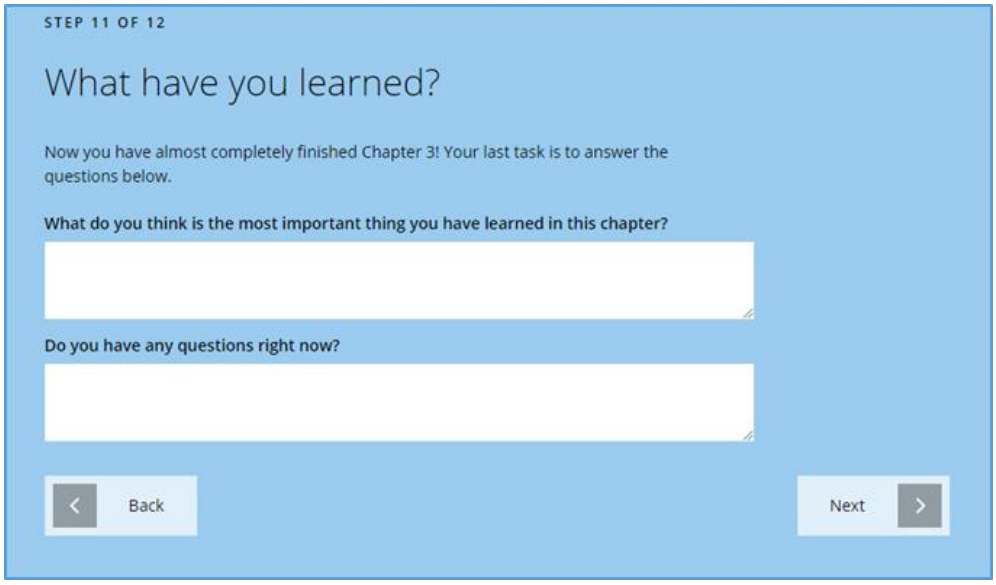
Tic list



Talk about tics



Tic stopwatch



End of chapter questions

Appendix B Full search strategy for systematic review

Search strategy - OVID SP interface

1 neurodevelopmental disorders/

2 child behavior disorders/

3 developmental disorder/

4 exp attention deficit disorder/

5 hyperkinesia/

6 exp autism/

7 exp asperger syndrome/

8 exp tic/

9 motor skills disorders/

10 stereotypic movement disorder/

11 communication disorders/

12 childhood-onset fluency disorder/

13 social communication disorder/

14 speech sound disorder/

15 Specific Learning Disorder/

16 exp developmental language disorder/

17 Intellectual Disability/

18 learning disorder/ or dyscalculia/

19 "Neurodevelopmental disorder*".tw.

20 "Developmental disorder*".tw.

21 (attenti* adj2 (deficit* or disorder*)).tw.

22 (adhd or addh or "ad hd" or ad??hd).tw.

23 ((hyperkin* or "hyper kin*" or hyper-kin*) adj2 (syndrome* or disorder*)).tw.

24 "pervasive development* disorder*".tw.

25 (autistic or autism or asperger* or "Kanner* syndrome" or "childhood disintegrative disorder").mp. or Rett*.tw.

26 (Tourette* or "tic disorder*").tw.

27 ("Stereotyp* movement disorders" or "stammering" or "cluttering").tw.

28 ("Communication Disorder*" or "Language* Disorder*" or "specific language impairment").tw.

29 ("Speech Sound Disorder*" or "Childhood?Onset Fluency Disorder*" or Stuttering or "Speech articulation disorder*" or "phonological disorder*" or "specific developmental disorder* of speech and language" or "specific speech articulation disorder").tw.

30 "Global developmental delay".tw.

31 ((intellectual* or learning*) adj3 (impair* or disab* or disorder* or difficult*)).tw.

32 ("Specific Learning Disorder*" or "Specific reading disorder" or "Disorder of written expression" or "Mathematics disorder" or "specific spelling disorder" or "dyslexia" or "disorder of arithmetical skills" or "dyscalculia" or "Specific developmental disorder of motor function" or "dyspraxia" or "developmental co?ordination disorder").tw.

33 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32

34 exp Mobile Applications/ or (Application or Applications or App or Apps or Intervention or Interventions).mp. or ((Smartphone or Smart-phone or Smart phone or Smartphones or Smart-phones or Smart phones or Mobile or iPhone or Android) adj2 (Application or Applications or App or Apps or Intervention or Interventions)).ti,ab. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

35 (Internet or computer or computer* or online or web or e-therapy or e-mental or e-health or telehealth or telecare or teletherapy or telemedicine or telemental or technolog* or virtual or cyber or cyberpsychology or cybertherapy or iCBT or cCBT or web-based or web-guided or web-supported or web-delivered or web-assisted or web-aided or web-facilitated or computer-based or computer-guided or computer-supported or computer-delivered or computer-assisted or computer-aided or computer-facilitated or internet-based or internet-guided or internet-supported or internet-delivered or internet-assisted or internet-aided or internet-facilitated or online-based or online-guided or online-supported or online-delivered or online-assisted or online-aided or online-facilitated).ti,ab.

36 34 or 35

37 (adolescence or adolescent or adolescent development or boy or child or childhood or elementary student or girl or high school student or high school or kindergarten or middle school student or middle school or

preschool child or puberty or student or minors or adolescent psychiatry or adolescent psychology or adolescent psychotherapy or adolescent psychopathology or child psychotherapy or child psychiatry or child* or juvenile* or teen*).ti,ab.

38 33 and 36 and 37

39 limit 38 to (humans and yr="2000 -Current" and randomized controlled trial)

Web of Science

#5 AND #4

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2018

5

TS=(RCT or Randomised Control or Randomized Contro*)

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2018

4

#3 AND #2 AND #1

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2018

3

TS=(adolescence or adolescent or boy or child or childhood or elementary student or girl or high school student or high school or kindergarten or middle school student or middle school or preschool child or puberty or student or minors or child* or juvenile* or teen*)

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2018

2

TS=(neurodevelopmental disorders or Communication Disorders or Language Disorder or Speech Sound Disorder or Childhood-Onset Fluency Disorder or Stuttering or Social Pragmatic Communication Disorder or Unspecified Communication Disorder or Autism Spectrum Disorder or Autism Spectrum Disorder or Attention-Deficit/Hyperactivity Disorder or Attention-Deficit/Hyperactivity Disorder or Other Specified Attention-Deficit/Hyperactivity Disorder or Unspecified Attention-Deficit/Hyperactivity Disorder or Specific Learning Disorder or Specific Learning Disorder or Motor Disorders or Developmental Coordination Disorder or Stereotypic Movement Disorder or Tic Disorders or Other Specified Tic Disorder or Unspecified Tic Disorder or Other Neurodevelopmental Disorders or Other Specified Neurodevelopmental Disorder or Unspecified Neurodevelopmental Disorder)

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC Timespan=2000-2018

1

TS=(Mobile Applications or Application or Applications or App or Apps or Intervention or Interventions or Smartphone or Smart-phone or Smart phone or Smartphones or Smart-phones or Smart phones or Mobile or iPhone or Android or Application or Applications or App or Apps or Intervention or Interventions or Internet or computer or computer* or online or web or e-therapy or e-mental or e-health or telehealth or telecare or teletherapy or telemedicine or telemental or technolog* or virtual or cyber or cyberpsychology or cybertherapy or iCBT or cCBT or web-based or web-guided or web-supported or web-delivered or web-assisted or web-aided or web-facilitated or computer-based or computer-guided or computer-supported or computer-delivered or computer-assisted or computer-aided or computer-facilitated or internet-based or internet-guided or internet-supported or internet-delivered or internet-assisted or internet-aided or internet-facilitated or online-based or online-guided or online-supported or online-delivered or online-assisted or online-aided or online-facilitated or Therapy, Computer-Assisted or *Therapy, Computer-Assisted or Computer-assisted treatment or Web-based treatment or *Multimedia or Software or *Computer Simulation or Computerized intervention)

PubMed

(Communication Disorders or Language Disorder or Speech Sound Disorder or Childhood Onset Fluency Disorder or Stuttering or Social Pragmatic Communication Disorder or Unspecified Communication Disorder or Autism Spectrum Disorder or Autism Spectrum Disorder or Attention Deficit Hyperactivity Disorder or Attention Deficit Hyperactivity Disorder or Other Specified Attention Deficit Hyperactivity Disorder or Unspecified Attention Deficit Hyperactivity Disorder or Specific Learning Disorder or Specific

Learning Disorder or Motor Disorders or Developmental Coordination Disorder or Stereotypic Movement Disorder or Tic Disorders or Other Specified Tic Disorder or Unspecified Tic Disorder or Other Neurodevelopmental Disorders or Other Specified Neurodevelopmental Disorder or Unspecified Neurodevelopmental Disorder) in Title Abstract Keyword

AND

(Mobile Applications or Application or Applications or App or Apps or Intervention or Interventions or Smartphone or Smart-phone or Smart phone or Smartphones or Smart-phones or Smart phones or Mobile or iPhone or Android or Application or Applications or App or Apps or Intervention or Interventions or Internet or computer or computer* or online or web or e-therapy or e-mental or e-health or telehealth or telecare or teletherapy or telemedicine or telemental or technolog* or virtual or cyber or cyberpsychology or cybertherapy or iCBT or cCBT or web-based or web-guided or web-supported or web-delivered or web-assisted or web-aided or web-facilitated or computer-based or computer-guided or computer-supported or computer-delivered or computer-assisted or computer-aided or computer-facilitated or internet-based or internet-guided or internet-supported or internet-delivered or internet-assisted or internet-aided or internet-facilitated or online-based or online-guided or online-supported or online-delivered or online-assisted or online-aided or online-facilitated or Therapy, Computer-Assisted or *Therapy, Computer-Assisted or Computer-assisted treatment or Web-based treatment or *Multimedia or Software or *Computer Simulation or Computerized intervention) in Title Abstract Keyword

AND

(adolescence or adolescent or boy or child or childhood or elementary student or girl or high school student or high school or kindergarten or middle school student or middle school or preschool child or puberty or student or minors or child* or juvenile* or teen*) in Title Abstract Keyword - (Word variations have been searched)

Central

(Communication Disorders or Language Disorder or Speech Sound Disorder or Childhood Onset Fluency Disorder or Stuttering or Social Pragmatic Communication Disorder or Unspecified Communication Disorder or Autism Spectrum Disorder or Autism Spectrum Disorder or Attention Deficit Hyperactivity Disorder or Attention Deficit Hyperactivity Disorder or Other Specified Attention Deficit Hyperactivity Disorder or Unspecified Attention Deficit Hyperactivity Disorder or Specific Learning Disorder or Specific Learning Disorder or Motor Disorders or Developmental Coordination Disorder or Stereotypic Movement Disorder or Tic Disorders or Other Specified Tic Disorder or Unspecified Tic Disorder or Other Neurodevelopmental Disorders or Other Specified Neurodevelopmental Disorder or Unspecified Neurodevelopmental Disorder) in Title Abstract Keyword

AND

(Mobile Applications or Application or Applications or App or Apps or Intervention or Interventions or Smartphone or Smart-phone or Smart phone or Smartphones or Smart-phones or Smart phones or Mobile or iPhone or Android or Application or Applications or App or Apps or Intervention or Interventions or Internet or computer or computer* or online or web or e-therapy or e-mental or e-health or telehealth or telecare

or teletherapy or telemedicine or telemental or technolog* or virtual or cyber or cyberpsychology or cybertherapy or iCBT or cCBT or web-based or web-guided or web-supported or web-delivered or web-assisted or web-aided or web-facilitated or computer-based or computer-guided or computer-supported or computer-delivered or computer-assisted or computer-aided or computer-facilitated or internet-based or internet-guided or internet-supported or internet-delivered or internet-assisted or internet-aided or internet-facilitated or online-based or online-guided or online-supported or online-delivered or online-assisted or online-aided or online-facilitated or Therapy, Computer-Assisted or *Therapy, Computer-Assisted or Computer-assisted treatment or Web-based treatment or *Multimedia or Software or *Computer Simulation or Computerized intervention) in Title Abstract Keyword

AND

(adolescence or adolescent or boy or child or childhood or elementary student or girl or high school student or high school or kindergarten or middle school student or middle school or preschool child or puberty or student or minors or child* or juvenile* or teen*) in Title Abstract Keyword - (Word variations have been searched)

Clinicaltrials.gov

Completed Studies | Interventional Studies | Neurodevelopmental Disorders | online therapy | Child

Appendix C SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents

Section/item	Item No	Description	Addressed on page number
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	79
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	87
	2b	All items from the World Health Organization Trial Registration Data Set	NA
Protocol version	3	Date and version identifier	83
Funding	4	Sources and types of financial, material, and other support	NA. Detailed information in study protocol
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	NA. Detailed information in study protocol

	5b	Name and contact information for the trial sponsor	NA. Detailed information in study protocol
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	NA. Detailed information in study protocol
	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	NA. Detailed information in study protocol
Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	83, 86
	6b	Explanation for choice of comparators	NA. Detailed information in study protocol

Objectives	7	Specific objectives or hypotheses	83
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	86, 87
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	89, 91
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	83
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	NA. Detailed information in study protocol
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	NA. Detailed information in study protocol
	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	NA. Detailed information in study protocol

	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	NA. Detailed information in study protocol
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	94, 95
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	87, 88
Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	91
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	90, 91
Methods: Assignment of interventions (for controlled trials)			
Allocation:			

Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	NA. Detailed information in study protocol
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	NA. Detailed information in study protocol
Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	NA. Detailed information in study protocol
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	NA. Detailed information in study protocol
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	NA. Detailed information in study protocol
Methods: Data collection, management, and analysis			

Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	88-95
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	NA. Detailed information in study protocol
Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	NA. Detailed information in study protocol
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	NA. Detailed information in study protocol
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	NA. Detailed information in study protocol
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	NA. Detailed information in study protocol

Methods: Monitoring			
Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	NA. Detailed information in study protocol
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	NA
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	NA. Detailed information in study protocol
Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	NA. Detailed information in study protocol
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	NA. Detailed information in study protocol
Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	NA. Detailed information in study protocol

Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	90, 91
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	NA
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	93
Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	NA. Detailed information in study protocol
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	NA. Detailed information in study protocol
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	NA
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	NA. Detailed information in study protocol
	31b	Authorship eligibility guidelines and any intended use of professional writers	NA. Detailed information in study protocol

	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	NA. Detailed information in study protocol
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	Additional files
Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	NA

Appendix D COREQ (Consolidated criteria for reporting qualitative research) checklist

Section/Topic	Item No	Checklist item	Reported on page No
Domain 1: Research team and reflexivity			
Personal Characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group? Interviewer/facilitator	98
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	101
Occupation	3	What was their occupation at the time of the study?	101
Gender	4	Was the researcher male or female?	101
Experience and training	5	What experience or training did the researcher have? Relationship with participants	101
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	101
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	101
Interviewer characteristics	8	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	101
Domain 2: study design			
Theoretical framework			
Methodological orientation and *Theory*	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	98-100
Participant selection			

Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	91
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	90
Sample size	12	How many participants were in the study?	119
Non-participation	13	How many people refused to participate or dropped out? Reasons?	119
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	89
Presence of non-participants	15	Was anyone else present besides the participants and researchers?	117
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	121-123
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	173-198
Repeat interviews	18	Were repeat interviews carried out? If yes, how many?	116
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	117
Field notes	20	Were field notes made during and/or after the interview or focus group?	98
Duration	21	What was the duration of the interviews or focus group?	121-123
Data saturation	22	Was data saturation discussed?	117
Transcripts returned	23	Were transcripts returned to participants for comment and/or correction?	NA
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	100

Description of the coding tree	25	Did authors provide a description of the coding tree?	NA
Derivation of themes	26	Were themes identified in advance or derived from the data?	99
Software	27	What software, if applicable, was used to manage the data?	98
Participant checking	28	Did participants provide feedback on the findings?	90
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	127 onwards
Data and findings consistent	30	Was there consistency between the data presented and the findings?	127 onwards
Clarity of major themes	31	Were major themes clearly presented in the findings?	127 onwards
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	223-244

Appendix E Interview schedules for child, parents, therapists, and clinicians

CHILD INTERVIEW SCHEDULE

Preamble

If interview is conducted face to face then child will have the option of having their parent sit with them.

If interview is conducted over the phone the child can have the option of placing the call on loudspeaker with their parent listening in.

In many places two options of words are given, as one word will be chosen over another depending on the child's age and linguistic ability.

- Check that the interviewee has received the information sheet, they/their parent (*depending on age*) has initialled the box stating they are happy to be contacted for an interview on the consent/assent form, understands the ORBIT project and his/her role in it
- Make sure refreshments available in room and that room is set-up ready for interview.

    - Explain that:
        - The aim of the ORBIT study was to see whether online therapy can help children and young people with tics.
            - The research team is speaking to many people involved in ORBIT e.g. parents, therapists, and clinicians
            - We are interested in your experiences and thoughts about ORBIT, so please give honest answers, as both positive and negative feedback will help us improve the therapy. You will be asked questions about the ORBIT therapy.
            - However, we will put all the data that we collect together in a report to give us an overall picture of ORBIT and no one will be named in the report or know what you answered to the questions, for example, "A young person/child commented that…"

Ask: Do you have any initial questions about the project?

Ethics

- Remind interviewee:
    - The interview will take about 30 minutes

- You do not have to answer any questions that you are not comfortable with and there are no 'right' or 'wrong' answers
- You can stop at any time, no explanation needed
- If you need a comfort/loo break, please just say, that's absolutely fine
- If any question doesn't make sense, ask me to explain

With your permission we are going to record the interview (audio only, on a Dictaphone) so that we can focus on what you are saying. This will be written out by a member of the research team or a company we know well. If you feel more comfortable that we write out the interview rather than the company then we will be happy to do so.

We will delete any mention of places, clinicians/therapists/family members that may give away yours (or others) name during writing.

The original writing will be put on a password protected hard drive and no one other than members of the research team will be able to view this.

The things you say in the interviews may be used in written reports, published articles and presentations including online but we will never use your name or any other information that may give away who you are.

Ask: Do you have any questions about how we use your comments? Please feel free to ask anything however small it may seem at this stage or at any time later.

Ask: Is it okay to record the interview?

- If participant not satisfied: answer any questions they have. If they do not want to participate, thank them for their time and finish the interview at this point.

Explain procedure

I will begin the interview with my name, the date, time and the code we have for you - this is just to keep the recordings organised. All your details will be hidden when the interview is written out. The first part will be a little about yourself and your tics, followed by general questions about the ORBIT project such as what you thought about the study and questionnaires, then moving on to the ORBIT therapy and then ending with any recommendations and your overall experience of being involved in ORBIT.

Ask: Do you have any questions before we start?

Ask: Is it okay for me to start recording now?

State researcher's name, date, time, and identifying code (for data management)

Warm up

1) At the beginning of the study, we sent out information about this study to your mother/father/parents (*personalise according to who the information was sent to*), do you remember if they spoke to you about it and did they speak to you about whether you wanted to participate or not?

2) Please tell me a little about yourself
- Hobbies/interests?
- Family, things you like to do together?
- School life

3) Can you tell me what tics you have?
Prompt
- Vocal/motor?
- Simple/complex? (*Give examples if child does not know the difference)*
- How often do they happen?
- How do they make you feel?
- Impact?

4) Have you noticed any difference in your tics in the last 3 months?
Prompt

- Type/frequency/severity

First I am going to ask you questions about being part of the ORBIT study, including how you felt about this and how you found the questionnaires:

Questions about ORBIT as a research project

5) What did you think about the sound of the ORBIT study?
- Who told you about it? (TA? Clinician? Parent?)
- How did you feel about taking part?

6) What did you think of the stuff you had to do before the therapy began?
- Face to face meeting (baseline appointment)
- Information sheet
- Consent/assent form
- Did you get any help from your parent?

7) Was it clearly explained to you that you would be put in to one of two groups?
   - How did you feel about this?
   - How did you feel about the group were put in?

8) Thinking about what was expected of you during the ORBIT study:
   - Can you remember filling in questionnaires? What did you think of them?
   - Was the study clearly explained to you?
   - How did you feel about online questionnaires?
   - How did you feel about face to face questionnaires?
   - Which did you prefer?
   - Has it been okay to manage or a lot of effort? How much help did you need?

Thank you for these answers, that's been really helpful. I'd now like to move on and ask you some questions about how you found the ORBIT therapy:

Questions on ORBIT therapy

9) I am now going to go through the different parts of the ORBIT therapy and I would like you to tell me how you found them:
   - How easy was it to log on?
   - Did you find it difficult to use anything in the online therapy?
   - What did you think of the lay out/graphics?
   - What did you think of the content/things included?
   - Anything that worked particularly well? Anything that could have been improved?
   - Did it make sense to you as you did it?
   - Any help needed from parents?
   - How did you link ORBIT therapy into everyday life?

10) How did you use the ORBIT therapy?
   - Did you do the chapters on your own?

11) Was there anything that stopped you from doing the ORBIT therapy?

12) Overall, what did you think about the different sections of ORBIT?
   - Any sections that you particularly liked or engaged with? **Prompt**: why?
   - Any sections that you did not engage with/found hard?

- Do you think the therapy was too long/too short/just right?
- What about the rewards – did they help/motivate you?

You are now half way through the questions so I want you now to think about the ORBIT therapy and I want to ask you some questions on the impact/effect it has had on you:

13) Before you started the ORBIT therapy, how did you think it would help your tics and everyday life?
    - How good did you expect it to be in reducing/cutting down tics?
    - Did you expect benefits/to help in any other areas of life?

14) How much do you think the ORBIT therapy has helped you with your tics and in everyday life?

15) Which parts of the therapy were particularly helpful to you?

16) Did you have any difficulties with the ORBIT therapy?
    - If so, what were they?
    - Technological difficulties? Did you manage to sort them out?
    - What did you use to access ORBIT? i.e. tablet/PC/smartphone etc.

17) Did you follow the ORBIT therapy exactly as it was laid out/did you do the online chapters in order?
    - Did you adapt/change anything as you went along?

18) Would you change anything about the ORBIT therapy?
- Should we add any information?
- Anything that was not needed?

19) How did you feel about talking with (*name of therapist*)?
- How often did you contact them?
- Was it helpful?
- How did you contact them? Through email? Through ORBIT website? Phone?
- Which way of contacting a therapist do you prefer?

20) How did you feel about getting the therapy online instead of face to face?
Prompt: how would you have preferred?

Thank you for answering those questions. We only have a few questions left now and these will focus on the future of the ORBIT therapy:

Future Direction

21) If the ORBIT therapy is found to be effective/helpful are there any changes we could make before it is offered to other children and young people?

22) Are there other ways that could be used for giving ORBIT therapy to people?
- Skype? WhatsApp?
- Any other apps or forms of technology?

23) Overall, how did you feel about the experience of taking part in this study?

24) Would you recommend ORBIT therapy to other children and young people with tics?
Prompt for clarification of response.

End of questions

That reaches the end of the interview and questions I wanted to ask you.

Thank you so much for your time.

- Do you have anything else you wish to speak about that hasn't been mentioned?
    - Let interviewee talk if they have anything else to add
    - If nothing else – then close interview

If you are okay to end the interview there, I will switch the Dictaphone off.

Switch Dictaphone off

Debriefing

- Ask how they are feeling – whether anything in the interview has troubled them or distressed them or if anything requires clarification
- They or their parents can email me if they have any follow up questions
- Thank them again, and ask if they are feeling okay to end interview here.

PARENT INTERVIEW SCHEDULE

Preamble

- Check that the interviewee has received the information sheet, has initialled the box stating they are happy to be contacted for an interview on consent form, understands the ORBIT project and his/her role in it
- Make sure refreshments available in room and that room is set-up ready for interview.

    - Explain that:
        - The aim of the ORBIT study was to investigate whether treatment delivered online can help children and young people with tics.
            - The research team is speaking to a range of people involved in ORBIT e.g. children who participated, therapists, and clinicians
            - We are interested in individual experiences and thoughts about ORBIT, so please give honest responses, as both positive and negative feedback will help us improve the intervention. Explain that they will be asked questions relating to their expectations of ORBIT, their thoughts on the treatment, impact on child, level of engagement, difficulties and challenges experienced, and any recommendations they may have
            - However, we combine all the data we collect to provide an overall picture of ORBIT and its implementation and any comments in the report are attributed very generally, for example, "A parent commented that…" All comments/opinions will be strictly confidential.

Ask: Do you have any initial questions about the project?

Ethics

- Remind interviewee:
    - The interview will take about 30 minutes
    - You do not have to answer any questions that you are not comfortable with and there are no 'right' or 'wrong' answers
    - You can stop at any time, no explanation needed
    - If you need a comfort/loo break, please just say, that's absolutely fine
    - If any question doesn't make sense, ask for an explanation

With your permission we are going to record the interview (audio only, on a Dictaphone) so that we can focus on what you are saying. The interviews will be transcribed by a member of our research team or an approved company. If you do not wish for interview to be transcribed by the approved company then please let us know and we will transcribe internally instead.

We remove any reference to any places, clinicians/therapists/family members that may give away your (or others) identity during transcription.

The original transcription will be stored on an encrypted hard drive and no one other than immediate members of the research team can access this.

Anonymised quotes from transcripts will be used in written reports, published journal articles and presentations including online. Again, any reference to places/family members/clinicians and so on will be removed.

Ask: Do you have any questions about how we use your comments? Please feel free to ask anything however minor it may seem at this stage or at any time later.

Ask: Is it okay to record the interview?

- If participant not satisfied: answer any questions they have. If they do not want to participate, thank them for their time and finish the interview at this point.

Explain procedure

I will begin the interview with my name, the date, time and the identifying code we have assigned to you and your child - this is just to keep the recordings organised. All your details will be anonymised when the data is transcribed. The first part will be a little about yourself and any other studies on tics you may have been involved in, followed by general questions about the ORBIT project such as how you were recruited and expectations, then moving on to the ORBIT treatment more specifically and

then ending with any recommendations and your overall experience of being involved in ORBIT.

Ask: Do you have any questions before we start?

Ask: Is it okay for me to start recording now?

State researcher's name, date, time, and identifying code (for data management)

Warm up

25) Please tell me a little about yourself and your family
Prompt (if no response)

- Things you like to do together?

26) Have you and your child ever taken part in any other studies on tics?
- What did that involve?

27) Can you tell me what tics your child has?
Prompt

- Vocal/motor?
- Simple/complex (*give examples if unsure of the difference*)
- How often do they happen?
- How do they make you feel?

28) Have you noticed any difference in your child's tics in the last 3 months?
Prompt

- Type/frequency/severity

First I am going to ask you questions about being part of this research trial, including how you felt about this and how you found the questionnaire completion:

Questions about ORBIT as a research project

29) How did you find out about the ORBIT project?
- Who told you about it? (TA? Clinician? Friend?)

- What did you hope to get out of the trial from both you and your child's point of view?
- What were your initial thoughts about the ORBIT project?

30) Why did you get involved in this project?

31) What did you think of the way you were approached to take part?
    - What did you think of the initial telephone screening?
    - What did you think of the face to face meeting (baseline appointment)?
    - Have you any comments on the information sheet and consent?
    - Anything that you would have liked to be done differently?

32) Was it clearly explained to you that you and your child would be allocated to one of two groups? One to learn strategies on how to control tics and one to receive information on tics?
    - How did you feel about being "randomised"?
    - How did you feel about the group that you/your child was allocated?

33) Thinking about what was expected of you during the ORBIT trial:
    - Can you remember what the study involved for you in terms of completing questionnaires?
    - Was the ORBIT trial clearly explained to you?
    - How did you feel about online questionnaires?
    - How did you feel about face to face questionnaires?
    - Which did you prefer?
    - Did you expect it to take a lot of effort to get your child to engage?

Thank you for these answers, that's been really helpful. I'd now like to move on and ask you some questions about how you found the ORBIT therapy:

Questions on ORBIT therapy

34) How did you feel about the delivery of the parents' materials in ORBIT?
    - How did you feel about the logging on process?
    - Was it technically easy to use/easy to understand?
    - How did you feel about how the material was presented?
    - What did you think about what was included? i.e. content
    - Anything that you felt worked particularly well? Anything that could have been strengthened?

- Did it make sense to you as you did it?
- Was it easy to fit into your everyday life?

35) How did you use the ORBIT treatment?
    - Did you use the parent sections?
    - Did you view the child sections with your child?

36) How did you feel about your level of involvement in the treatment?
    Prompt
    - Did anything stop you getting involved?

37) How did it influence your approach to your child's tics?
    Prompt
    - Any changes you made/strategies used?

Now some questions about how your child found using the ORBIT treatment:

I think you said that you viewed the child sections with your child/your child completed ORBIT on their own?

38) What do you feel about your child's level of involvement with ORBIT treatment?
    - Were there any barriers?

39) Overall, thinking about the child's sections of ORBIT:
    - Were there any sections that you think your child particularly enjoyed or engaged with and why?
    - Were there any sections that did not engage your child or they found difficult? Why do you think this is?
    - Do you think the therapy was too long/too short/just right?
    - How did you feel about the level of the content for a child the age of yours?
    - What about the rewards – how did you find them? Were they difficult to think of or stick too?
    - Is there anything else you would like to add about the child's section?

Thinking about the ORBIT therapy as a whole – parent and child sections:

40) Considering your expectations of the ORBIT treatment in terms of impact on your child:
    - How effective did you expect it to be in reducing tics?
    - Did you expect benefits in any other aspects of life?

41) In reality, what impact did the ORBIT treatment have:
    - On your child's tics?
    - On any other areas of your child's life?

42) What aspects of the treatment were particularly helpful?

43) Did you encounter any difficulties with the ORBIT treatment?
    - If so, what were they?
    - Were there technological difficulties? Did you manage to resolve these?
    - Did that affect your overall view of the treatment?

44) Did you follow the ORBIT treatment exactly as it was structured?
    - If not, how did you change it?

45) Would you change anything about the ORBIT treatment?
    - What additional information, if any, should be included?
    - Was anything included that was unnecessary?

46) How did you feel about communicating with (*name of therapist*)?
    - How often did you contact them?
    - Was it helpful?
    - How did you contact them? Through email? Through ORBIT website? Phone?
    - Which method did you prefer?

47) How did you feel about receiving treatment digitally?
    - How would you have preferred?

Thank you for answering those questions. We only have a few questions left now and these will focus on the future of ORBIT:

<u>Future Direction</u>

48) If the ORBIT treatment is found to be effective are there any changes that we should make before it is routinely offered?

49) Are there other ways that you think could be used for delivering ORBIT?
- Skype? Webex?
- Other forms of technology?

50) Overall, how did you feel about the experience of participating in this trial?
- Would you recommend ORBIT treatment to other parents of children with tic disorders?

Prompt for clarification of response.

End of questions

That reaches the end of the interview and questions I wanted to ask you.

Thank you so much for giving me your time.

- Do you have anything else you wish to speak about that hasn't been mentioned?
    - Let interviewee talk if they have anything else to add
    - If nothing else – then close interview

If you are okay to end the interview there, I will switch the Dictaphone off.

Switch Dictaphone off

Debriefing

- Ask how they are feeling – whether anything in the interview has troubled them or distressed them or if anything requires clarification
- They can email me if they have any follow up questions
- Thank them again, and ask if they are feeling okay to end interview here.

THERAPIST INTERVIEW SCHEDULE

Preamble

- Make sure refreshments available in room and that room is set-up ready for interview.

- Explain that:
    - We are interested in individual experiences and thoughts about ORBIT, so please give honest responses, as both positive and negative feedback will help us improve the intervention. Explain that they will be asked questions relating to their involvement in ORBIT, their thoughts on the treatment, feedback they received, experience of supervision, and any recommendations they may have
    - However, we combine all the data we collect to provide an overall picture of ORBIT and its implementation. Any comments in the report are attributed very generally, for example, "A therapist commented that…" All comments/opinions will be strictly confidential.

Ask: Do you have any initial questions?

Ethics

- Remind interviewee:
    - The interview will take about 25 minutes
    - You do not have to answer any questions that you are not comfortable with and there are no 'right' or 'wrong' answers
    - You can stop at any time, no explanation needed
    - If you need a comfort/loo break, please just say, that's absolutely fine
    - If any question doesn't make sense, ask for an explanation

With your permission we are going to record the interview (audio only, on a Dictaphone) so that we can focus on what you are saying. This will be transcribed by a member of the research team or an approved company.

We remove any reference to any places, clinicians/therapists/family members that may give away yours (or others) identity during transcription.

The original transcription will be stored on an encrypted hard drive and no one other than immediate members of the research team can access this.

Ask: Do you have any questions about how we use your comments?

Ask: Is it okay to record the interview?

- If participant not satisfied: answer any questions they have. If they do not want to participate, thank them for their time and finish the interview at this point.

Explain procedure

I will begin the interview with my name, the date, and time - this is just to keep the recordings organised. All your details will be anonymised when the data is transcribed. The first part will be a little about yourself and your role in ORBIT, followed by general questions about the ORBIT project, then moving on to the ORBIT treatment more specifically and then ending with any recommendations and your overall experience of being involved in ORBIT.

Ask: Do you have any questions before we start?

Ask: Is it okay for me to start recording now?

State researcher's name, date, and time (for data management)

I want to start by asking a bit about you:

Background Questions

51) Please briefly describe your professional background
- Profession
- If applicable, how long have you worked as a therapist with children/young people?

52) What was your particular role on the ORBIT trial?
- Were you involved in the creation of the ORBIT trial?
- Supervisor/supervisee?

53) What previous experience did you have that was relevant to your role as therapist/supervisor on ORBIT?
Prompt

- Training
- Education

54) What were your thoughts about online therapy before you began in this role?

Now I am going to ask you about your involvement in the trial:

Questions about ORBIT as a trial

55) How did you find out about the ORBIT trial?

56) Why did you get involved in this trial?
    - How did you feel about being involved?

57) Are there any specific challenges for the therapist because the therapy is being delivered as part of a trial?
    Prompt

    - Keeping treatments separate/avoiding contamination
    - Rigour of protocol
    - Having sufficient time to adhere to the protocol
    - Sense that you are offering a helpful, effective therapy in both arms of the trial

Thank you for these answers, that's been really helpful. I'd now like to move on and ask you some questions on the role of the therapist and its subsequent demands:

Therapist role and demands

58) Can you tell me a bit about the role of the therapist in therapist assisted online treatment?
    Prompt

    - Any advantages/rewarding aspects to the role (e.g. convenience, job satisfaction etc.)?
    - Any limitations (e.g. safety issues, feasibility etc.)?
    - Any suggestions for overcoming identified limitations?

59) What personal skills/experience do you think are needed for a therapist to effectively implement the ORBIT intervention?
    - How experienced do you think a therapist needs to be to deliver the intervention?
    - Experience with digital interventions?
    - Experience working with young people? Are there any specific challenges because the therapy is with young people?
    - Prior clinical training?

60) Are there any training needs you can identify that may aid a therapist in delivering the intervention?
Prompt

- Tics and other neurodevelopmental conditions (OCD, ASD, ADHD)
- Training in assessments of tics
- Training in online therapy
- Training in ERP

61) How have you structured/managed this role alongside your other commitments?
- How many hours did you dedicate to ORBIT per day?
- How has the workload felt?
- Has anything felt particularly difficult/stressful?
- Were there any tools you used/found useful that helped manage your workload? E.g. excel sheets
- Are there any structural changes you can identify that would make the therapists' role more effective/manageable?

62) Can you please share your experiences of the supervision you gave/received?
Prompt

- Quality of sessions – what went well/less well?
- Quantity of sessions
- Structure – how did the supervision work?
- Common issues that arose – general trial issues vs delivery of the intervention issues?

Now I would like to ask you some questions about delivering the specific treatments:

<u>Perceptions of delivering the different treatments</u>

63) Do you believe the online intervention is being delivered as planned (*describe what "as planned" means i.e. 10 chapters over 10 weeks, supporting patients by email etc*.)?
- If so, how? If not, why?
- Predictable outcomes?
- Any unanticipated consequences?

64) How do you see the role of the therapist in the ERP arm?
Prompt

- What sort of support do the children/parents need?
- Any examples where you felt the remote therapy went particularly well in the ERP arm?
- Any difficulties?

65) How do you see the role of the therapist in the Psychoeducation arm?

Prompt

- What sort of support do the children/parents need?
- Any examples where you felt the remote therapy went particularly well in the Psychoeducation arm?
- Any difficulties?

66) How do you feel about delivering online therapy?
- What are the benefits/limitations?

67) What feedback have you received from children/parents?

Prompt

- Benefits
- Problems encountered
- Frustrations
- Participant characteristics that influenced their feedback e.g. age/gender/comorbidities?

68) How often did you interact with participants online?

Prompt

- Daily/every other day/once a week/twice a week/more?
- What were the main types of comments you received?
- Was it manageable?
- What format were these interactions (F2F, phone, messages and comments on the worksheets via BiP)?
- Was the contact mainly with parents or children?
- Were there any difficulties in responding to participants?

69) How do you feel about the relationships you have developed with young people and their parents?
- Did the interactions feel meaningful?
- Was this more difficult to develop online than F2F (*if therapist has had prior experience of F2F therapy*)?
- Did this hinder/help the effectiveness of the therapy?

70) What is your view on the ERP arm and the things included in it?
Prompt

- Structure
- Content
- Use of videos/animation, quizzes
- Language/flow
- Too long/too short?

71) What is your view on the Psychoeducation arm and the things included in it?
Prompt

- Structure
- Content
- Detail
- Too little/too much information?

72) Would you change anything about the ERP/Psychoeducation programs?
- Additional information? Unnecessary information?

73) Why do you think children/parents may not wish to engage/persist with the interventions?
Prompt

- Barriers?
- Could we have done anything differently?
- How can we better engage them in future work?
- Characteristics of those who found it difficult to engage e.g. age/gender/comorbidities?

74) What do you believe were the main barriers to effectively implementing the interventions?
- Internal/external factors?
- Any solutions?

75) What do you think have been the overall effects of the intervention on participants?

76) Do you think face to face therapy is more effective than digital?
- If so, why?
- A combination of the two?
- Do you think face to face therapy may have given us a different outcome?

Thank you for answering those questions. We only have a few questions left now and these will focus on the future of ORBIT and your overall thoughts:

Future Direction

77) Is there anything else we could have done differently?

78) Overall, would you recommend the ORBIT intervention to children?
- Why?
- At what point of diagnosis/age?

End of questions

That reaches the end of the interview and questions I wanted to ask you.

Thank you very much for your time.

- Do you have anything else you wish to speak about that hasn't been mentioned?
    - Let interviewee talk if they have anything else to add
    - If nothing else – then close interview

If you are okay to end the interview there, I will switch the Dictaphone off.

Switch Dictaphone off

Debriefing

- Ask how they are feeling and if anything requires clarification
- They can email me if they have any follow up questions/comments

Thank them again, and ask if they are feeling okay to end

CLINICIAN INTERVIEW SCHEDULE

Preamble

- Check that the interviewee has received the information sheet, understands the ORBIT project and his/her role in it
- Make sure refreshments available in room and that room is set-up ready for interview (*if interview is done face to face*).

- Explain that:
    - The aim of the ORBIT study was to investigate whether treatment delivered online can help children and young people with tics.
        - The research team is speaking to a range of people involved in ORBIT e.g. children and parents who participated, therapists, and clinicians
        - We are interested in individual experiences and thoughts about ORBIT, so please give honest responses, as both positive and negative feedback will help us improve the intervention. Explain that they will be asked questions relating to their involvement in the ORBIT trial, experiences with recruitment, and factors relating to their institution e.g. NHS
        - However, we combine all the data we collect to provide an overall picture of ORBIT and its implementation and any comments in the report are attributed very generally, for example, "A clinician commented that…" All comments/opinions will be strictly confidential.

Ask: Do you have any initial questions about the project?

Ethics

- Remind interviewee:
    - The interview will take about 20 minutes
    - You do not have to answer any questions that you are not comfortable with and there are no 'right' or 'wrong' answers
    - You can stop at any time, no explanation needed
    - If you need a comfort/loo break, please just say, that's absolutely fine
    - If any question doesn't make sense, ask for an explanation

With your permission we are going to record the interview (audio only, on a Dictaphone) so that we can focus on what you are saying. This will be transcribed by a member of the research team or an approved company.

We remove any reference to any places, therapists/family members that may give away yours (or others) identity during transcription.

The original transcription will be stored on an encrypted hard drive and no one other than immediate members of the research team can access this.

Ask: Do you have any questions about how we use your comments?

Ask: Is it okay to record the interview?

- If participant not satisfied: answer any questions they have. If they do not want to participate, thank them for their time and finish the interview at this point.

Explain procedure

I will begin the interview with my name, the date, and time - this is just to keep the recordings organised. All your details will be anonymised when the data is transcribed. The first part will be a little about yourself, followed by general questions about the ORBIT trial, moving on to your views on recruitment, and ending with institutional issues and future direction.

Ask: Do you have any questions before we start?

Ask: Is it okay for me to start recording now?

State researcher's name, date, and time (for data management)

I want to start by asking some questions about you:

Background Questions

79) Please briefly describe your professional background
Prompt (if not covered)

- What is your job title?
- How long have you worked as a clinician with children/young people?
- How much contact do you normally have with children with tics?

80) What treatment recommendations would you normally prescribe for young people with tics?
Prompt (if not covered)

- Referral to a specialist therapist?

- Behavioural treatments and/or medication (referred for? Or given by themselves?)
- How confident are you in diagnosing tic disorders?

81) What % of children do you refer to behavioural treatments (BT)?
- What type of BT (CBIT/ERP/HRT)?

Prompt

- How easy is it to currently assess BT?
- What influences your decision to refer/give BT?
- How long is the waiting list?
- Do you believe BT is useful for tics?

Now I am going to ask you questions about being part of the ORBIT trial:

Questions about ORBIT as a trial

82) How did you find out about the ORBIT trial?

83) Why did you get involved in this trial?

84) How did you feel about being involved in this trial?

85) What were your expectations of the ORBIT trial?
    - Did it sound like something that would be effective?
    - Did you expect people to take part?

Thank you for these answers, that's been really helpful. I'd now like to move on and ask about your thoughts on recruitment for the trial:

Recruitment for ORBIT

86) What was your experience of recruiting participants to the ORBIT trial?

Prompt

- Did it take a lot of time?
- How difficult was it to recruit to the trial?
- Were all the procedures (e.g. returning of consent to contact forms) clear?

87) Were there any factors that affected recruitment?
Prompt
- Drivers to recruitment?
- Ability to offer a service for patients?
- Barriers?
- Employ any strategies to improve recruitment?

88) What factors influenced whether you approached a family about the trial?
Prompt

- Having the materials to hand?
- Remembering at the time?
- Characteristics of the family that you approached (e.g. engaged parents or those not currently in crises)?
- Availability of treatment options in your own clinic and locally

89) Why do you think children/parents may not have agreed to take part?

90) Why do you think children/parents may not have persisted with the intervention?
- How can we better engage children and families in future work?

91) Have you received any feedback from parents/children about the ORBIT trial?
- If so, what was it?

92) Do you think face to face therapy is more effective than digital?
- If so, why?

93) Overall, how do you feel about inviting patients to participate in studies external from your care?
Prompt

- Motivations for doing so?
- Is the fact the therapy is delivered externally a positive? Why?

Thank you for answering those questions. We only have a few questions left now and these will focus on institutional factors:

Institutional factors

94) What, if anything, have you/your clinic learnt from being involved in this trial?
- Anyone else from team involved?
- Outcomes?

95) How do you think the NHS could incorporate the ORBIT intervention into everyday practice?
Prompt

- Feasibility
- Benefits
- Obstacles

96) Do you think the NHS would be able to/willing to fund such a project?
- Costs versus benefits
- Good use of money?

Future Direction

97) Is there anything we could have done differently on this trial?

98) Overall, would you recommend the intervention to children?
- Why?
- At what point of diagnosis/age?

End of questions

That reaches the end of the interview and questions I wanted to ask you.

Thank you very much for your time.

- Do you have anything else you wish to speak about that hasn't been mentioned?
    - Let interviewee talk if they have anything else to add
    - If nothing else – then close interview

If you are okay to end the interview there, I will switch the Dictaphone off.

Switch Dictaphone off

Debriefing

- They can email me if they have any follow up questions/comments

- Thank them again, and ask if they are feeling okay to end interview here.

Appendix F Assent form for young people under 16 years and consent forms for young people over 16 years and parents/carers

ASSENT FORM FOR YOUNG PEOPLE UNDER 16 YEARS

Centre Name: Nottinghamshire Healthcare NHS Foundation Trust

REC reference: 18/NW/0079

Participant Identification Number for this trial:

ASSENT FORM

Title of Project: Online Remote Behavioural Intervention for Tics (ORBIT)

Name of Researcher:

Please initial box

1. I have read the information sheet dated 26 FEB 2018 (version 2.0) for the ORBIT study. I have discussed it with my mum/dad/carer and the researcher and I have asked questions.

2. I understand that I don't have to take part and I can stop taking part any time. This is my choice and no-one will be upset with me if I stop. ☐

3. I understand that the ORBIT team may look at my medical records and the data will be kept in a database both in England and in ☐

Sweden. This will be kept safe and only the research team will see my data.

4. I understand that the research team will write a report about the project. My name will not be mentioned in any reports. ☐

5. I agree to my Doctor knowing that I am taking part in the ORBIT study. ☐

6. The researcher might ask me to take part in an interview about my experiences of the ORBIT trial. I do not have to take part. If I agree to take part, the interview will be recorded but only the research team will know that I did the interview. ☐

7. I agree to take part in the ORBIT study. ☐

_____	_____	_____
Name of young person	Date	Signature

_____	_____	_____
Name of Person taking assent	Date	Signature

When completed: 1 for participant; 1 for researcher site file; 1 (original) to be kept in medical notes.

This research was funded by the NIHR Health Technology Assessment (ref 16/19/02). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

CONSENT FORM FOR YOUNG PEOPLE 16 YEARS AND OVER

Centre Name: Nottinghamshire Healthcare NHS Foundation Trust

REC reference: 18/NW/0079

Participant Identification Number for this trial:

CONSENT FORM

Title of Project: Online Remote Behavioural Intervention for Tics (ORBIT)

Name of Researcher:

Please initial box

1. I confirm that I have read the information sheet dated 25-MAY-2018 (version 3.0) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that relevant sections of my medical notes and data collected during the study, may be looked at by individuals from the ORBIT team, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. I ☐

understand this data will be stored in the UK (sealed envelopes) and Sweden (BiP and BASS) secure databases and servers.

4. I understand that the information collected about me will be used to support other research in the future, and may be shared anonymously with other researchers. ☐

5. I agree to my General Practitioner being informed of my participation in the study. ☐

6. I understand that I may be asked to take part in research interviews, which will be recorded and anonymous direct quotes from these interviews may be used in study reports.

7. I agree to take part in the above study.

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Person taking consent	Date	Signature

When completed: 1 for participant; 1 for researcher site file; 1 (original) to be kept in medical notes.

This research was funded by the NIHR Health Technology Assessment (ref 16/19/02). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

CONSENT FORM FOR PARENTS/CARERS

Centre Name: Nottinghamshire Healthcare NHS Foundation Trust

REC reference: 18/NW/0079

Participant Identification Number for this trial:

CONSENT FORM

Title of Project: Online Remote Behavioural Intervention for Tics (ORBIT)

Name of Researcher:

Please initial box

1. I confirm that I have read the information sheet dated 25-MAY-2018 (version 3.0) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that mine and my child's participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that relevant sections of my child's medical notes and data collected during the study, may be looked at by individuals from the ORBIT team, from regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. I ☐

understand this data will be stored in the UK (sealed envelopes) and Sweden (BiP and BASS) secure databases and servers.

4. I understand that the information collected about me and my child will be used to support other research in the future, and may be shared anonymously with other researchers. ☐

5. I agree to my child's General Practitioner being informed of our participation in the study. ☐

6. I understand that I/my child may be asked to take part in research interviews, which will be recorded and anonymous direct quotes from these interviews may be used in study reports. ☐

7. I agree for me and my child (named below) to take part in the above study.

_____	_____	_____
Name of Parent/carer	Date	Signature

_____

Name of child

_____	_____	_____
Name of Person taking consent	Date	Signature

When completed: 1 for participant; 1 for researcher site file; 1 (original) to be kept in medical notes.

This research was funded by the NIHR Health Technology Assessment (ref 16/19/02). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Appendix G Confirmation letter for ethical approval of interview schedules

North West - Greater Manchester Central Research Ethics Committee

3rd Floor Barlow House

4 Minshull Street Manchester

M1 3DZ

16 July 2018

Professor Chris Hollis

Professor of Child and Adolescent Psychiatry The University of Nottingham

Developmental Psychiatry E Floor, South Block

Queen's Medical Centre, Nottingham NG7 2UH

Dear Professor Hollis

Study title:	**Therapist-guided, parent-assisted remote digital behavioural intervention for tics in children and adolescents with Tourette syndrome: an internal pilot s**
	and single-blind randomised controlled trial
REC reference:	**18/NW/0079**
Protocol number:	**Hollis201117**

Amendment number:	**substantial amendment number 2.0 28-JUNE-2018**
Amendment date:	**28 June 2018**
IRAS project ID:	**239173**

Amendment relates to submission of interview schedules (mentioned in the original submission) that have now been developed.

The above amendment was reviewed at the meeting of the Sub-Committee held on 05 July 2018 by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

The Sub-Committee reviewed the amendment and no ethical issues were raised.

Approved documents

The documents reviewed and approved at the meeting were:

Document	*Version*	*Date*
Interview schedules or topic guides for participants [Child Interview Schedule]	1	25 June 2018
Interview schedules or topic guides for participants [Clinician Interview Schedule]	1	25 June 2018
Interview schedules or topic guides for participants [Parent Interview Schedule]	1	25 June 2018
Interview schedules or topic guides for participants [Therapist Interview Schedule]	1	25 June 2018
Notice of Substantial Amendment (non-CTIMP)	substantial amendment number 2.0 28- JUNE-2018	28 June 2018

Membership of the Committee

The members of the Committee who took part in the review are listed on the attached sheet.

Working with NHS Care Organisations

Sponsors should ensure that they notify the R&D office for the relevant NHS care organisation of this amendment in line with the terms detailed in the categorisation email issued by the lead nation for the study.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

We are pleased to welcome researchers and R & D staff at our Research Ethics Committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

18/NW/0079: Please quote this number on all correspondence

Yours sincerely

Signed on behalf of the Chair, Mr J Addison

E-mail: nrescommittee.northwest-gmcentral@nhs.net

Enclosures: *List of names and professions of members who took part in the review*

Copy to: *Shirley Mitchell, Nottinghamshire Healthcare NHS Foundation Trust*

Dr Charlotte Hall, University of Nottingham

North West - Greater Manchester Central Research Ethics Committee
Attendance at Sub-Committee of the REC meeting on 05 July 2018

Committee Members:

Name	*Profession*	*Present*	*Notes*
Mr J Addison	Retired Librarian	Yes	Chair
Mr Rodney Lighton	Retired Software Engineer	Yes	Committee Member

Also in attendance:

Name	*Position (or reason for attending)*
Miss Katherine Ashley	REC Manager
Ms Harriet Wood	REC Assistant

Appendix H Good Reporting of A Mixed Methods Study (GRAMMS) Checklist

Good Reporting of A Mixed Methods Study (GRAMMS)

Guideline	**Section: page**
Describe the justification for using a mixed methods approach to the research question	Design: p102-103 Strengths and limitations: p104-105
Describe the design in terms of the purpose, priority and sequence of methods	Design: p102-103
Describe each method in terms of sampling, data collection and analysis	Data collection: p88-97 Data analysis: p98-103
Describe where integration has occurred, how it has occurred and who has participated in it	Design: p102-103
Describe any limitation of one method associated with the present of the other method	Strengths and limitations: p104
Describe any insights gained from mixing or integrating methods	Discussion: p104

Appendix I Analytical framework

CATEGORY 1	DESCRIPTION
Motivation for participating	
To remove tics	*Participants stated that they wanted to participate so that their or their child's tics will be gone completely or decrease in severity and frequency*
To help others/research	*Altruistic reasons for participating*
Some sort of support	*Lack of support from services therefore looking for any type of support available*
Hoped to learn more about tics	*Lack of information and knowledge of tics so wanted to learn more to help themselves/their child*
Due to it being done online	*Participants motivating factor was because it was online*
CATEGORY 2	
Initial response to ORBIT	
Participant responsiveness	*How participants and therapists initially responded to ORBIT. Includes assessments by participants about the outcomes and relevance of ORBIT*
Quality of ORBIT trial description	*Degree to which the ORBIT trial was sufficiently and clearly described*
Quality of delivery	*Concerns whether the intervention was delivered in a way appropriate to achieving what was intended including participants thoughts on therapists*
Strategies to support therapists	*Refers to strategies such as provision of manuals, guidelines, training, and supervision*
Clinician perceptions of and contribution to recruitment	*Refers to consistency of recruitment procedures, perceptions of reasons for non-participation among potential participants, and subgroups less likely to participate*
Perception of initial recruitment strategies	*Includes participants views on the initial telephone screening and baseline assessment*
Relevance of questionnaires	*Participants views on the relevance of the questionnaires to themselves*

Expectations of role of the therapist	*Perception that 'therapist' was a misleading name*
CATEGORY 3	
ORBIT program content	
Perceptions of ORBIT organisation	*Includes views on whether ORBIT was an appropriate length, the structure of sessions, and frequency of therapist contact*
Lack of fit between content and child	*Includes judgment on the videos, animations, appropriateness to child's age, and missions*
Useful and enjoyable program resources	*What participants felt they have learnt from ORBIT (e.g. strategies parents have made as a result) and what were the most useful and enjoyable resources used*
Ease of use	*The ability to use ORBIT even if you lack IT skills*
ORBIT recommendations	*What participants and therapists feel could be added or removed in ORBIT to improve the program*
CATEGORY 4	
Mechanisms of impact	
Features of online therapy to support tic reduction	*Perception of online therapy working to help reduce tics and related behaviours including acceptability and satisfaction with ORBIT*
Perceived benefits of therapist support	*Having a therapist provided continued focus and motivation and the ability to answer any queries*
Limitations of online therapy	*ORBIT was limited by being delivered online and participants would have preferred face-to-face therapy*
Working together	*Instances of parent and child going through ORBIT together and the impact on how ORBIT was used and their relationship*
Unanticipated consequences	*This captures anything that happened unexpectedly as a result of ORBIT*
CATEGORY 5	
Intervention outcomes	
Level of control	*The child has better control over their tics in their daily life*

Expectations vs. reality	*Considering the participants expectations of ORBIT, what has the reality been in outcomes*
Long-term outcomes	*Going forward what does the future hold for participants. This includes anything the participant has said about future plans regarding use of services and whether they will continue to use ORBIT*
Routine clinical practice	*This refers to what clinicians feel are the main enablers or barriers to implementation of ORBIT in clinical practice (e.g. lack of funding)*
Improved self-esteem and confidence	*The intervention improved the child's sense of self, confidence, and quality of life*
Improvement in tics	*The intervention improved the frequency and severity of the child's tics*
Impact on parent	*The intervention had a positive impact on the parent in caring for their child*
CATEGORY 6	
Intervention characteristics that enabled implementation	
Flexibility of online therapy	*Being able to do online therapy at your own time and pace is seen as a positive*
Therapist support	*Having therapist support was seen as essential*
Use of computers	*Children and young people prefer using computers over face-to-face contact*
Perceived impact of therapy	*If the participant started to perceive the intervention as having a positive impact they were more likely to engage*
Adaptations	*Participants tailoring the intervention by making modifications to suit their needs*
CATEGORY 7	
Trial related enablers to implementation	
Opportunity to discuss tics	*This captures how children could open up and talk about their tics to someone other than their family members for the first time*
Follow-ups	*Having continuous support through follow-up appointments had a positive impact*
Financial reimbursement	*The use of vouchers as a reward for completing each follow-up aided implementation as well as expenses being reimbursed for initial baseline assessment*

Trust in experts	*Refers to how participants felt positive about the therapy as it was conceptualised and delivered by tic experts*
CATEGORY 8	
Trial related barriers to implementation	
Staffing resources	*Staffing issues and demands placed on the ORBIT team affected quality of implementation*
Demand on participants	*Trial related demands on participants (e.g. travelling long distances for baseline assessment and ability to participate in follow ups)*
Therapists workload	*Overworking of therapists affected quality of implementation*
Therapeutic relationship	*Therapists struggled to build an alliance with participants due to lack of visibility*
Therapists background and confidence	*Therapists didn't feel confident in their qualifications or ability to carry out their role expertly*
CATEGORY 9	
Intervention characteristics that supported tic reduction	
Visualisation of progress	*Participants were more likely to engage better as they could see the progress they were making and competing to beat their times on tasks*
Use of rewards	*Children were more likely to engage as they knew they would be receiving a reward for completing the tasks and practises*
CATEGORY 10	
Intervention characteristics that hindered engagement	
Repetitiveness	*Participants found the content highly repetitive and therefore would lose motivation and disengage*
Perceived lack of utility	*Participants would disengage if they didn't see an immediate impact on their tics*
Lack of interaction	*Participants wanted more face-to-face contact with therapists even if this was via videoconferencing and were more likely to stop persisting with ORBIT if they didn't receive this*
Negative impact on tics	*As can be an effect of ERP, tics began to worsen and therefore participants would disengage*

Lack of relevance	*If participants began to feel some of the components of the intervention were not relevant to them, they would disengage*
Perceptions of lack of engagement	*Reasons clinicians and therapists felt that some may have not engaged as well as others*
CATEGORY 11	
Participant contextual factors	
Perceived utility	*Participants who expected long term benefit of ORBIT persisted to complete the chapters and tasks*
High motivation levels	*Participants who were highly motivated to engage in ORBIT continued to engage with it*
Parental persuasiveness	*Parents were the main motivating force behind their child's level of engagement*
CATEGORY 12	
Family contextual factors	
Life stressors	*This captures how families struggled with ORBIT due to various stressors (e.g. child about to move to a new school)*
Busy lives	*The context of how families fit ORBIT into their everyday lives despite being busy (e.g. work, extracurricular activities)*
Family dynamics	*Parents with other children who also have neurodevelopmental or health issues*
School life	*How the exam period or holidays affected participation in ORBIT*

Appendix J Interpretation of framework data

MEMO: Category 1: 'Motivation for participating'

Definition

Removal of tics was perceived as desirable and the main motivating factor but was difficult to achieve. Participants were mainly aware that they shouldn't expect their tics to be removed completely as a result of ORBIT and most just wanted some kind of support.

Themes

To remove tics; To help others/research; Some sort of support; Hoped to learn more about tics; Due to it being done online

Summary of data

The majority of child participants felt that the main motivating force behind their participation in the ORBIT intervention was to help eradicate most, if not all, of their tics: ***"Well I thought good it will help me with my tics. I felt good. I was going to get rid of my tics." (Child 10, 10 years old, male)***. Parents had similar motivations for participating, however they soon understood that removing tics completely may have been an unrealistic goal: ***"Well I was hoping it would cure his tics which I know is being very optimistic. And then when I realised that wasn't possible I hoped it would make them decrease." (Parent 13, Mother)***.

There was also a need from parents for some sort of support and were grateful to receive any help for their child's tics, as access to therapeutic interventions for tic disorders is limited within the UK: ***"So when we heard about the trial, when I read about it I just thought you know what if***

there's nothing out there…there needs to be something out there. So I thought its research but at the same time, [child's name] getting some input so that I was really excited to be honest that I…but for someone that's in a position where you sort of think there's nothing out there…then that was brilliant really." (Parent 8, Mother). There was also an attraction to ORBIT being delivered online, which for one participant meant that their tics could not be seen by anyone: ***"I mostly prefer online…because half the time it doesn't even feel like my therapist is there which makes it a lot easier for me. Cause I've started talking about it in private. In face to face you have to do it in public…they might see me and say what's up with it." (Child 28, 10 years old, male).***

There were also altruistic reasons for participating, which involved children taking part so that the outcomes of the study could help other children similar to them and simply to help out with research: ***"Yeah I was interested because I'm quite interested in science as well and like medicine. So and I wanted to help other people with Tourette's." (Child 22, 15 years old, female).***

Deviant cases

One parent wanted some support for their child, as they were going to a new school next year and were worried about that transition so wanted to offset some of the stress by receiving some education and tools about tics.

Points for further consideration

- Do participants' motivations and expectations impact on their overall engagement and adherence to the intervention?

- If participants didn't see any immediate change in their tics, did they stop engaging?

MEMO: Category 2: 'Initial response to ORBIT'

Definition

Participants, therapists and clinicians initial response to the trial and intervention. This includes the quality of the descriptions of ORBIT, participants views on their assigned therapist, how supported the therapists felt with the use of supervision and training, and clinicians contributions to recruiting for ORBIT.

Themes

Participant responsiveness; Quality of ORBIT trial description; Quality of delivery; Strategies to support therapists; Clinician perceptions of and contribution to recruitment; Perception of initial recruitment strategies; Relevance of questionnaires; Expectations of role of the therapist

Summary of data

Most child and parent participants initially felt anxious and daunted by the baseline appointment, however once they met the researchers and therapists involved in ORBIT they quickly settled down: ***"I think [child's name] talking through his tics cause he'd obviously been quite nervous and he'd been through a really bad phase for a few months…And actually once that meeting, I think [child's name] just seemed to calm down completely…and he was much happier with himself actually so we found that a really positive experience." (Parent 28, Mother).*** Although one child stated how he felt under pressure at the baseline meeting: ***"It was***

a bit uncomfortable. Face to face meetings I've always found a bit like strange if that's the right word? Bit daunting…like I was alright listening to them but I felt a bit under pressure when I was talking to them [the researchers]." (Child 24, 14 years old, male).

There were mixed views on whether the ORBIT intervention was described appropriately at the baseline appointment. Some felt they understood the nature of the study and intervention: ***"Yeah because I think I mean they explained how it was going to be over 10 weeks and you would get chapters on the trial and stuff like that. And I think they were the main things that you needed to know and I think they explained it really well." (Child 14, 13 years old, male).*** Whilst others did not understand what the trial consisted of despite this being explained to them at baseline: ***"I didn't know what each one [treatment] consisted of really so I wasn't really hoping for any particular one." (Child 27, 13 years old, male).***

Therapists had various strategies in place which made their role somewhat easier. One such example was the use of standardised documents with various stock replies that they could respond to participant queries with: ***"We had standardised documents, of like a collection of standardised responses so any time we'd come across something unique or difficult or not immediately obvious to answer, after sort of emailing around and reviewing potential answers we'd obviously say how to come up with an answer to send to the participant and once I'd done so, I'd add a section into the collection of responses and add it in. So basically, we had something we could look at and call upon when we see someone and go 'look, we're not sure how to answer that, let me check this***

document' and then you can see if there was anything similar, or it's been answered before…that was very useful." (Therapist 2, second interview). They also highly valued their supervision sessions, which gave them an opportunity to discuss difficult cases and any general ORBIT related issues: ***"Our supervision has been amazing…once a week clinical supervision where we discuss specific patient queries or just generally how everyone is doing and how I'm finding it, yeah, it's been absolutely amazing, really really helpful. I couldn't really ask for a better supervisor, to be honest." (Therapist 3).*** However, they did agree that perhaps the CBIT training that they received during the trial should have been given at the beginning of the trial in order to aid the quality of delivery: ***"We only had CBIT training a couple of months ago and that would've been useful at the very start, and it's like I know we have had our supervisors and stuff like that, but it would've been nice to have a much more concrete programme and not just being given the manuals and told to read that because again it doesn't make much sense without theoretical background to it." (Therapist 1, second interview).***

Overall, clinicians have not had any issues with recruiting for ORBIT, as most of them stated that if they mentioned the trial to potential families then they were immediately interested: ***"It's been relatively easy in lots of ways in that we've had you know a number of families that have been interested I think…so there were lots there were families that would potentially kind of meet the criteria…and were interested." (Clinician 3, Psychiatrist).*** However, one clinician did have trouble getting the interest of her colleagues: ***"So but the interesting thing is to get clinicians interested in it and thinking about the children because we have a big***

Trust with three areas and I have sent it out over and over and over and over again and I think the uptake has been really low from the other…professionals." (Clinician 2, Psychiatrist).

Some participants were confused about the role of their assigned therapist and did find the responses somewhat generic: ***"The therapist wrote to us…it was a little bit standard. I could see there were bits that were copy and pasted and obviously you have to expect that from something that's given on such a large scale but it's nice if you know if it was he was only speaking to you and not copy and pasting." (Parent 13, Mother).*** Perhaps it was the case that the term 'therapist' was misleading to participants, as this gives connotations that they will be clinically trained to deliver the treatment when in reality they were there to motivate participants: ***"I don't know that the therapist was any use. We didn't utilise the therapist I don't think. It was more sort of it felt like it was more sort of they were cheering you on. They are more like a motivator than a therapist I think. I don't I kind of maybe expected a little too much from the ORBIT study." (Parent 30, Mother).*** The therapists themselves agreed that this term may have carried too much weight: ***"I think part of it would come down to whether it we would want to use the word therapist within ORBIT, because there's a lot of semantics and meaning about that word and I'm not sure off the top of my head if therapist or… what's the lay meaning of therapist basically? Does that mean psychotherapist, does that mean someone who's got a doctorate, who knows? So, everyone could… participants come into that with their own meaning and it also assumes that I… they've got expectations about what a therapist is, it assumes that I'm the expert***

and I really felt like I wasn't in this. My supervisors were experts." (Therapist 1, second interview).

Deviant cases

The only deviant case was the clinician who struggled to get her colleagues interested in the ORBIT trial. It was a large Trust so perhaps they had access to treatment for tics already.

Points for further consideration

- Did the quality of delivery affect outcomes? Even though this was a self-help intervention, there still required a level of input from therapists.
- Should therapists have been given more comprehensive training (e.g. CBIT) earlier in the trial?

MEMO: Category 3: 'ORBIT program content'

Definition

Perceptions of the content and organisation of the ORBIT intervention, including what participants found particularly useful, how easy they found navigating the intervention, where they felt the content was not age appropriate, and recommendations for the future version of the program.

Themes

Perceptions of ORBIT organisation; Lack of fit between content and child; Useful and enjoyable program resources; Ease of use; ORBIT recommendations

Summary of data

The majority of child participants accepted that the 10 week length of treatment was just right, however one participant felt that they needed more contact time with their assigned therapist: ***"I just liked doing the whole bit of ORBIT and chatting to my therapist but I think it was too short. Cause I could only chat to my therapist for 10 weeks, but then we had a full year logging on to ORBIT but we could not chat to our therapist which I found a bit annoying." (Child 20, 12 years old, male).*** One participant was getting tired of the treatment and stated that this was because of their ADHD: ***"I think it was just getting tired of like there were too many chapters. That might be my ADHD." (Child 7, 10 years old, male).*** Parents also appreciated the length of the intervention and found it suitable for their chid. Parents also appreciated that they could see their child's sections before their child so they could anticipate any queries or comments: ***"I liked the fact that in the parents it did give me some slides of what he was going to see so I had an idea without actually needing to see the whole thing. I thought that was really good." (Parent 16, Mother).***

The content of the ORBIT intervention was overall well received by all participants and child participants tended to particularly like the graphics and videos: ***"I liked the videos because I didn't have to read it. And they were telling you it." (Child 16, 10 years old, male); "I think the graphics were pretty amazing actually." (Child 5, 10 years old, male).*** However, the older child participants did find some of the content somewhat childish: ***"Some of it was really a bit young for me because I am on the older end of like test study but…some of it was good to like go over the basics. But some of it did get a bit repetitive." (Child 22, 15 years***

old, female), including perhaps two separate versions of the intervention, one for older children and one for younger: ***"But the layout and stuff was very much directed to younger kids…and I think if there was like a separate part of ORBIT that was for more like teenagers and stuff…and…the videos were a bit more…accustomed to young children. And…I think if there was just a bit there that was more directed to teenagers I think it would be better in that way." (Child 14, 13 years old, male).***

The most useful program resources seemed to be the tic ladder and the tic stopwatch. The tic ladder was useful, as it allowed participants to visualise their progress and to see exactly what tics they had in an organised manner: ***"I was able to write down my tics and how common they were and I was able to see how it was getting better or worse or if I needed to focus on that particular tic." (Child 24, 14 years old, male).*** The tic stopwatch was appreciated as it seemed to add an element of competition to the child participants: ***"Doing his tic therapy and then trying to beat him in the stopwatch afterwards and trying to beat his time so it gave him a little bit of competition. So that was good." (Parent 1, Mother).*** Overall, participants found the treatment easy to use and navigate and many of the parents stated that they didn't need to be experts in using computers: ***"Oh yeah anybody could use it and understand it, it was quite easy to follow and understand." (Parent 26, Mother).*** The overwhelming majority of participants thought that ORBIT could be improved if there was an app that worked concurrently with the treatment: ***"Yeah an app might be easier…yeah because…or maybe having the stopwatch as a separate app…cause that would be easier to get it out on your phone and then***

you could do that on the bus or something." (Child 22, 15 years old, female).

Deviant cases

One participant wanted the ORBIT treatment to have bonus sections in as they were enjoying it so much.

Points for further consideration

- Did the older children who found it childish eventually disengage with the treatment?

MEMO: Category 4: 'Mechanisms of impact'

Definition

How the ORBIT intervention worked or did not work in order to produce tic severity change and overall clinical improvement. Exploring the elements of success or failure of the online intervention including the nature of online therapy.

Themes

Features of online therapy to support tic reduction; Perceived benefits of therapist support; Limitations of online therapy; Working together; Unanticipated consequences

Summary of data

The main benefits of online therapy for child participants centred around the idea that they were not "seen", which is why they would prefer online to face-to-face therapy: ***"I preferred it because I'm not very good at face to face." (Child 1, 12 years old, male)***. The simplicity and straightforwardness

of the online method was very much appreciated: ***"Because it's really simple and straightforward because all you need to do is go over there and they will make you an account." (Child 12, 11 years old, male).*** Despite the perceived benefits of online therapy, there were some participants who felt that ORBIT did not work for them***: "I mean I don't think it's worked for [child's name] at all. I think it was a good thing to do but for [child's name] it hasn't worked. I don't think he engaged in it perhaps as fully as he could have done to get the actual benefit from it…and I don't know whether that's an age thing. Whether maybe he might have been a bit too young. Cause he's only just turned 10 so maybe a little bit older…cause at the moment all he wants to do is go out and play with his friends. He doesn't want to be thinking about if he's ticcing particularly badly." (Parent 30, Mother).*** One parent stated that the lack of an immediate response from their assigned therapist impacted on their child's engagement with the intervention: ***"You don't get an instant response from the therapist. Obviously they don't work after 5 or 6 o'clock at night…but sometimes they're in every three days or so. So if he didn't get a response the next day, there wasn't an immediate answer to his questions, which again for kids, they want something a little more immediate." (Parent 5, Mother).***

Parents seemed to appreciate working together on the therapy with their child, as it gave them an opportunity to interact more than they usually would with their child: ***"I think it was nice. I think [child's name] we kind of felt like a team working together on this." (Parent 11, Mother); "Most of the time it ended up being a nice time that we ended up spending together doing something that was just the two of us. When others in***

the family weren't really there. We had the room to ourselves and things so that was an incentive in a way for him." (Parent 21, Mother).

One parent found the sudden ending of interaction with their assigned therapist somewhat disheartening and it actually increased the severity of their child's tics. So much so that they sought the help of a CAMHS service immediately after ORBIT finished: ***"It was a really interesting like when we finished it finished really suddenly and we hadn't quite finished everything and it was almost like oh that's it and then it was ended. And now…the therapist was gone and it was quite a shock for [child's name] and his tics got much worse. Like worse than they'd ever been. And that was quite traumatic and we kind of reached out to CAMHS and they put us in touch with someone. She did specialise in tics and she just kind of talked to him and talked him through it all and did a bit." (Parent 18, Mother).***

Deviant cases

One parent (a mother) tried to engage the child's father to sit with them during the therapy to "shake things up".

Points for further consideration

- If the ORBIT intervention is successful and is implemented in routine healthcare, it may be worth changing the name from 'therapist' to 'coach' or 'mentor' so to avoid confusion on their role.
- Parental support seems to be the main factor in engaging the child.

MEMO: Category 5: 'Intervention outcomes'

Definition

This describes the level of impact that the intervention has had on child and parent participants, which includes any psychological improvements or improvements in the severity or frequency of their tics. This also captures clinicians' thoughts on how the intervention could be incorporated into routine healthcare, including barriers and facilitators.

Themes

Level of control; Expectations vs. reality; Long-term outcomes; Routine clinical practice; Improved self-esteem and confidence; Improvement in tics; Impact on parent

Summary of data

The main outcomes as a result of participating in the ORBIT trial according to participants was that their tics seemed to have improved and it has given them a sense of control over their tics: ***"Just how well I can control them and…how much they annoy me. Well I think it has really helped me to control my tics. Really helped me to stop them when I want them to stop so now I can do them for at least not for I'd say maximum about an hour and 40 minutes." (Child 5, 10 years old, male).*** The main impact for the parent was that their child now had a tool that they could use in order to control their tics in certain situations: ***"I think that it hasn't reduced the tics, it hasn't increased the tics, but [child's name] can control the tics. So…that actually is probably as good as in a way of reducing them because he took control." (Parent 8, Mother)***. The other pertinent impact it had on parents was that it gave them more understanding of their child's tics and it also showed that pointing out their child's tics to them is possibly not the best strategy: ***"[ORBIT] taught me not to comment and***

yeah it has made me realise that he can't help it. And how difficult it is for [child's name] to control his tics. And I saw that he worked really hard at it. It's given me more understanding of his tics." (Parent 13, Mother).

Psychological improvements were rare, however some parents did notice that their child's self-esteem and confidence had improved as a result of ORBIT: ***"And it's effected his self-esteem positively. It's effected his outlook on himself…you know sort of being more positive about what he's got." (Parent 8, Mother); "Not in her tics per se but I do think she's a little more confident I mean she's always been…reasonably confident about you know just saying to people if they ask she'll just be reasonably confident in her answers but I do think that she's more so and more self-assured in herself about them. So I think that's a really big positive for her." (Parent 23, Mother).***

Clinicians felt that ORBIT would be beneficial to the NHS and in improving access to evidence based treatment for CYP with tic disorders, however they did feel that money may be the biggest barrier to implementation within routine healthcare: ***"I think they could incorporate into a national…tics clinic where you could recruit patients even like this the whole time for Internet interventions which could be useful for the whole UK. I mean the money of course. The resources." (Clinician 2, psychiatrist); "So…I think that the way that things get commissioned…most things are commissioned at a local level basically so…it depends on what the offer was…knowing [name of PI]'s team…I think from an intervention point of view…I think it would be really understanding the cost effectiveness of it. And that would so if it was found to be a cost***

effective intervention then I can imagine…and its more cost effective than actually doing that face to face I can imagine that certain local CCG's (clinical commissioning groups) would potentially buy it." (Clinician 3, psychiatrist).

Deviant cases

One parent described how their child's tics become worse when they are in their company therefore she had to learn not to react or make any comments to exacerbate the situation further.

Points for further consideration

- Is it worth noting that clinicians feel this would be very welcome within the NHS when we think about future implementation?

MEMO: Category 6: 'Intervention characteristics that enabled implementation'

Definition

The components or aspects of the intervention that facilitated successful implementation. This included the fact that it was online and on a computer rather than face-to-face, the flexibility, and the potential to make adaptations.

Themes

Flexibility of online therapy; Therapist support; Use of computers; Perceived impact of therapy; Adaptations

Summary of data

Child participants appreciated the flexible nature of the ORBIT intervention. The idea that they could participate in treatment from the comfort of their own

homes and not have to travel long distances for face-to-face therapy was highly attractive: ***"I probably rather be like online because then it would be easier to like answer it because you have everything you have if you need it. And also because the face to face…if its far away, you have like 10 sessions cause you have to keep going forwards and backwards sort of thing." (Child 23, 10 years old, female)***. Moreover, participants liked that even if they had a busy schedule during the day, they could still practise their treatment: ***"The way it was done, it was almost designed for kids who have a busy school life." (Child 4, 11 years old, male).*** Some participants also felt that it was having an impact or it will have an impact on their tics therefore that encouraged and motivated them to engage more with the intervention: ***"Sometimes I didn't want to do it because I just wanted to do my own thing and stuff. I didn't want to ask the…like sitting in the living room with my mum and do like the see how long I could control my tics for…but I thought it's going to help…it's going to help so I thought I'll just do it but sometimes I didn't want to." (Child 14, 13 years old, male).***

The use of therapist support also enabled participants to engage more with the intervention, as it gave participants an opportunity to ask questions about elements of the therapy for which they were unsure about: ***"I thought it was helpful if you had like a question about something that you could ask her and you'd get a response pretty quickly. And yeah I thought it was just helpful to have someone there to answer your questions if you're unsure about anything." (Child 18, 14 years old, female).*** Participants made minor adaptations to the intervention and this mainly centred on making modifications to the 'tic ladder' or 'tic stopwatch' in order to make it more

tailored to their personal preferences: ***"I had to answer questions in the chapters and when I finished it I could go back and change it and I could change my ladder of when I do my tics and where I do my tics most often and my tic list of what I have. I liked the idea that I could change it. And it helped me." (Child 20, 12 years old, male).***

Deviant cases

None of the child participants mentioned that using a computer enabled them to engage more with the intervention, however, this theme was mainly mentioned by their parents.

Points for further consideration

- If found to be effective, does the ORBIT intervention need to ensure that these components are adhered to for successful implementation?

MEMO: Category 7: 'Trial related enablers to implementation'

Definition

Whereas the previous category was all about the specific intervention enablers to implementation, this category describes what trial related factors facilitated successful implementation. This includes the idea that it was created by a team of experts and financial reimbursements, such as vouchers.

Themes

Opportunity to discuss tics; Follow-ups; Financial reimbursement; Trust in experts

Summary of data

The main trial related enabler to help implement ORBIT was that this was an online therapy that was designed and delivered by a team of experts. This gave participants a great deal of trust in the intervention which enabled effective implementation and engagement: ***"I didn't quite know how it was going to work but I thought people who made ORBIT had obviously they obviously know what they're doing so…we'll see what happens. Basically I just trusted the people who made ORBIT and people involved in ORBIT knew what they were doing in making online questionnaires and therapy and they knew how to help us through instead of having to wait a long time." (Child 14, 13 years old, male)***. Some parents described how their child was now openly talking about their tics to other children, which was not the case before ORBIT: ***"Oh yeah understanding it and being able to talk about it in itself has had a big impact…Just understanding what they are and I've heard him…we went on holiday during it and he met some children on the campsite we were at and he did a tic and one of them said what are you doing and I heard him explain it to them and I'd never heard that before. Like before he would have gone "ohh um" but he actually explained what he had and why he did it. That was like this revelation that he could talk about it openly. Because he understood what it was and he understood it's nothing to be ashamed of or and that was I think that's something he's taken from it as well as everything else." (Parent 18, Mother).*** Parents also appreciated that their child would be followed up and not just left alone after the treatment ended: ***"I think the follow-ups are good as well the fact that you know after 3-months and 6-months and what have you stay in contact just to see how you going***

all the time is good rather than that just being it." (Parent 16, Mother).

Deviant cases

Only one child described that earning vouchers was a large motivating factor for them to engage in ORBIT.

Points for further consideration

- These factors are all specific to the trial therefore will removing some of them affect implementation of the intervention in routine healthcare?

MEMO: Category 8: 'Trial related barriers to implementation'

Definition

This relates to any factors external to the intervention itself which may have affected implementation negatively. Mainly this category relates to therapists and staffing issues which may have hindered implementation however it also covers the demands placed on participants, such as travelling long distances for the baseline appointments.

Themes

Staffing resources; Demand on participants; Therapists workload; Therapeutic relationship; Therapists background and confidence

Summary of data

Participants described how they found the trial overall quite demanding. From the initial baseline appointment to the intervention itself, some participants felt it was tiring to complete and this may have affected their engagement levels: ***"And it was a huge time commitment for me to do all the you***

know like I don't think I anticipated that quite that it would be my bit and then sitting down with him to do his bit which took ages cause we had to do all the questions. And then it was practising as well and then it was like it sometimes felt quite overwhelming and that's when the time thing really bothered me. Cause I felt like we were rushing through it and not necessarily making the most of it." (Parent 18, Mother).

Near the start of the trial, the two therapists who were interviewed again later in the trial, described feeling quite anxious initially about their lack of expertise and experience in delivering treatments for tic disorders: ***"To start off with, I was really quite terrified of it all, and am I doing it right and whatever? I had to get a lot of input from the two supervisors, but as time's going on and I'm getting more familiar with the Tourette's literature and the community, I am feeling more confident in my responses." (Therapist 1, first interview).*** They also stated that it would probably have been a good idea to have some sort of training package in ERP therapy before they delivered the treatment: ***"I think the training of ERP, or whatever behaviour therapy for tics would have been really good. Actually, I would have really liked to have some more in-depth training. I think, more training would have been really good, or some sort of training package." (Therapist 1, first interview).*** Two of the therapists also felt that the ORBIT staffing levels were not sufficient enough: ***"The only issue is if one of us is off sick, or one of us is ill, I mean one of us is away, then it may sometimes become a little bit unmanageable, so maybe having a bit more rigid backup in place,***

should that happen, that might be slightly more reassuring."

(Therapist 3).

Deviant cases

One parent described how they did the ORBIT treatment late in the evening time when the child was very tired so that affected their engagement.

Points for further consideration

- It would be sensible to have the participants meet their assigned therapist in person or on a video call, as this increases the chances of developing a rapport. Participants see that there is an actual human and not a chat robot.

MEMO: Category 9: 'Intervention characteristics that supported tic reduction'

Definition

Any characteristics of the intervention that helped participants to engage better with the treatment and had an impact on their tic reduction or overall clinical improvement. Initially this framework category included 'sense of control' and 'perceived impact of therapy' however no participants mentioned this in their interviews so they were subsequently removed.

Themes

Visualisation of progress; Use of rewards

Summary of data

The only two themes that were captured at this category were that participants could visualise their progress and that they were motivated to engage due to the reward system in place. Child participants described how

they liked the idea of visualising their tic cycle and to see their progress: ***"It was like a circle, a vicious circle, where it was like urge, tics, it goes away, urge, tic, go away. And that helps you visualise what goes on and there was another one that was like, the urge, then tic, resist, urge, tic, resist. That helped you visualise what you needed to do." (Child 4, 11 years old, male).*** Child participants also felt more motivated to take part in the treatment due to gaining a reward: ***"I liked the…reward thing because it was like a constant practising you'll get a reward so it was like the motivation to do the practise." (Child 27, 13 years old, male).***

Deviant cases

Some parents felt that the rewards were not needed to motivate their child as they were already highly motivated to engage.

Points for further consideration

- Will the reward system be required if the ORBIT intervention is rolled out within routine healthcare?

MEMO: Category 10: 'Intervention characteristics that hindered engagement'

Definition

This captured any aspect of the intervention that may have impacted on engagement in a negative way. Examples include repetitiveness and the lack of interaction. This also captures speculations on behalf of clinicians and therapists as to why participants may not have engaged.

Themes

Repetitiveness; Perceived lack of utility; Lack of interaction; Negative impact on tics; Lack of relevance; Perceptions of lack of engagement

Summary of data

Mainly child participants felt that they would have preferred more face-to-face interaction with their assigned therapist. This didn't necessarily have to be in person, as some felt a Skype session would have sufficed: ***"If it's just like answering questions like ticking on a computer I think that's quite good but if it's like asking questions, I think I prefer it in person like it feels a bit more connected and human." (Child 22, 15 years old, female); "It would be good if we could speak to him on like Skype thingy." (Child 16, 10 years old, male)***. Some participants also found the therapy itself quite repetitive which may have impacted on their engagement towards the end of the 10-12 weeks: ***"It was ok. It got a little bit tedious towards the end because it was very repetitive and it was hard work as well. I knew it would be obviously aimed at younger children as well but I think it just got very repetitive and it just especially towards…from about week 7 I was a bit I didn't look forward to doing it and that made…I think that made it more difficult to you know get good results." (Child 21, 15 years old, female).***

Therapists and clinicians had their own theories as to why some participants may not have engaged as much as others. One therapist explained that some may have been motivated to participate in ORBIT in order to help with their child's comorbid conditions, however ORBIT was not aimed at this: ***"It may be that if other co-occurring conditions are impacting the child's wellbeing and quality of life…then treating the tics which is the focus of the exposure with response prevention intervention is not really***

going to address the needs that the child has and often services can be quite limited in the community and it may be that families participate in this study in the hope that it may benefit some of the other conditions when indeed that isn't the target of it…so that could well be a barrier to accessing it." (Therapist 4). One clinician felt that maybe people will stop engaging due to having busy lives and other children to look after: ***"I can kind of assume is that…sometimes the family are very busy and the family may have a lot of other children and a lot of other things to sort out and deal with and that could be just you know forgotten about. It could be quite difficult for the child especially if they do have other comorbid issues…they may be struggling a bit with it especially with the treatment arm of it." (Clinician 5, Research Nurse).***

Deviant cases

One clinician described how one family complained to her that the child's medication could not be changed whilst participating in the intervention and this impacted on their engagement levels.

Points for further consideration

- It may be an idea to have one Skype session with therapists' midway through treatment in order to help re-engage participants.

MEMO: Category 11: 'Participant contextual factors'

Definition

This category is about anything external related to participant issues that may have impacted on either implementation or mechanisms of impact.

Themes

Perceived utility; High motivation levels; Parental persuasiveness

Summary of data

Parents mainly outlined how they were the driving force behind their child's engagement with the intervention. Some felt their child would not have engaged at all if it wasn't for their encouragement: ***"He didn't ever go off his own back and do it. I always had to say come on you've got to do it! You've got to do it! He's not a very motivated child anyway." (Parent 30, Mother).*** Some parents did find this challenging too, especially when their child had a comorbid condition such as ADHD: ***"Obviously for me trying to keep [child's name] engaged…on the computer and with the time aspect…you know that was the challenging part." (Parent 28, Mother).*** However, many parents did state that their child was already motivated to engage and did not need much encouragement: ***"I think [inaudible] engaging [child's name] so that part was fine because he was engaged without my effort." (Parent 22, Mother).***

Deviant cases

One child described how he was motivated to engage in the intervention as he simply wanted to control his tics and could see that the treatment was beginning to have an impact.

Points for further consideration

- It is clear that parents were the main motivator for their child to engage in the treatment and therefore perhaps require a more substantial role going forward.

MEMO: Category 12: 'Family contextual factors'

Definition

Similar to the last category, this explains any external factors related to family dynamics and how this may have affected implementation or mechanisms of impact.

Themes

Life stressors; Busy lives; Family dynamics; School life

Summary of data

Some parents described how their busy lives impacted on how much time they could give to their child and the intervention: ***"It was a challenge as I said because I work 4 days a week…ideally it would have been better to do it after school when we had plenty of time. It was a bit sort of frantic at times…you know trying to fit cooking tea in and…try and fit it in before bed time so from that point of view…as I said I knew that would be our biggest challenge was the time aspect." (Parent 28, Mother).*** One parent explained they felt they were performing the role of a therapist and felt somewhat guilty they could not give their child the time and energy due to the demands placed on them as a mother: ***"It's a bit difficult sometimes when you're the mum to do what the therapist would do. Because as a mum I might have just told [child's name] to do nothing…I might have told him off for something or I might in the afternoon be busy with my other children having to make dinner and sometimes I can't give it my full attention and energy with motivating and praising so I felt bad sometimes that I couldn't give it enough time and energy." (Parent 13, Mother).***

Deviant cases

One parent explained that the main difficulty they faced with engaging in ORBIT was their child was transitioning to senior school and this was a stressful time for them as a family.

Points for further consideration

- It is difficult to mitigate any external factors to the intervention.

Appendix K Content analysis tables

Number of participants in the ERP allocation			Number of participants who did not report any codes (did not complete Chapter 10 or send a message highlighting feedback)		
Child	**Supporter**	**Total**	**Child**	**Supporter**	**Total**
112	113 (One child had two supporters)	225	45 / 112	41 / 113	86 / 225

Category	**Number of participants reported a code related to this category.**			**Number of participants who reported a code related to this category more than once.**		
	Child	**Supporter**	**Total**	**Child**	**Supporter**	**Total**
A – Improved Perception	63	68	131	59	62	121
B – Feeling Supported	19	41	60	2	21	23
C – Limitations of ORBIT	51	55	106	29	43	72
D – ORBIT is Suitable	49	59	108	34	48	82
E – Problems associated with ORBIT	20	39	59	3	24	27

Code	Number of participants reported this code.			Number of participants who reported this code more than once.		
	Child	Supporter	Total	Child	Supporter	Total
A - Increased tic control	60	47	107	40	24	64
A – Increased Knowledge/Awareness	19	50	69	3	20	23
A - Acceptance	17	26	43	5	6	11
A – Becoming empowered	18	49	67	4	29	33
B – Therapist support	16	33	49	1	8	9
B – Open to expressing feelings	2	7	9	0	2	2
B – No support before ORBIT	0	7	7	0	4	4
B – Increased Child/Supporter collaboration	2	15	17	0	2	2
C – Struggle to engage	8	37	45	2	22	24
C – ORBIT is unclear	3	4	7	2	0	2
C – Symptoms increase during ORBIT	1	16	17	0	1	1
C – Remaining concerns regarding tics	39	6	45	2	1	3
C – Improvement required	33	40	73	5	15	20

C – Technical limitations	2	8	10	0	0	0
D – No difficulties reported	6	30	36	0	0	0
D – No adverse effects reported	0	42	42	0	1	1
D – No obvious changes required	19	17	36	0	0	0
D – Helpful aspect	14	4	18	0	1	1
D – Positive experience of ORBIT	42	42	84	11	19	30
D – ORBIT is clear	4	10	14	0	0	0
D – Easy to adhere to	1	10	11	0	1	1
E – Caused negative feelings	2	27	29	0	10	10
E – Interpersonal issues	2	15	17	0	7	7
E – Practice is difficult	16	11	27	0	1	1
E – No benefit from ORBIT	4	9	13	0	4	4
E – Face-to-face therapy more suitable	1	6	7	0	1	1

Appendix L Interpretation of content analysis data

CATEGORY A: Improved perception/experience of living with tics after ORBIT

Quotes:

"Since I started the ORBIT study I have become better at controlling my tics and my life has been getting easier as my tics aren't as much as a problem now." - Child

"It has helped me have a better understanding as to what tics are and how to manage them. It has made my life easier because now I know that I'm not the only one so I feel more comfortable doing them." - Child

"Yes, it has taken away the worry associated with not really understanding [my child's condition]. I previously had no idea what to do with his tics - ignore / talk about them etc. I had felt quite helpless and uneducated. I now feel more knowledgeable and confident in this area, and feel that if he decides he wishes to engage in trying to control his tics, I feel that I am in a position to support him." - Supporter

Codes:

Increased tic control – Anything related to a reported decrease in tics or an increased ability to control them. Also includes supporter feeling more able to support child with controlling tics, as well as being more knowledgeable about ERP.

Increased knowledge/awareness– Anything related to a reported increase in knowledge or awareness (e.g. greater understanding of tics / knowing what can trigger them etc.). Usually being 'taught' something.

Acceptance – Anything related to the acceptance of having a tic disorder – including understanding, they may continue to be an issue in the future and that others have tics too. Also reductions in concerns about tics.

Becoming Empowered – Anything related to becoming empowered such as increased confidence, optimism and being able to apply treatment content. Includes reports of being more comfortable talking about tics and feeling positive towards the future management of their condition. Feeling more able to manage their condition in general. Also includes supporter feeling more able to help child.

CATEGORY B: Feeling supported in a way they have never been before

Quotes:

"[The most helpful thing about ORBIT was] being able to express my feelings" - Child

"[ORBIT has] given me more hope than I've felt before, and it's been incredibly comforting to have someone to be able to talk to and ask questions of, because I've literally never had that before." - Supporter

"[ORBIT has helped] to give me and her a common dialogue so that we can talk about it with the common language and I can try to make her make sense of the tics and the practise by referring to things that we have both studied" - Supporter

Codes:

Therapist support – Anything related to the benefit of a therapist, includes messages thanking the therapist.

Open to expressing feelings – Anything related to increased expression of feelings and emotions (e.g. child is more open to talking about their issues than previously).

No support outside ORBIT – Anything related to having had little to no support from healthcare professionals prior to engaging in ORBIT.

Increased child/supporter collaboration – Anything related to child and supporter being more willing/able to work together to achieve common goals. Child feeling more supported by the supporter (or whole family) during and after ORBIT.

CATEGORY C: Limitations of ORBIT – ORBIT is helpful but is limited by certain factors

Quotes:

"I still have tics and we found the technique information quite basic as it was just to focus and try and stop them." – Child

"I find it really hard to make myself want to [be] proactive [with] it because it just ruins nice time and it's really frustrating." - Child

"I think it was rather repetitive. I fully understand that the practicing obviously needs to be but the same questions being asked got a bit annoying personally." - Supporter

Codes:

Struggle to engage – Anything related to not being able to devote the necessary time to ORBIT. Including motivational issues, ORBIT not being engaging and reports of having not done enough work. External issues leading to lack of engagement are included as if a lot of people struggle to find the time for ORBIT alongside other responsibilities, this is a limitation of ORBIT as it may be too time demanding.

ORBIT is unclear – Anything related to the treatment information presented poorly.

Symptoms increased during ORBIT – Anything related to symptoms of tics or comorbid conditions increasing: not listed a 'problem of ORBIT' as these are expected despite being problematic.

Remaining concerns about tics – Expressed concerns about tics still being problematic, can be a limitation but not a 'problem' as tics are not expected to go completely during the 10-week programme.

Improvement required – Anything related to an aspect of ORBIT being unhelpful or inappropriate. Examples include repetitiveness of treatment, treatment too short or too long, unhelpful aspects, and suggested improvements.

Technical limitations – Anything related to ORBIT being limited by its technical aspects (e.g. problems with the platform or users not being comfortable with using computers).

CATEGORY D: ORBIT is suitable as a treatment for tic disorders

Quotes:

"I thought that the videos were very helpful because they explained [the information] very well." - Child

"We have really enjoyed the treatment programme and it is particularly useful for a teenager who needs to not miss school for daytime treatment appointments" - Supporter

"[ORBIT] has only been a positive experience for us." – Supporter

Codes:

No difficulties reported – Reports of finding nothing difficult about ORBIT

No adverse effects reported – Reports of no adverse effects from ORBIT

No obvious changes required – Reports of no improvements being required.

Helpful aspect – Reports of something specifically being helpful (e.g. videos or tasks).

Positive experience of ORBIT – General comments regarding the treatment being beneficial overall. Anything related to being pleased to have taken part and finding it enjoyable. Recommending this to other individuals with tic disorders. In addition, reporting that there was nothing they did not like or that nothing was unhelpful.

ORBIT is clear - Information and content are easy to understand.

Easy to adhere to – ORBIT being easy to complete (e.g. being engaging/motivating and user-friendly). Also reports that ORBIT does not

disrupt daily life (e.g. no need to miss school). Reports noting the benefits of online treatment (e.g.. far-reaching access).

CATEGORY E: Problems with using ORBIT – ORBIT is not helpful or is associated with significant negative issues.

Quotes:

"I think the treatment may work for others however, I have had my tics for 8-9 years so it is something I have lived most of my life. Because I can't remember not having tics, I found it incredibly difficult to feel a tic signal and as a result, I can't hold back my tics (I couldn't feel them coming)." - Child

"[ORBIT] has made me more anxious. I was relaxed and calm and I accepted my son's condition but now I feel like I haven't done enough to help him and makes me feel like a failure." - Supporter

"I am upsetting my son by trying to get him to do this because he does not deal well with change. He was really excited to do this and really loved doing it with me but now he does not want to log on [after multiple changes in therapist] which is stressing me out and causing a rift between us despite trying to keep it light and positive. This sort of thing needs consistency from your end as well as mine." - Supporter

Codes:

Caused negative feelings – Anything related to ORBIT being associated with negative feelings (e.g. anxiety, becoming upset, stressed, frustrated, annoyed, or angry).

Interpersonal issues – Anything related to problems with the working relationship (e.g. disagreements between child and supporter or child and supporter not working well together). Any problems with their relationship with the therapist such as not being able to relate to them.

Practise is difficult – Anything related to the practise being hard / uncomfortable / painful / tiring and thus aversive and unlikely to be completed. Includes not being able to use it due to lack of tic signals.

ORBIT is difficult – Unspecified reports of the treatment being difficult in general.

No benefit from ORBIT – Any comments suggesting that the users have received little to no benefit from their engagement with the programme (i.e. ORBIT not being useful at all).

Face-to-face therapy more suitable – Any comments related to the idea that face-to-face therapy is more suitable than ORBIT (or that the online treatment is inappropriate or unsuitable). Does not include a suggestion of videoconferencing via ORBIT, as this would be a suggested improvement rather than a replacement of ORBIT with something else.