

## mHealth Apps Delivering Early Intervention to Support Parents of Children With Autism Spectrum Disorder: A Scoping Review

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**Context:** Early intervention, and parent-mediated intervention are effective in achieving early childhood development goals for children with autism spectrum disorder. There is a surge in mHealth technologies delivering such interventions. This review aims to explore the concept, context and methodology of implementation of such mHealth apps. **Evidence Acquisition:** A search was conducted using NICE (National Institute of Clinical Excellence) healthcare database, including keyword 'early intervention,' 'mHealth,' 'parent support,' 'apps,' and 'autism.' The quantitative, qualitative, mixed-methods, case reports, grey literature, systematic reviews, clinical trials, and feasibility studies of children between 2 to 6 years with ASD were included from inception of database to December, 2021. Web/Internet-based or computer-dependent programs were excluded. The initial search yielded 3786 studies; 17 were finally included based on the inclusion and exclusion criteria. **Result:** Studies on a total of 17 mhealth apps were reviewed. Nine apps, apart from TOBY (Therapy outcome by you), lacked a holistic approach and instead targeted a specific difficulty in autism. The provision of support to parents using apps was equally beneficial as in-person support, reduced costs, and improved outcomes in children. **Conclusion:** The review revealed limited evidence-based mHealth apps available currently in a community setting. This also underscores an opportunity for clinicians to re-direct parents towards evidence-based information and interventions.

**Keywords:** Early digital intervention, Digital technology, Mobile application-based support, eHealth, Parental support.

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Autism spectrum disorder (ASD) is characterized by persistent deficits in the ability to initiate and sustain reciprocal social interaction and social communication with a range of restricted, repetitive, and inflexible patterns of behavior, interests or activities that are atypical or excessive for the individual's age and socio-cultural context [1]. Appropriate early interventions improve a child's development and behavior and reduce symptoms [2-4]. Early intervention has been defined as "services and supports available to babies and young children with developmental delays and disabilities, who are at risk of poor outcome and their families" [5]. The primary purpose of early intervention is to help in the acquisition and generalization of critical developmental skills, and to achieve independent functioning across environments [6]. Early intervention programs are more effective, if provided early [7]. The definition of early varies according to the age and developmental status of the child; areas where problems have been identified; the availability of pro-

fessionals, the community and other resources at a local level; and individual choices made by parents [8,9].

Parents are key participants in the early intervention process. Information from parents, or carers can contribute to a better understanding of the complex interactions between neurodisability and its consequences. It helps in the planning of early intervention and providing support to parents through various implementation and theoretical models [10]. Early intervention through parents or caregivers, based on an integrated framework in a community setting, is helpful [11]. The limiting factors at the community, schools, parent group-based and home-based levels were lack of trained professionals, lack of such services in remote areas, time factor, parents' adherence and cost-effectiveness [12-14]. An early intervention must continue beyond the formal hours of contact to transfer skills into everyday activities [15]. To achieve this, there has been a rapid increase in the conversion of evidence-based in-person early inter-vention programs into remote and telehealth programs [16,17].

The emergence of mobile health (mHealth) has opened a new frontier for the delivery of early intervention [18]. The term mHealth was coined to describe a subset of eHealth that uses mobile technologies, including advancements in innovative applications to address health priorities [19]. It has great potential as a scalable and cost-effective delivery mechanism. This scoping review aims to present a review of currently available mHealth apps, which are used to deliver the early intervention to support parents of children with ASD between 2 to 6 years of age.

## METHODS

A scoping review design based on Joanna Briggs Institute (JBI) methodology [20] for the conduction, and PRISMA extension (PRISMA-ScR) checklist and flow diagram [21] were utilized to guide procedures for identification, screening, eligibility, and inclusion of articles for review.

*Search Strategy and Selection:* A search was conducted from the inception of the database until December, 2021. Keywords for mHealth application, technology, early intervention, autism spectrum disorder, parent support and training, and digital program, were used (**Web Table I**, Piori protocol [10]). The following databases were used: NICE Healthcare Databases Advanced Search, Cochrane Library, EbscoHost, Sabinet, SAGE Journals, Directory of Open Access Journals (DOAJ), BioMed Central, Scopus, and ScienceDirect. Furthermore, grey literature was searched through Google Scholar, ShodhGanga, Journal Storage (JSTOR), CORE, and Bielefeld Academic Search Engine (BASE).

We defined autism apps as apps developed to support parents of children with autism aged 2-6 years. We defined a parent support app as any app to be used by parents, which helps them during the diagnosis pathway, during diagnosis, and after diagnosis during early intervention, in a community-based, hospital, clinic or research setting. We also aimed to understand the nature of the outcome measurements, their concept, context of implementation, methodological framework, and evidence quality.

Classification of mHealth applications was done using the NICE Evidence standards framework for digital health technologies [22]. TiDieR checklist reported the type of intervention, context, and outcome [23]. The quality and level of evidence was reported using the Evidence-Based Practice (EBP) tool developed by the Center for Evidence-Based Practice [24].

Eligible studies were uploaded to the Google Data extraction sheet (DES) (**Web Table II**). DES was screened for duplicates. In the second step, all the titles and

abstracts were screened using the eligibility criteria, and those not matching were excluded. The final papers meeting the eligibility criteria were included for full data extraction using the DES.

*Population/participants:* Studies that included parents and carer of children with ASD between the ages of 2 to 6 years were included to review the apps supporting parents in the early years. Parents were defined as a biological parent, birth parents, carer or foster parents of children with ASD.

mHealth applications (apps) were defined as applications developed for use on mobiles or smartphones, tablets, or iPad that can be easily downloaded from the Play Store or App Store. Web/internet-based programs, or computer-dependent programs were excluded. The studies conducted or implemented for parents of children with ASD to provide support during the early intervention in community settings, school settings, special schools, clinics, hospitals, at home and child development centers were included. The inclusion was independent of region, gender, socio-cultural, or language factors.

*Data extraction and analysis:* Data extraction was done in two steps. The DES (**Web Table II**) included authors' names, year of publication, the purpose of the study, population and sample size, context, concept, outcomes, key findings, strengths, limitations, parental feedback, and theoretical framework. In the second step, the final papers meeting the eligibility criteria were analyzed using the Summary of the findings table (SOFT; **Web Table III**) developed based on the TiDieR checklist [23], by two authors. The quality and level of evidence and classification, for the included apps, are shown in **Table I**.

## RESULTS

The process of screening is shown in **Fig. 1**. The papers were excluded after being screened are mentioned in (**Web Table IV**). Seventeen papers were screened in full using TiDieR checklist and web-based software called Scholarcy (**Web Table III**).

All 17 papers were published between years, 2013 and 2021, with an increase from year 2017 onwards (15 of 17 papers) in the number of publications on mHealth. All papers were from high-income countries, most commonly from United States of America ( $n=6$ ) and Australia ( $n=6$ , 35.3% in each). The sample size of parents and children in the studies ranged from 3 to 62 (415 mothers and 13 fathers), and 2 to 1514 (2735) children. All the papers included children within the age range of 1-12 years. In the final analysis, the findings for the age range 2-6 were included.

**Table I Quality and Level of Evidence, and Classification as per the NICE Evidence Standards Framework for Digital Health Technologies**

<i>Research title</i>	<i>App name</i>	<i>NICE</i>	<i>Quality</i>	<i>Level of evidence</i>
A pilot investigation of an iOS-based app for toilet training children with an autism spectrum disorder.	Toilet training app	Tier C: Interventions	B: Good quality	Level I (RCT)
A randomised controlled trial of an iPad-based application to complement early behavioural intervention in Autism Spectrum Disorder	Therapy outcome by you (TOBY)	Tier C: Interventions	B: Good quality	Level I
A Randomised Controlled Trial of an Information Communication Technology Delivered Intervention for Children with Autism Spectrum Disorder Living in Regional Australia.	Therapy outcome by you (TOBY)	Tier C: Interventions	B: Good quality	Level I
A twelve-month follow-up of an information communication technology delivered intervention for children with autism spectrum disorder living in regional Australia.	Therapy outcome by you (TOBY)	Tier C: Interventions	B: Good quality	Level III (Mixed
TOBY play-pad application to teach children with ASD – A pilot trial	Therapy outcome by you (TOBY)	Tier C: Interventions	C: Low-quality	Level III (Pilot Trial, with no control group, or randomisation)
Appropriateness of the TOBY Application, an iPad Intervention for Children with Autism Spectrum Disorder: A Thematic Approach	Therapy outcome by you (TOBY)	Tier C: Interventions	B: Good quality	Level III: Qualitative
Parental experiences using the Therapy Outcomes by You (TOBY) application to deliver early intervention to their child with autism.	Therapy outcome by you (TOBY)	Tier C: Interventions	B: Good quality	Level III: Qualitative
A trial of an iPad™ intervention targeting social communication skills in children with autism.	Findme	Tier C: Interventions	B: Good quality	Level I: RCT
Brief Report: Mobile Technology to Support Parents in Reducing Stereotypy.	iStim Interventions	Tier C:	C: Low-quality Experimental	Level II: Quasi-Experimental
The use of behaviour modelling training in a mobile app parent training program to improve functional communication of young children with autism spectrum disorder.	Map4speech	Tier C: Interventions	C: Low-quality	Level 2
The Effectiveness of a Psychoeducation Intervention delivered via WhatsApp for mothers of children with Autism Spectrum Disorder (ASD) in the Kingdom of Saudi Arabia: A randomized controlled trial.	Intervention delivered via whatsapp	Tier B: understanding and communicating	B: Good quality	Level I
A Comparison of PECS and iPad to Teach Requesting to Pre-schoolers with Autistic Spectrum Disorders	Sounding Bird	Tier C: Interventions	C: Low-quality	Level II
Evaluating the Effectiveness of a Tablet Application to Increase Eye Contact in Children Diagnosed with Autism	Look in my eyes steam train	Tier C: Interventions	C: Low-quality	Level II

*Contd....*

table contd. from pre-page

Research title	App name	NICE	Quality	Level of evidence
An Evaluation of a Mobile Application Designed to Teach Receptive Language Skills to Children with Autism Spectrum Disorder	Camp Discovery	Tier C: Interventions	B: Good quality	Level I randomized controlled trial (RCT)
Tablet-Based Cognitive Exercises as an Early Parent-Administered Intervention Tool for Toddlers with Autism - Evidence from a Field Study	Mental Imagery Therapy for Autism (MITA)	Tier C: Interventions	A: High quality	Level III
Mental Imagery Therapy for Autism (MITA) - an Early Intervention Computerized Language Training Program for Children With ASD	Mental Imagery Therapy for Autism (MITA)	Tier C: Interventions	B: Good quality	Level III: non-experimental, descriptive study
Children with Autism Appear to Benefit from Parent-Administered Computerized Cognitive and Language Exercises Independent of the Child's Age or Autism Severity	Mental Imagery Therapy for Autism (MITA)	Tier C: Interventions	B: Good quality	Level II

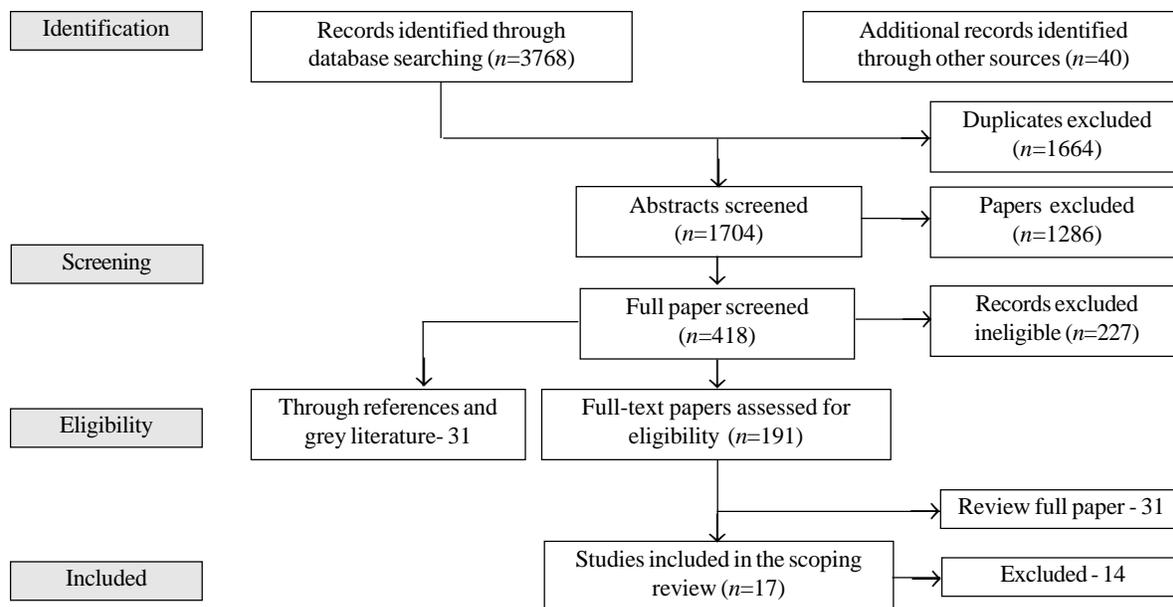
*Level I: studies include randomized control trials (RCTs) or experimental studies; Level II: studies have some degree of investigator control and some manipulation of an independent variable but lack random assignment to groups and may not have a control group; Level III: studies lack manipulation of an independent variable; can be descriptive, comparative, or correlational; and often use secondary data. Quantitative Studies: A High quality: Consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on a comprehensive literature review that includes thorough reference to scientific evidence. B Good quality: Reasonably consistent results; sufficient sample size for the study design; some control; fairly definitive conclusions; reasonably consistent recommendations based on a fairly comprehensive literature review that includes some reference to scientific evidence. C Low quality: Little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn. Qualitative Studies: A High quality: Contains high-quality quantitative and qualitative study components; highly relevant study design; relevant integration of data or results; and careful consideration of the limitations of the chosen approach. B Good quality: Contains good-quality quantitative and qualitative study components; relevant study design; moderately relevant integration of data or results; and some discussion of integration limitations. C Low quality: Contains low quality quantitative and qualitative study components; study design not relevant to research questions or objectives; poorly integrated data or results; and no consideration of limits of integration.*

Ten apps were included in the final review; nine apps were available only on iPhone operating system (iOS) [25-35,37], and three apps were available on both iOS and android platforms [35,38-41] (**Web Table III**). Nine apps [25-34,36-41] were classified as Tier C: Intervention apps (**Table I**). All the apps differed in terms of interventions viz., toilet training [25], developmental abilities [28-31], social communication skills [32], reducing stereotypy [33], naturalistic language intervention [34], psychoeducation intervention [35], picture exchange communication system [36], increasing eye contact [37], teaching receptive language skills [38], and cognitive exercises through a tablet [39-41]. The method of determining a participant's diagnosis also varied across all the studies, three studies did not mention the use of any diagnostic or screening tools used, two mentioned diagnosis was self-reported by parents, and four mentioned the use of the Autism Diagnostic Observation Schedule 2 (ADOS-2) [42], two mentioned diagnosis being done by the multi-professional team but did not mention any specific tool, one study reported use of Childhood Autism Rating Scale (CARS2) [43], and two used the criteria mentioned in

Diagnosis and Statistical Manual of Mental Disorders (DSM-5) [44]. The context of delivery was home [28], home along with treatment as usual [28-35], remote at home [28-30], community- and school-based [32,34], intervention room/research setting [36,37], home and treatment center [38], and clinics [39-41].

Out of the seventeen papers included; one was rated high quality, eleven were rated as good quality and five were rated as or low quality. And using the EBP tool for the level of evidence rating, six papers were rated as level I, six were rated as level II and five were rated as level III (**Table I**).

The apps reported a variety of outcomes- a greater rate of skill acquisition in the intervention group [25]; no group difference on the primary outcome, significant improvements at the 6-month follow-up on three secondary outcomes [28]; no significant difference between baseline and post-intervention on other variables apart from expressive language [29]; improvements in receptive language, social skills, pragmatic language and playfulness [28]; positive feedback from parents on Therapy



**Fig.1** PRISMA flow diagram of the study.

outcome by you (TOBY) app [29-31]; no impact on real-world social communication skills [32]; reductions in stereotypy [33], improvements in parent’s NLI skills and children’s functional communication [34]; improvements in material happiness, and reducing maternal stress, depression, parent-reported ASD symptoms, child behavior problems [35]; and successful in teaching requesting skills [36].

The various theoretical framework which the included papers used were psychological models of stress and coping, and the double ABCX model ( $n=1$ ), applied behavioral analysis ( $n=7$ , 41.2%), behavioral inter-ventions ( $n=7$ , 41.2%), theory of mind cognitive model ( $n=1$ ), and two papers did not mention the theoretical framework used.

Out of the included 11 mHealth interventions, only two did feasibility and usability testing. For implementation, clinical trials ( $n=1$ ), randomized control trials ( $n=5$ , 29.4%), pilot investigations ( $n=2$ , 11.8%), and original research ( $n=7$ , 41.2%) were done.

**DISCUSSION**

This scoping review summarizes the evidence on current mHealth apps delivering early intervention in children with ASD. These mHealth apps were equally beneficial as in-person support, reduced cost, and improved outcomes in children, which were maintained till after 12 months. This review identified a gap in such technology support for parents in lower- and middle- income countries, as all publications were from high-income countries. The mHealth apps were similar in terms of the target popu-

lation including parents (mostly mothers), and children aged between 2 years to 6 years, training parents, improving the child’s skills, and treatment fidelity. Most of the studies used standardized measures of diagnosis; although, they varied in the type of assessment used. Few reported no method of diagnosis or did not use one, thus raising a question on the sampling process.

There was a significant difference in primary and secondary outcomes across all studies that did not meet the defined goal of early intervention i.e., to assist in the acquisition and generalization of developmental skills. Instead, most mHealth apps focused on one aspect of daily life activities (DLA) or focused on improving autism-related behavior like eye contact, social communication, reducing stereotypy behavior, and teaching to request. This highlights the lack of interventions focusing on overall development, which might help in achieving the goal of early intensive evidence-based intervention for children with ASD.

All included mHealth apps were rated as Tier C: intervention level as per the NICE framework, but none were scrutinized for clinical safety, using Organization for the Review of Case and Health Apps (ORCHA) rating or WHO criteria for mHealth apps, apart from Mental Imagery Therapy for Autism (MITA). This suggests a clear lack of scrutiny of such apps on aspects like data security, clinical safety and clinical efficacy. They lack scientific evidence of being conducive to improve the outcome in affected children. The review suggests a clear

need for a mandatory real-world trial, patient and public involvement, and Digital Technology Assessment Criteria (DTAC) and ORCHA rating of all mHealth apps before making them available for parents and children with special needs. We also found a lack of any regulations or guidelines for such apps for app providers and publishers like the android play store.

All the mHealth apps have been grounded in a strong theoretical foundation, mostly based on behavior analysis, but the findings suggest most of them lack usability, feasibility, and efficacy before being used with a vulnerable population. Before being utilized by parents in general, only two apps, TOBY and MITA, underwent a pilot, RCT, feasibility, and usability test. However, TOBY lacks a sufficient sample size to generalize the findings.

The review revealed an opportunity for mHealth technology to aid early intervention in ASD. Although, there is an abundance of technology available, we found a lack of scientific rigor in the current mHealth apps. There is a need to create clear guidelines for the mHealth app stores to screen the apps for scientific evidence, and quality before making them freely available for parents of children with ASD. We suggest the need for a community-based mHealth app deliver early intervention to support parents of children with ASD based on the child's needs and at home, along with regular intervention. There is a need for a large-scale population trial of such apps, to generalize the finding to a larger population.

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**Note:** Additional material related to this study is available with the online version at [www.indianpediatrics.net](http://www.indianpediatrics.net)

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**Web Table I Result from search done on 21<sup>st</sup> December 2021 using National Institute for Health and Care Excellence (NICE) Healthcare Databases Advanced Search (HDAS)**

Search	The search strategy used in MEDLINE (NICE Healthcare Databases Advanced Search)	Records retrieved
#1	Digit* OR exp TECHNOLOGY/ OR exp ELECTRONICS/ OR exp "DIGITAL TECHNOLOGY"/ OR exp "ANALOG-DIGITAL CONVERSION"/ OR digitisa* OR digitiza* OR onlin* OR technolog* OR computeriz* OR digitaliz* OR cell phone* OR mhealth* OR mobile technology* OR smartphone* OR mHealth apps* OR digital health intervention* OR digital health technology* OR e-health* OR telehealth* OR telemedicine*	2,263,054
#2	paren* OR exp PERSONS/ OR paren*or guardi* OR famil* OR Parent training* OR psychoeducation* OR parent education* OR Parent Education Programmes* OR Parent Education Groups* OR Parent Psychoeducation* OR Parent Education Training*	178,797
#3	"Autism spectrum disorder"/ or "autistic disorder"/ or "pdd"/ or "asperger"/ or "neurodis"/ or "autism spectrum conditions"/ or "autistic spectrum conditions"/ or "autism"/ or "complex autistic spectrum"/ or "social communication disorders"/ or "neurodisability"/ or "autistic disorder"/ or "autistic condition"/ or "asperger syndrome"/ or "spectrum"	461,50
#4	Child health services"/ or "preventive health services"/ or "early intervention, educational"	88604
MEDLINE	COMBINED- (1 AND 2 AND 3 AND 4)	500
Pubmed		546
PsycINFO®		904
EMBASE		765
HMIC		53
<p><b>Note:</b> The search keywords shown, are the one used in MEDLINE  Abbreviations:  MEDLINE - Medical Literature Analysis and Retrieval System Online  EMBASE- Excerpta Medica database  HMIC - Health Management Information Consortium</p>		

Web Table II Data extraction sheet

Origin	Population and sample size	Methodology	Classification as per the NICE	Key findings that relate to the scoping review question	Major strengths and limitations	Parental feedbacks
United States of America	74 potential participants were screened, and 33 (45%) were randomized to either WMP or SBT.	pilot randomized controlled trial	Tier C: interventions	Parents used the app and related technology with few difficulties or malfunctions.	strength: RCT  limitations: larger number of participants and longer intervention period (e.g., 6months) may have yielded different results; sessions, it is unknown how these interventions would fare under guidance from less academically trained providers or with fewer opportunities for consultation during intervention.	- parent satisfaction was high for both groups, parents saw benefit in participation.  - most parents found the technology reliable and easy to use  - minor challenges: replacing a dead battery, activating device, connectivity between transmitter and iPod, troubleshooting by interventionist and broad research team
Australia	80 children, randomised to either the 'TOBY group' (n = 41,80.6%male) or the 'Therapy as Usual' (TAU; n = 39,76.9%male) group.	This was a multi-centre, stratified (site, socioeconomic status and developmental quotient, with 1:1 randomisation), parallel group RCT		Mhealth based support led to small improvements in developmental skills, and provided evidence that well-designed therapeutic apps can provide assistance to caregivers in delivering therapy, and increased exposure to therapy at relatively low cost.	Type of study, Limitation-lower level of use of App during the second 3-6 month, no significant improvement in autistic severities and drop outs.	Like' statements Helpful curriculum and therapy planning tool; lots of ideas for therapy and activities Easy to use Positive learning experience with off-iPad and social activities Front end of app attractive; presentation, structure and layout; colourful Relevant and reinforcing reward system Enjoyable experience for child and parent Enhanced understanding about child profile; increased awareness about therapy 'Dislike' statements Off iPad activities time consuming to prepare Curriculum too challenging Tasks were too repetitive; lacked variety Curriculum difficult to implement Curriculum too easy; below child's cognitive level and general abilities Child not interested Old interface
Australia	59 children and their families - 2-6 years	Exploratory Study		For hypothesis one, the expressive language subscale of the MSEL was the only statistically significant difference between the intervention and waitlisted groups between baseline and post intervention. For hypothesis two and three, when all the participants' scores were pooled and measured over time, statistically significant improvements were shown in receptive and pragmatic language and social skills and these gains were maintained, thus suggesting skill acquisition. These findings indicate limited effectiveness of the TOBY app for families living in regional areas. However, this was an exploratory study with a lower intervention dosage and fidelity than prescribed and a high partici-	strengths: RCT, significant gains were observed in the areas of receptive and pragmatic language and social skills from the intervention, suggesting skill acquisition.  limitations: participant drop out, poor dosage and intervention fidelity, individual differences, location	

				pant drop-out rate.		
Australia	15 parents and their children with ASD (2-6 years)	12-month follow up of RCT		Findings demonstrate the receptive language, social skills, pragmatic language and playfulness of children with autism spectrum disorder improved during the three-month intervention period and were maintained at least 12 months after ceasing the Therapeutic Outcomes by You app intervention.	limitations - non-randomised sample, ceiling effect due to long term follow up, decrease in sensitivity of measures to detect change	<ul style="list-style-type: none"> <li>- Twelve out of 15 parents reported their child had maintained at least one skill at 12 months post-intervention in one of the areas of receptive language, social communication or daily living skills, despite them no longer using the TOBY app.</li> <li>- Further, responses from the parents indicated 13 out of the 15 children were no longer using the TOBY app after twelve months, citing a lack of time and a loss of interest from their child as common reasons.</li> <li>- Parents reported the activities on the TOBY became too easy for their child and did not match their child's changing preferences since the initial intervention period.</li> </ul>
Australia	33 families	Pilot trial study	Tier C: interventions	The TOBY play pad is an early intervention application through parent-mediation. This pilot trial sought out to collect information on the usage of the application rather than its feasibility.	limitation: no independent pre or post intervention measures, nor was there a control group for comparisons; no independent data on indicators of functioning	positive - majority of families used toby to some extent during the trial, even without therapist support and in the absence of any kind of encouragement, parents were able to utilize this tool. Negative - accessibility issues, high levels of parenting stress,
Australia	24 parents of children with ASD	3-month trial		<ul style="list-style-type: none"> <li>- Findings from this study partially support the appropriateness of the TOBY app for children with ASD and their parents who live in regional Australia.</li> <li>- Thematic analysis of interviews of parents who used the TOBY app as part of an effectiveness study identified the core theme that the TOBY app is not a panacea for the challenges associated with ASD.</li> <li>- Collectively, parents reported that that the TOBY app was appropriate for some children and not others, and should be used to complement other therapies and not in isolation.</li> <li>- Ongoing support from therapists, increased customisation through more choice and control, and a focus on user-experience was highlighted by parents as strategies that may improve the overall appropriateness of the TOBY app.</li> <li>- toby app provided variable benefits and experiences for parents and children.</li> <li>- the app did not accommodate the individuality of families by providing enough choice and control.</li> </ul>	<ul style="list-style-type: none"> <li>- Limitations: selection bias, generalisation to other sees, bias due to conflict of interest.</li> <li>- Strengths: first study to investigate the experience of using ICT based intervention for families of children with asd in regional areas,</li> </ul>	<ul style="list-style-type: none"> <li>- Most parents stated the TOBY app was straightforward to use, with clear instructions and easy navigation.</li> <li>- parents reported some issues with the TOBY app that tainted their experience: (1) it was challenging to get their children to engage with the app for 20 min per day; (2) a limited ability to choose and control the activities completed on the app; (3) the manifestation of problem behaviours in their children associated with using the TOBY app; and (4) the need for ongoing support from therapists, which they did not receive as part of this research project.</li> <li>- Parents in the study acknowledged the relevance of the TOBY app, with all participants expressing their desire to help their children overcome their developmental challenges.</li> <li>-Additionally, all parents interviewed would recommend the TOBY app to a friend, even if they felt it was not beneficial for their children, indicating they believe its utility and relevance for helping children with ASD.</li> </ul>
Australia	17 parents of children with ASD	Semi-structured interviews and thematic analysis of parents' experiences using the		<ul style="list-style-type: none"> <li>- positive experience with application use.</li> <li>-With sufficient support and guidance, parents reported that they were able to use TOBY effec-</li> </ul>		<ul style="list-style-type: none"> <li>- positive experience</li> <li>- One of the most significant barriers reported by parents was the time required in the organization of materials and equipment</li> </ul>

		application.		<p>tively in their home to provide successful intervention to their child with ASD.</p> <ul style="list-style-type: none"> <li>- The primary barriers identified by parents were occasional information overload, difficulty solving behavioural challenges, and a lack of sufficient support using the app.</li> <li>- Parents reported greater knowledge of the ASD condition and appreciated the guidance and structure by which TOBY provided so as to best support their child.</li> <li>-</li> </ul>		<p>to run the lesson plan, before using the TOBY app with their children.</p> <ul style="list-style-type: none"> <li>- Some parents found it challenging to orient themselves to the application's layout and structure.</li> <li>- Many parents reported feeling too time-poor and overwhelmed with the volume of information contained within the TOBY introduction.</li> <li>- Parents felt that training empowered them to deliver activities to their fullest potential, alleviated stress, and reduced time spent learning how to navigate the app itself.</li> </ul> <p>Parents also reported that this support also helped with understanding their contribution in delivery of the interventions and the importance of the NET for generalization of learning.</p>
United Kingdom	54 children	Randomized Controlled Trial	Tier C: Interventions	<p>There were no significant group differences in parent-report measures postintervention, nor in a measure of parent-child play at follow-up. Therefore, this intervention did not have an observable impact on real-world social communication skills and caution is recommended about the potential usefulness of iPad™ apps for amelioration of difficulties in interaction. However, positive attitudes among participants, lack of harms and the potential of apps to deliver therapeutic content at low economic cost suggest this approach is worth pursuing further.</p>	<p>strength: study design, limitation: usage of new, invalidated measure, lack of intervention effects no immediate effect on behaviours targeted by app.</p>	<ul style="list-style-type: none"> <li>- app was highly rated by parents</li> <li>- There were no problems with access of inappropriate content via the iPad and no parent reported concerns about the child becoming obsessive.</li> <li>- Parent perceptions of the intervention were largely positive and it is probable that one of the main advantages of this kind of approach is in the potential beneficial impact on family life and reduction of burden.</li> <li>- Some parents reported that their child was able to play and concentrate for longer using the FindMe app than with other toys, even at the end of the 2-month access period.</li> <li>- Other parents enjoyed the iPad as a way to sit with their child while mutually focussing on a rewarding activity.</li> </ul>
Canada	12 children with ASD and one of their parents - 5 parents withdrew - 7 parents total	quasi-experimental AB design	Tier C: Interventions	<ol style="list-style-type: none"> <li>1. a mobile application used by parents can teach them how to implement behavioural interventions to effectively reduce stereotypy.</li> <li>2. more families could have access to effective services to reduce stereotypy in their child with ASD.</li> <li>3. cost-effective since it does not require a professional being present during multiple sessions.</li> <li>4. parents may need to use the iSTIM for longer periods of time in order to produce meaningful changes in functional engagement.</li> </ol>	<p>limitations: study design, no participation in functional analysis, participant withdrawal from study, didn't study placebo effect</p> <p>strengths: replication of intervention effects, a greater number of observation sessions to reduce participant bias.</p>	
Singapore	three young children with asd and their mothers	multiple-baseline single-case experimental design	Tier C: Interventions	<ul style="list-style-type: none"> <li>- mobile technology promising platform to deliver intervention for children with ASD.</li> <li>- effectiveness of specially developed PT program</li> </ul>	<p>limitations: low sample (3), response bias among participants, only included mothers.</p> <p>strengths: Findings from this study suggest that mobile apps may improve</p>	

					access to those who want to develop their skills and desire more flexibility and convenience to access the training. Training apps may also be a valuable adjunctive tool for face-to-face training programs.	
United Kingdom/KSA	62 months of children with asd	randomized controlled trial	Tier B: understanding and communicating	<ul style="list-style-type: none"> <li>- significant reduction in maternal depression post intervention</li> <li>- decrease in child behavioural problems</li> <li>- parental mean total stress significantly reduced</li> </ul>	<p>Strengths: This study has many strong points. This study used a randomized controlled trial (RCT) design to evaluate the efficacy of the intervention, which is considered to be the golden design for programme evaluation. The CONSORT statement guidelines for reporting RCTs were used in this study, which ensured a clear and comprehensive reporting of RCTs. Moreover, a follow-up data collection was used in this study to test the stability of findings overtime.</p> <p>limitations: lack of objective measures of maternal wellbeing and child behavioural problems, limited sample size, no info on health economics, low alpha value in some measures</p>	
United Kingdom	3	A multiple baseline design (MBD) across participants was combined with an adapted alternating treatment design	Tier C: Interventions			
United States of America	3 Children with ASD	multiple baselines across participants design	Tier C: Interventions	- no significant result after usage of application, however after differential reinforcement was implemented, all three participants showed sig. increase in eye contact.	limitations: assessments run by researcher and not parent, inconsistent eye contact across different assessments, small sample size.	not given
United States of America	28 children	randomized, controlled design	Tier C: Interventions	the current findings show that participants demonstrated relatively high rates of learning over a short duration (i.e., 12 h in 1 month). Finally, CBI may increase the efficiency and accessibility of treatment for ASD.	limitations: small sample size, did not control for differing levees of asd severity, wide range in participant age, lack of treatment fidelity data.	not given
United States of America	823 children and their families	feasibility study	Tier C: Interventions	App based cognitive exercise for children with autism.	Study of tablet-based cognitive exercises administered to two-year-old toddlers with autism.	not given
United States of America	59 parents and 14 children	App development	Tier C: Interventions	Hypothesis children who begin training at an early age, and who make consistent progress over the course of training, will see drastic improvements in their language function.	The findings are from a feasibility study.	not given
United States of America	1514 children and their parents	feasibility study	Tier C: Interventions	MITA worked as designed, and parents were able to implement it an engage their children as young as 2 years with the app.	Major Strength: sample size, age range, Limitation: ATEC done by parents, and not professionals	not given

Web Table III Summary of finding table based on Template for Intervention Description and Replication (TIDieR) checklist

Author & Year	Brief Name <sup>1</sup>	Why <sup>2</sup>	What		Who/ trainer <sup>5</sup>	How <sup>6</sup>	Where <sup>7</sup>	When and How <sup>8</sup>	Tailoring <sup>9</sup>	Modifications <sup>10</sup>	How well	
			Materials <sup>3</sup>	Procedures <sup>4</sup>							Planned <sup>11</sup>	Actual <sup>12</sup>
<b>Mruzek et al., 2019</b>	Parent mediated toilet training intervention app	An innovative toilet training intervention that consists of WMP; an iOS-based app with transmitter/disposable sensor; and a corresponding manualized training program for use by parents in the home.	WMP and SBT intervention manuals, moisture paging device, connected to iPod.	At start of intervention, parents received a 1.5-h center-based training. During this initial training, all key aspects of the WMP or SBT intervention were reviewed, with a special emphasis on completing an individualized training program. For the WMP group, this initial review included development of an individualized training program based on the content of all six modules of the WMP intervention manual. Parents were then expected to carry out the intervention for 12 weeks in their home and participate in four 1-h, center-based 1:1 study visit (i.e., “booster sessions”) at weeks 2, 4, 6, and 9 to troubleshoot and collect data on adherence and efficacy, and a closeout visit at week 12. Also, during these sessions, interventionists encouraged parents to continue with their training efforts and complete the data logs on the 3 days prior to the next booster session. Parents in both groups received a brief telephone call immediately prior to the onset of the 3-day data collection interval to remind them to complete the data logs. At 3 months following the close of intervention, parents were reminded by telephone to complete the data logs for 3 consecutive days and return them to the study team in a self-addressed stamped envelope.	Trained study interventionist (each with a master’s or postdoctoral level of training in psychology) at each study visit using only the manual for their randomly assigned intervention.	delivered through manuals.	Home	Parents were then expected to carry out the intervention for 12 weeks in their home and participate in four 1-h, center-based 1:1 study visit (i.e., “booster sessions”) at weeks 2, 4, 6, and 9 to troubleshoot and collect data on adherence and efficacy, and a closeout visit at week 12.	None	None	Yes, by measuring the number of sessions attended by participants of both group	At all visits, both study groups achieved mean treatment fidelity percentage scores greater than 80 (SBT mean = 94%, WMP mean = 90%) with median scores of 100.
<b>Moore, et. al., (2015)</b>	Therapy Outcomes By You (TOBY)	Pilot trial of TOBY app providing a comprehensive system for facilitating the delivery of intensive early intervention by parents in the home and as part of daily routines.	An iPad for each participating child loaded with the TOBY app and connected to the internet.	All participant responses were uploaded, automatically in the case of Solo and Partner activities and manually, by the parents, for NET activities, as an integrated part of TOBY use. Dependent variables generated by TOBY algorithms were (i) participant use patterns including total time engaged in Solo, Partner and NET activities, number of sessions and of completed learn units (stimulus, response, feedback – sequences) and (ii) indicators of child progress: correct/incorrect response patterns differentiated across the four curriculum areas.	parents	iPad	Home using iPad	20 minutes per day	None	None	None	None
<b>Whitehouse, et. al.,</b>	TOBY	Use of the TOBY app as an addition to	The TOBY app installed on iPad	The length of the intervention period was 6 months, with follow-up	Trained Therapist	iPad	At home along	at least 20 min/day of TOBY based thera-	None	None	Yes	Yes, there was

(2017)		community-based therapy would help support home-based therapy, and thus facilitate greater improvement in a range of ASD-specific and broader developmental skills.		assessments taking place at the mid-point (3 months postbaseline) and conclusion (6 months postbaseline) of this period. Treatment group: TOBY intervention. Caregivers of children randomised to the TOBY intervention group received an initial 2-hr training session during which they were familiarised with the TOBY curriculum, and the entry point in the curriculum was determined for each child in consultation with caregivers. Caregivers were contacted by the study team every fortnight during the trial period to encourage use of the TOBY app, to provide an opportunity for caregivers to ask any questions, and for the research team to enquire about perceived barriers to use of the TOBY app.			with TAU.	py for the next 6 month				no change in the number of fortnightly telephone calls made to families, however, there was a large drop in usage of TOBY in the second 3 months.
Parsons, et al., (2019)	TOBY	To evaluate the appropriateness of the ICT intervention and toby app and to examine the barriers and facilitators identified by parents who used TOBY app living in regional Australia.	The TOBY app installed on iPad	Twenty-four mothers of a child with ASD from a pool of 59 families from the RCT participated in a three-month RCT using the TOBY app were included in this study. Participants were ranked for use on three measures: (1) time spent using the app on the device; (2) items attempted; and (3) items completed. Phone interviews - semi structured interview: experience using the app; (3) if parents perceived the TOBY app to be effective for their child; (4) if parents perceived the TOBY app to be effective for themselves; (5) the ease of use, including the planning needed to implement the suggested dosage; (6) the level of support required to use the app effectively; (7) their intended future use of the app; and (8) suggested improvements to the app. Interviews lasted between 16 and 45 min in duration, and digital voice recorder was used to record the interviews, which were subsequently transcribed verbatim by a professional transcription service.	Occupational therapist and qualitative researcher	The TOBY app is a tablet (iOS©) along with face-to-face therapy.	Australia, remote intervention - phone interviews.	App use was measured using backend server data that is automatically gathered from the tablet device. Semi-structured interviews between 20 and 45 min in duration were conducted to explore the experience of the TOBY app	None	None	None	None
Parsons et. al., (2019)	TOBY	Comparative study of 3 months TOBY users and waitlist control group improving visual motor, imitation, language and social skills of children with ASD.	The TOBY app installed on iPad	In addition to receiving therapy-as-usual, the intervention group were instructed to practise at least 20 min on the TOBY app daily for 3-months using an iPad. Participants were then re-assessed at 3 and 6 months after the baseline assessment to establish post-intervention and follow-up measurements, respectively. The waitlisted group received an iPad without the TOBY app in-	psychologists and occupational therapists	Toby app, I-Pad	home, remote	20 min once per day, follow up every 2 weeks for 3-6 months. The intervention has three methods for the delivery of therapy: solo, partner, and Natural Environment Training (NET) (Venkatesh et al. 2013). The syllabus includes a variety of activities that utilise	None	None	20 min/day using the TOBY app.	low fidelity after three months

				stalled and therapy-as-usual after the baseline assessment. After the waiting period of 3-months, the control group received the TOBY app for 3-months. The waitlisted group were then assessed at 6 and 9-months to establish the post-intervention and follow-up measurements.				different methods of delivery to address the four targeted skill areas. The TOBY app solo activities involved the child interacting directly with the iPad. Caregivers then inputted the result directly into the TOBY app to track their progress. The NET activities of the TOBY app aimed to generalise learning from the solo and partner activities into natural situations by educating, prompting, and logging the caregiver's translational intervention with their child.				
<b>Rogerson et al., (2019)</b>	TOBY	Parental experience of using the TOBY app designed to provide targeted training in imitation, language, sensory discrimination, and joint attention; all of which are typically delayed or disrupted in young children with ASD.	The semi-structured interview guide	Data were obtained through semi-structured interviews with parents of children with ASD that were later analysed by initially identifying content manifesting perceived barriers and facilitators to the use of TOBY. A thematic analysis followed in which meaning-bearing units related to facilitators, barriers, and to parents' experiences were identified and later analysed as described in the data analysis section.	Paediatric occupational therapy student	In person and telephone interviews.	home	Prior use of the application within 2 years of child's diagnosis.	None	None	None	None
<b>Parsons et al., (2020)</b>	TOBY	Use of the TOBY app was anticipated to lead to improvements in the longer term for the skills of language, social communication and playfulness as the children developed.	The TOBY app installed on iPad	This study used a single-site cohort design, with data collected at baseline (T1), post-intervention (T2) and follow-up at 12 months post-intervention (T3). After the assessment, participants were asked a series of open-ended questions lasting between 5–15 minutes to provide further explanation regarding the continued use and maintenance of skills learnt while using the TOBY app. The TOBY app comprises the following three types of tasks: solo, partner, and natural environment tasks (NET). Children begin the intervention with activities at their current level of functioning and progress through the curriculum at their own rate of development and ability.	parents	Through TOBY app using iPad. The NET tasks are performed separately from the iPad with caregiver support and are integrated into daily life to encourage generalisation of skills learnt during solo and partner	at home	Parents in this RCT, in the intervention group were provided with an iPad which had TOBY app installed and were instructed to use the applications for 20 min per day at a time convenient to the family. One-hour training by the researchers (occupational therapists and psychologists) on how to navigate and use the intervention was provided.	None	None	None	None

						tasks. Responses to each task are inputted into TOBY app, and a syllabus of future tasks is tailored for the child.						
<b>Fletcher-Watson et al., 2016</b>	FindMe	FindMe aimed to enhance the real-world social communication skills of the children through motivating, daily rehearsal of very basic sub-skills.	FindMe app	The length of the experiment/intervention was 72 days on average, and parents were suggested to aim for game play of about five minutes per day, or ten minutes every other day. Parents and children were filmed for 10 min playing with a standard set of toys with no specific instructions given. Intervention group: 2 months of app access at the same time as all usual treatments. Wait-list group: only treatment as usual.	parents	iPads were sent out to each child's home, for the intervention group, before shutting down functions aside from the app. Brief instruction document which dealt with the basics of working and charging the iPad and offering advice on troubleshooting, and suggested that parents aimed for game play of about five minutes per day, or ten minutes every other	one to one support in nursery or primary school, including specialist units and integrated mainstream classes.	Children in the intervention group had access to the FindMe app for a period of 72 days on average (95% CI = 70–75 days).	None	The trial design set a high bar for measuring benefit by selecting as the outcome measure a parent-child play-based observational measure taken at the Follow-Up appointment and not immediately following the intervention.	Children in the intervention group had access to the FindMe app for a period of 72 days on average	The mean number of days on which children actually played the app was 28. Median length of game play was 339 min (interquartile range = 206–1074) over the intervention period (minimum 15 min, maximum 3522 min). Only four children in the Intervention group failed to reach the most complex level of the game. Of the 23 children reach-

						day.						ing the highest level, 22 carried on to repeat the game cycle after achieving that top level.
<b>Dunn et al., 2017</b>	iStim	This application offers parents a solution and a method to reduce stereotypy in children who do not have the ability to use a self-monitoring method.	The iSTIM is an iOS application, currently available for research purpose only, with four parent training and support modules.	To assess the effects of the app, researchers conducted a series of AB quasi-experiments wherein each participant served as their own control. Research assistant measured stereotypy before and during the implementation of the intervention while the parent was using the iSTIM.	research assistants and Parents	iOS devices	home	Families participated in sessions once or twice per week over a period of 8 to 16 weeks.	None	None	None	None
<b>Trudel, L., Lannonovaz, M. J., &amp; Préfontaine, I. (2021)</b>	Map4speech	Map4speech uses the BMT framework to conduct naturalistic intervention with young children with ASD to improve their functional communication.	Each parent was loaned an iPad containing the Map4speech mobile app.	There were five phases in this experiment: baseline, PT, post-training intervention (PTI), novel settings, and 1-month follow-up. Phases 1, 2, and 3 (i.e., baseline, PT, and PTI) used a concurrent design and were conducted in the children's homes with the same toy materials within each parent-child dyad. Phases 4 and 5 (i.e., novel settings and 1-month follow-up) used a non-concurrent design and were conducted to learn how parents generalized their new skills in different contexts.	Psychologists	i-pad, assessment face to face	community playgrounds, family dining areas, skype call	Phase 1: The shortest baseline period lasted 1 day with 5 sessions, and the longest baseline period lasted 7 days with 14 sessions. Phase 2: For 5 days a week, they were asked to spend 15 min to practice the learned intervention skills with their child. They used the app to take two or three 2-min video clips of themselves practicing the skills with their child and uploaded them to a secure server via the app. Phase 3: The average post-training period was around 9 days across three parents. The average feedback sessions in Phase 3 were two sessions across three parents. Phase 4: settings. The average intervention period on the playground and the snack time setting were 8 and 7 days, respectively. The average feedback sessions for two novel settings were 3.3 sessions across three parents.	None	None	Parents were required to attain 90%–100% of the intervention skills in two consecutive practice videos in order to advance to the next stage of the app where they learned new skills while continuing to use the previously learned skills.	Parents were able to maintain a high level of implementation fidelity. They achieved 88%92% fidelity for intervention implementation during the PTI, 83%–88% during novel setting—playground, 91%97% during novel setting at snack time, and 90%–93% during the 1-month follow-up.
<b>Law, G.</b>	Psy-	The transac-	The interven-	Mothers who consented	Three thera-	Whats	Whats	Sessions 2–5	Non	None	None	None

<b>C., Neihart, M., &amp; Dutt, A. (2018)</b>	choeducation Intervention delivered via WhatsApp	tional model of stress and the Double ABCX Model contributed to the development of the intervention in three sessions. Session 1 to inform mothers about the aetiology of ASD; Session 2 to target stress in mothers and how can they approach different stressful situations; Session 3 to child behaviour problems to help the mothers cope with the initial stressor of having a child with ASD; and Session 5 to inform mothers about the available resources in KSA.	tion was developed as a guided self-help intervention in line with the main principles and recommendations of NHS Good Practice Guidance on the use of self-help materials within Increasing Access to Psychological Therapies IAPT services.	were randomly allocated to the trial arm, and study information packs, and Copies of the training manual were provided. Sessions 2–5 consisted of 30-min therapist support via WhatsApp. Mothers in the CAU group received advice about their child's educational and behavioural problems from the organizations.	pists and one certified clinical psychologist assisted in delivering the intervention.	App	App	consisted of 30-min therapist support via WhatsApp.	e			
<b>Hemdi, A., &amp; Daley, D. (2017)</b>	Sounding Bird	Investigating the use of an iPad as a SGD and to compare the relative efficacy of the iPad with PECS for developing requesting and navigational skills with preschoolers with ASD.	Child's table and chairs, a computer, A standard PECS book, An iPad-4 with a Big-Grips™4, and SoundingBoard™ 5 app	Stimulus preference assessment, parent interview and children were observed during unstructured free play prior to baseline. Modality Preference Assessment was conducted at the beginning of each baseline, intervention, and post-intervention to determine if a participant had a preference for one of the two AAC options.	researcher	face to face	intervention room	Each participant received six sessions of intervention over a 4-week period in each condition. Each session was of 20-min duration and focused on one AAC condition, PECS or iPad.	None	none	Treatment integrity was measured.	Overall treatment integrity for the three researchers was 97%
<b>Agius, M. M., &amp; Vance, M. (2016)</b>	Look in My Eyes Steam Train	This application allows children to practice eye contact by displaying a number in a person's eyes and having the child complete a match-to-sample.	An Apple iPad® was used to allow the child to use the Look in My Eyes Steam Train application.	<p>1. Before beginning the study, to ensure the child has the prerequisite skills required to use application, they were asked to complete a match-to-sample test while in the individual therapy room. The child was presented with a grid numbered 1 to 9, and he had to replicate that grid on the iPad application. On completion of the sample task only he was eligible for the study.</p> <p>2. During baseline, the child participated in a two manding session that typically took place during therapy sessions. One took place in the individual therapy room and the other took place in the natural environment. For each baseline session, the occurrence or non-occurrence of eye contact when the child made a request was recorded for the first 10 times. Once there was a stable pattern of eye contact in both locations, the child was then moved to the intervention phase.</p> <p>3. After baseline data were obtained, the child</p>	Therapist	face-to-face and mhealth app	Each session took place in either the individual therapy rooms or the natural environment training room. The individual therapy rooms were 3x3 m with three individual cubicles in each. A 1.8 m wall divided the work-	A session consisted of 10 trials	None	none	None	None

				<p>was instructed to play with an iPad application designed to increase eye contact while in the individual therapy room. The child only had access to this application during training.</p> <p>4. Immediately after the child used the application, eye contact was assessed in the individual therapy room. After this assessment there was a 5 min delay in which the child was brought to the natural environment training room and was required to complete demands not associated with this study. Once the delay was complete an immediate generalization assessment was conducted to see if the change in eye contact generalized to another setting. If the eye contact application showed an increase in eye contact to 80% in all of the assessments, the child would be finished with the study. However, if the eye contact application was unsuccessful, the child then moved on to a differential reinforcement phase.</p> <p>5. This phase consisted of 10-min training sessions in the individual therapy room. If the child made eye contact with the therapist when requesting an item, the therapist immediately reinforced the child's behaviour by providing him with praise and the requested item. If the child did not make eye contact with the therapist when requesting an item, the therapist waited until the child made the request again while using eye contact before reinforcing eye contact by allowing the child to have the requested item. The same prompting procedure that was used in baseline was used if a mand was not made within 5 s.</p> <p>6. Immediately after the child completed the differential reinforcement training, eye contact was assessed in the same manner it was assessed following the iPad intervention.</p>			spaces and each cubicle had a table and chairs, program materials, and reinforcers that were chosen by the child. The natural environment training room was 6x4 m open room with multiple reinforcing items available for the child to engage with.					
<b>Jeffries, T. (2013)</b>	Camp Discovery	The application incorporates modified discrete-trial training (DTT) procedures and other behavioural principles of ABA to teach receptive language targets across different lessons.	iPad tablet with Camp Discovery open. Application settings were adjusted to ensure that the participant only worked on the targets identified as unknown	1. Pre- and Posttreatment Probes: Probes were conducted lesson by lesson, in a random order. During probe sessions, reinforcement, corrective feedback was not provided for incorrect responses. Reinforcement was only provided for maintaining attention and exhibiting appropriate behaviour. Reinforcers were	Practicing behavioural therapists with extensive ABA training for ASD and field work.	through mhealth app on iPad, individually.	participant's home or treatment center	Probes took anywhere between 1 and 3 h and were conducted across one or multiple sessions performed within a 1-week period. Treatment sessions occurred for 3 h per week (i.e., three 1-h sessions) for 4	None	Application settings were adjusted to ensure that the participant only	None	None

			during his or her initial probe.	<p>identified via a preference assessment conducted by the research assistant. Each participant experienced three total probe sessions. The first probe was used to identify approximately 100 unknown targets that were covered within the mobile application's learning content. Subsequent probes assessed the targets identified as unknown during the initial probe.</p> <p>2. Immediate-treatment IT group and delayed-treatment control DTC group: After an initial probe, the IT group began interacting with the mobile application, whereas the DTC group continued with treatment as usual with no manipulations. After 4 weeks, both groups received a second probe (i.e., post-treatment for the IT group; pre-treatment for the DTC group) to determine if learning took place in the presence or absence of the mobile application. Following the probe, the DTC group entered the treatment phase while the IT group discontinued use of the mobile application, receiving only treatment as usual. After 4 weeks, both groups were administered a final probe to determine if any learning occurred (i.e., DTC group), as well as to evaluate whether previously acquired skills were maintained (i.e., IT group) without access to the mobile application.</p>				weeks, separate from ongoing ABA sessions.		worked on the targets identified as unknown during his or her initial probe.		
<b>Dunn, R.S., &amp; Vyshedskiy, A. (2015)</b>	Mental Imagery Therapy for Autism (MITA)	This paper is on the development of MITA app based on Pivotal Response Treatment (PRT), which was developed to deliver evidence-based early-intervention therapies made especially for very young children with ASD.	MITA app	MITA's exercises follow a systematic approach for training the skill of multiple cues responding.	N/A	using MITA app	at home	None	The MITA program follows a systematic approach for developing a child's ability to respond to multiple cues, starting	None	None	None

										with very simple exercises that require attending to only one cue or characteristic, namely colour			
<b>Dunn et al., (2017)</b>	MITA	Data from feasibility study of parent-administered tablet-assisted therapy for 1514 children of different ages and varying ASD severities for twelve months.	MITA app, Supplementary material	MITA was made available for free to download, and sample was selected from the pool of registered users on the app based on the pre-defined criteria; i.e., a self-reported diagnosis of ASD, availability of two ATEC scores at least three months apart, and age must be 12 or below.	Parents	using MITA app on mobile	at home	MITA consists of nine different developmental activities. To be done on a daily basis for 10 minutes, for a period of twelve months, using mobile app	Each of the nine MITA activities consists of multiple levels, starting with easier levels that require attending to a single cue, moving on to intermediate levels that require attending to two cues and culminating in challenging levels that require attend-	None	Yes, by recommending to be used at least for 10 minutes per day.	Subjects across all age and severity groups adhered to the recommendation at least 64 ± 19% of the time	

									ing to three or four cues at a time. Most activities have as many as 50 levels which range from easy to difficult in a gradual and systematic manner.			
<b>Dunn et al., (2017)</b>	MITA	This study describes data from the feasibility study of this therapeutic intervention, through MITA.	MITA app	The objective of this study was to determine whether children as young as two who have been diagnosed with ASD could engage on a daily basis and over an extended period of time with a therapeutic application, and whether their parents would be willing to administer such an application.	Parents	through MITA app	home	At home, using the app. For a period of three to ten months.	None	None	Yes, by recommending to be used at least for 10 minutes per day.	There was one subject who worked with MITA every day for over six months, the actual median (IQR) number of days MITA was used per week was 1.6 (0.9-2.6), significantly less than the recommendation. Only 161 subjects (20%) worked with MITA more than 3 days per

