



# Parent-Mediated Naturalistic Developmental Behavioral Interventions for Young Autistic Children: A Systematic Literature Review of Single-Case Research

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## Abstract

Naturalistic developmental behavioral interventions (NDBIs) are a class of supports that may lend themselves to a parent-mediated approach. This systematic literature review synthesizes single-case research evaluations of parent-mediated NDBIs for young autistic children. Of the 353 articles screened, 17 were eligible for inclusion. Child outcome measures included engagement, joint attention, language/communication, imitation, and ‘compliance’/avoidance. Most studies found positive effects for at least some children on at least one measure. However, there were no consistently positive effects across studies. Most parents increased their NDBI fidelity, but many did not reach specified fidelity criteria. Only three studies met all Council of Exceptional Children quality indicators. These results suggest that parent-mediated NDBIs are a promising approach to supporting young autistic children, but more high-quality research is needed.

**Keywords** Parent-mediated · Naturalistic developmental behavioral interventions · NDBI · Autism · Early intervention · Literature review

## Introduction

Autism is a form of neurodivergence (Pellicano & den Houting, 2022) characterized by differences in social communication, the presence of passionate interests, and a preference for predictable activities and routines (American Psychiatric Association, 2013). It is estimated that 1 in 59 children is autistic (Baio et al., 2018). There is increasing capacity for early identification of children who are likely to receive an autism diagnosis, which is essential for providing appropriate supports early in a child’s life, and therefore improving their developmental outcomes (Mozolic-Staunton et al., 2020; Whitehouse et al., 2021; Zwaigenbaum et al., 2015).

Naturalistic developmental behavioral interventions (NDBIs) have been recommended as a promising type of early support approach (Schreibman et al., 2015). NDBIs are based on both behavioral and developmental principles

(Schreibman et al., 2015; Tiede & Walton, 2019). NDBIs use behavioral teaching principles to integrate developmentally appropriate learning targets into daily routines and activities. NDBIs also emphasize the development of high-quality positive relationships with shared control between adult and child. NDBIs also involve the use of strategies aimed at increasing child motivation for learning and the use of naturally occurring contingencies (Bruinsma et al., 2019; Schreibman et al., 2015).

According to Schreibman et al. (2015), several different support strategies fit under this umbrella of NDBIs, including, Incidental Teaching (IT), Pivotal Response Treatment (PRT), the Early Start Denver Model (ESDM), Enhanced Milieu Teaching (EMT), Reciprocal Imitation Training (RIT), Project ImPACT, and the Joint Attention Symbolic Play Engagement and Regulation (JASPER) program. These different approaches can also be categorized by whether they are focused programs that target only a small number of outcomes such as imitation (Ingersoll & Schreibman, 2006), or comprehensive approaches that target many skills across a range of developmental domains (Dawson et al., 2010).

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Several systematic literature reviews and meta-analyses have evaluated specific NDBI approaches, including reviews of JASPER (Waddington et al., 2021), ESDM (Fuller et al., 2020), and PRT (Ona et al., 2020). These reviews have found that autistic children receiving specific NDBI approaches have shown improvement with respect to communication (Fuller et al., 2020; Ona et al., 2020; Waddington et al., 2021), social engagement or joint attention (Ona et al., 2020; Waddington et al., 2021), cognition (Fuller et al., 2020), and other behaviors. There is also an increasing shift towards a collective understanding of the programs that are considered NDBIs, including the development of generic NDBI fidelity tools (Frost et al., 2020; Vibert et al., 2020), and reviews that evaluate NDBI studies collectively and in comparison to non-NDBI supports (Sandbank et al., 2020; Tiede & Walton, 2019; Trembath et al., 2022). These reviews and meta-analyses have found that NDBIs can improve a range of child outcomes including social communication, language, cognition, and play skills, as well as possibly reducing certain characteristics associated with autism (Sandbank et al., 2020; Tiede & Walton, 2019). However, null effects for NDBIs have been found on outcomes relating to overall autistic characteristics, social emotional/challenging behavior, restrictive and repetitive behaviors, adaptive behaviors, as well as mixed results for social-communication (Sandbank et al., 2020; Tiede & Walton, 2019; Trembath et al., 2022). Two meta-analyses have evaluated the effectiveness of parent-mediated approaches to early autism support and found small to moderate positive effects for autism characteristics, socialization, and cognition (Nevill et al., 2018), also in parent-child interactions and language skills (Oono et al., 2013). Null or “trivial” effects were found for communication-language (Nevill et al., 2018), child initiations, social communication skills, and reductions in maladaptive behavior (Oono et al., 2023).

A key component of NDBIs is that they can be implemented by parents and caregivers (hereafter “parents”; Schreibman et al., 2015). Indeed, including parents in early support programs for autistic children is considered best practice by research and clinical guidelines (National Institute for Health & Care Excellence, 2013; National Research Council, 2001; Whaikaha, 2022). Parents seem well-placed to deliver support to their own child as they may be able to create many learning opportunities throughout the day and across settings (Nevill et al., 2018; Oono et al., 2013). Coaching parents to implement supports is also a potentially more time- and cost-effective service delivery model (Shalev et al., 2020).

Given the potential utility of providing parent-mediated NDBIs in the community, it is timely to review the evidence in this area. Further, most systematic reviews and meta-analyses in the parent-mediated autism support and NDBI

literature have only included studies with controlled group designs (Nevill et al., 2018; Oono et al., 2013; Sandbank et al., 2020; Tiede & Walton, 2019). Potentially important and more nuanced findings from single-case research have been excluded from these syntheses (Oono et al., 2013). Single-case designs are often used in research with autistic individuals as they can demonstrate whether there is a clear, replicable effect on specific behaviors for specific individuals (Patterson et al., 2012; Smith et al., 2007). This may be particularly important given the heterogeneity of autistic individuals. Single-case designs also involve repeated observations and can therefore highlight the progression of effects over the period of a study and not just at the pre and post testing times. Another potential advantage of experimental evaluations using single-case designs is that if progress is lacking, troubleshooting steps can be undertaken in an effort to modify the program to meet the unique needs and circumstances of individual participants (Smith et al., 2007).

This systematic literature review aimed to provide a narrative synthesis of single-case studies that have evaluated the effects of parent-mediated NDBIs for autistic (or likely autistic) children under 8 years of age. The primary aim was to evaluate the effects of parent-mediated NDBIs on child outcomes and the secondary aim was to evaluate the effects of parent-mediated NDBIs on parent outcomes.

## Method

This systematic review was conducted according to the procedures outlined in the updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Page et al., 2021).

## Protocol

The study protocol was submitted to Prospero on 13 April 2023 and was registered on 23 April 2023 ([https://www.crd.york.ac.uk/prospero/display\\_record.php?RecordID=416790](https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=416790)).

## Eligibility

Studies were eligible for inclusion in the systematic review if they met all the following inclusion criteria: (a) the study was published in English, (b) the study was published as a thesis, conference paper, publicly available scientific report, or peer-reviewed journal article, (c) the study was published in the last 10 years (2014–2023), (d) the average age of participating children was  $\leq 8$  years, and no participating children were over 12 years of age, (e) the majority of

participating children were diagnosed with autism or autism spectrum disorder or pervasive developmental disorder – not otherwise specified (PDD-NOS), or had been shown to have a ‘high likelihood’ of receiving one of these diagnoses on an established screening tool, (f) the study involved empirical research evaluating the effects of a program classified as an NDBI based on Schreibman et al. (2015) or the program was identified by the study’s authors as an NDBI with an explanation of how the study meets the definition of an NDBI, as per Schreibman et al. (2015), (g) the study focused on teaching parents or primary caregivers to implement the NDBI strategies with their child, (h) parents or primary caregivers were the only people who implemented strategies directly with the child, (i) at least one quantitative child or parent outcome measure was reported: Specifically, (a) behavioral/developmental/wellbeing outcomes for autistic children, and/or (b) parent implementation fidelity, and/or (c) parent well-being outcomes (e.g., stress, sense of competence), (j) the study had an experimental design, (k) the study included a baseline phase (single-case) in which NDBI was not delivered and at least one intervention phase in which the parents implemented the NDBI in isolation. That is, NDBI was not combined with another type of support, such as music therapy, unless that other type of support was also provided during the baseline phase.

Studies were excluded if they did not meet these inclusion criteria. Additionally, given the quantity of publications that were identified for inclusion, only studies using a single-case experimental design were included in this review. A separate review of studies involving the use of group designs was conducted with the results to be published separately.

## Literature Search

The literature search was conducted on 12 April 2023, using the ProQuest dissertations & theses global, Education Resources Information Centre (ERIC), Scopus, PubMed, PsycINFO, and Web of Science databases. Search terms related to (a) a diagnosis or high likelihood of autism, (b) parent or caregiver implemented, and (c) naturalistic developmental behavioral interventions (NDBIs). The full search strings are presented in Supplementary Table 1. In each database, the search was limited to keywords, titles, and abstracts.

## Study Selection

The lead reviewer conducted all database searches and imported the results into Covidence, a web-based collaboration software platform for systematic literature reviews (Covidence, 2023). Duplicate studies were removed.

The lead reviewer screened the titles and abstracts of the studies against the inclusion/exclusion criteria. A second reviewer independently screened 21% ( $n=75$ ) of the titles and abstracts. The lead reviewer then full-text screened all potentially relevant articles. The second reviewer independently full-text screened 21% ( $n=31$ ) of the potentially relevant articles. The percentage agreement on whether a study should be included at each stage of the screening process was calculated as:  $\text{Agreements} / (\text{Disagreements} + \text{Agreements}) \times 100$ . Rate of agreement for inclusion/exclusion on the title and abstract screen was 84%, and 83% on full-text screening. Following each stage, the two reviewers met to discuss the disagreements and reached consensus on whether to include or exclude each study. A third reviewer was also consulted on certain inclusion/exclusion decisions.

## Data Extraction

Data from each study were extracted and summarized in a Microsoft® Excel spreadsheet. If the same data were published in both a thesis and a journal article, only the journal article was included. Data relating to participant characteristics were extracted from each original study including: (a) number of parent and child participants; (b) child age, gender, ethnicity, and diagnosis; and (c) parent gender, employment, and education. Data pertaining to program characteristics were also extracted, specifically: (a) study design; (b) NDBI model and teaching focus; (c) delivery method and setting; (d) quantity, frequency, and duration of coaching sessions; (e) program duration; and (f) location of program.

Outcome data for both parent and child participants were extracted. Data from pre-post measures such as Vineland Adaptive Behavior Scales (Sparrow et al., 2016) were not included as there is no experimental control over such measures in a single-case research design (Horner et al., 2012). Effects on parent and child outcomes that were compared between a baseline phase and a program implementation phase were rated as either positive (+), null (O), or negative (-). A positive effect (+) indicated an increase in an outcome the researchers intended to increase, or a decrease in an outcome the authors intended to decrease, during or after program implementation compared to baseline. A negative effect (-) was the opposite, and a null effect (O) indicated that there was no clear impact of the program implementation on this outcome compared to baseline. Ratings were determined through visual analysis of graphed results, including level, trend, and variation, as well as proportion of overlap with baseline and immediacy of the effect in each program as per Kratochwill et al. (2010). In cases where there was a strong increasing trend in baseline for an outcome, results were interpreted cautiously as null effects. The

data across all characteristics and outcomes, for all studies, were independently extracted by one reviewer (L.v.N). A second reviewer (S.G) independently extracted the data for a randomly selected 20% of the studies. The reviewers discussed any discrepancies and reached consensus. Percentage agreement on the independent extraction was 89%.

### Risk of Bias/Quality Assessment

The Council for Exceptional Children's (CEC) standards for evidence-based practices in special education (CEC standards) were used to evaluate the quality and risk of bias of the studies included in this review (Cook et al., 2015). The CEC standards include 28 quality indicators (QIs) across (a) context and setting, (b) participants, (c) intervention agents, (d) description of practice, (e) implementation fidelity, (f) internal validity, (g) outcome measures/dependent variables, and (h) data analysis. Most of the QIs apply to both group and single-case designs, four are specific to single-case studies, and six indicators are specific to group designs and were therefore not relevant to this review. The CEC standards uses a dichotomous rating system, where "YES" indicates the quality indicator is met, and "NO" indicates that the quality indicator has not been met. One reviewer (L.v.N) independently rated each included study against the 22 relevant QIs. A second reviewer (S.G) independently rated 20% of the studies. Percentage agreement on the QIs was 88%. The reviewers discussed any discrepancies and reached consensus.

### Synthesis of Results

A narrative synthesis was utilized to report the findings of this systematic literature review. That is, tables were used to summarize the findings, and further description of the findings were included in-text. A narrative synthesis was deemed appropriate given the heterogeneity across the studies included in this review (Aromataris et al., 2020). This includes, for example, significant variation in the type of support model, the parent and child outcomes, and the duration of support.

## Results

### Study Selection

The study selection process is outlined in the PRISMA flow diagram in Fig. 1 (Page et al., 2021). The initial database search identified 750 studies, and an additional 50 theses were identified through a grey literature search. Duplicate references were removed ( $n=447$ ), resulting in 353 studies

for further screening. Through title and abstract screening, 210 studies were excluded. A total of 143 studies were full-text screened for eligibility, and 96 studies were excluded because they met one or more exclusion criteria (see Fig. 1). The most common reason for exclusion was that the study did not have a non-NDBI comparison group or baseline phase. Supplementary Table 2 lists all studies excluded at this stage. Forty-seven studies were eligible for inclusion in this review. Given the significant heterogeneity of these studies and the scope of this review, 27 group-design studies that met the inclusion criteria will be evaluated in a separate review. During data extraction, a further three studies were identified as not meeting the inclusion criteria and were excluded based on reviewer discussion and consensus. Therefore, 17 single-case studies are included in this qualitative synthesis. These are all original studies, comprising six unpublished theses and 11 peer-reviewed journal articles.

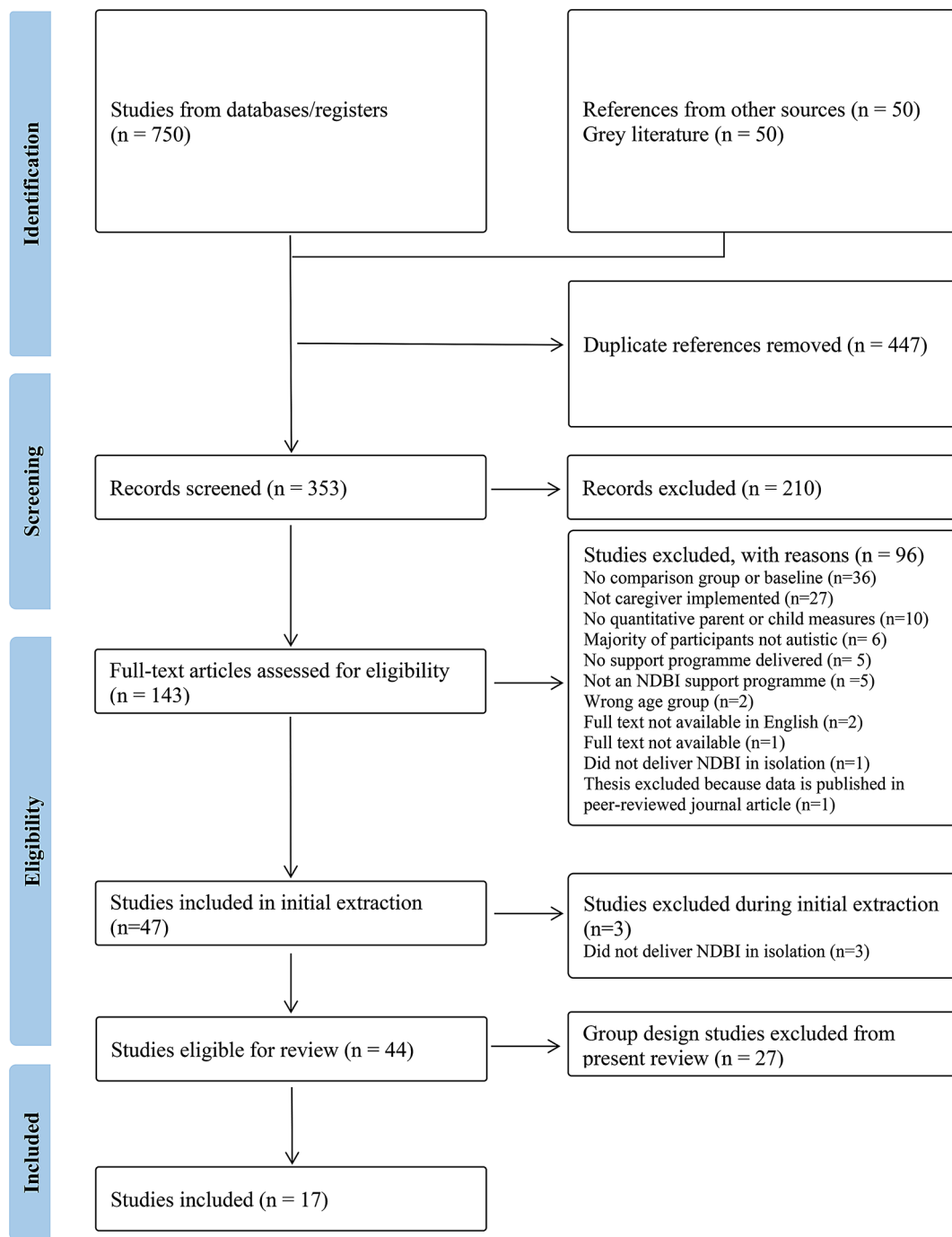
### Child and Parent Characteristics

Table 1 summarizes the characteristics of the participating children. These studies included a total of 69 children (9 girls, 13.0%) aged between 15 and 94 months. Children in most studies were diagnosed as autistic, and in four studies children had a high likelihood of autism based on screening measures. Across the 12 studies that reported ethnicity, the most common ethnicity was Caucasian ( $n=34$ ), followed by Latinx/Hispanic ( $n=5$ ). Four studies included only Caucasian participants.

Parent characteristics are summarized in Table 2. A total of 69 parents (15 males, 21.7%) participated, one parent per participating child. Of the studies that reported these characteristics, English was the most spoken language (82%), most parents were married or lived in two-parent households (85%), a slight minority of parents were not employed outside the home (41%), and most parents had some post-secondary education (80%), with 60% of parents holding a tertiary degree.

### Program Location and Characteristics

Table 3 summarizes the location and characteristics of the programs reported in each study, the studies are grouped by NDBI model. Two studies based in Japan and China respectively, evaluated incidental teaching programs focused on teaching parents to elicit specific child communication behaviors (Hong et al., 2018; Ma, 2022). Both programs involved a web-based training module that parents completed independently, followed by delayed video feedback. In Ma (2022) the coaching was delivered entirely via 9–14 pre-recorded videos per parent (average video length



**Fig. 1** PRISMA flow diagram

10.9 min), in Hong et al. (2018) the clinician met with the parents for some in-person sessions and delivered 19–20 video feedback sessions per parent across 20 weeks.

One study evaluated the delivery of Joint Attention Symbolic Play Engagement Regulation (JASPER) in rural Canada (Shire et al., 2021). Parents were taught the focused social communication model in 24 sessions across 12 weeks, each session was 40-min and was delivered in a 1–1 format.

Most sessions were delivered remotely via telehealth, with three home-visits. Two studies in the USA evaluated programs teaching parents NDBI strategies in a 1–1 format to enhance child expressive communication (Gevarter et al., 2022; Ousley, 2022). Gevarter et al. (2022) intended to deliver all coaching sessions in-home, but due to COVID some of the coaching sessions were delivered via telehealth. Ousley (2022) used delayed video feedback in synchronous



**Table 1** Child characteristics

Study	n	Months of age mean (range)	Gender (M:F)	Ethnicity (n)	Diagnosis
Abda (2021)	3	56 (50–61)	2:1	Libyan (3)	Autism
Bradshaw et al. (2017)	3	18 (15–21)	3:0	European-American (1) Caucasian (2)	High likelihood
Buckley et al. (2014)	1	72	1:0	NR	Autism
Cain (2017)	4	23.3 (18–26)	3:1	Caucasian (4)	High likelihood
Gevarter et al. (2022)	3	25 (21–33)	3:0	Latinx (3)	Autism (1) High likelihood (2)
Hong et al. (2018)	3	56.7 (51–62)	2:1	NR	Autism
Keough (2016)	3	49 (37–72)	2:1	NR	Autism
Ma (2022)	4	47 (42–54)	4:0	NR	Autism
Ousley (2022)	5	43.2 (24–59)	5:0	White/Non-Hispanic (4) NR/Hispanic (1)	Autism
Penney and Schwartz (2019)	3	57 (48–65)	2:1	Caucasian (3)	Autism
Popovic et al. (2020)	3	50 (45–56)	3:0	White (3)	Autism
Rooks-Ellis et al. (2020)	10	29 (25–33)	6:4	Caucasian (8) American Indian/Alaska Native (1) Hispanic (1)	High likelihood or autism
Shire et al. (2021)	6	53.5 (36–94)	6:0	Caucasian (4) Inuit (1) Innu (1)	Autism
Taylor (2014)	4	38.8 (29–52)	4:0	Caucasian-African-American (1) Caucasian (2) Indian American (1)	Autism (3) PDD-NOS (1)
van Noorden et al. (2022)	7	42.3 (36–52)	7:0	NZ European (2) Māori-NZ European (2) Chinese-NZ European (1) Samoan (1) Pakistani (1)	Autism
Waddington et al. (2020)	5	40.2 (23–59)	5:0	Cambodian (1) NZ European (2) Indian (1) Māori (1)	Autism
Zaghlawan and Ostrosky (2016)	2	48.5 (37–60)	2:0	NR	Autism

telehealth sessions with each participant. Families in both programs received an initial training session that was 60 to 90 min long, followed by two 10-min coaching sessions per week for three to five weeks (Gevarter et al., 2022), or one 30-min coaching session per week for a minimum of four weeks (Ousley, 2022).

Four studies evaluated comprehensive Parent Mediated Early Start Denver Model (P-ESDM; Cain, 2017; Rooks-Ellis et al., 2020; van Noorden et al., 2022; Waddington et al., 2019). These studies all used a 1–1 coaching approach and van Noorden et al. (2022) also evaluated 9–10 sessions of group coaching. Two studies delivered sessions in a clinical setting (Cain, 2017; van Noorden et al., 2022), one was in a home setting (Waddington et al., 2019), and one was provided via telehealth (Rooks-Ellis et al., 2020). The van Noorden et al. (2022) and Waddington et al. (2020) studies were conducted in New Zealand, the other studies were in the USA. Program intensity ranged from three 60–90-min sessions per week for four weeks (Cain, 2017), to one

50–90 min session per week for up to 22 weeks (van Noorden et al., 2022).

Four studies evaluated teaching parents to use PRT strategies to target specific child goals (Abda, 2021; Bradshaw et al., 2017; Buckley et al., 2014; Popovic et al., 2020). All these studies were conducted in the USA except for Popovic et al. (2020) which was conducted in Canada. All the studies were delivered in a 1–1 format, three were delivered in-home (Bradshaw et al., 2017; Buckley et al., 2014; Popovic et al., 2020), and one was delivered via telehealth (Abda, 2021). Intensity and duration of PRT studies ranged from 12 h of support over 12 weeks (Bradshaw et al., 2017), to 12 h of support over three weeks (Popovic et al., 2020).

Four studies in the USA evaluated teaching parents to target child imitation using RIT strategies (Keough, 2016; Penney & Schwartz, 2019; Taylor, 2014; Zaghlawan & Ostrosky, 2016). All four programs involved 1–1 sessions in-home, although Penney and Schwartz (2019) also included an initial group training session for the parents before the individual sessions began, and Taylor (2013) included an

**Table 2** Parent characteristics

Study	n	Years of age	Gender (M:F)	Languages spoken at home	Marital status (n)	Parent employment (n)	Parent education (n)
Abda (2021)	3	NR	3:0	Arabic (3)	Two-parent household (3)	NR	NR
Bradshaw et al. (2017)	3	NR	NR	NR	Married (3)	Stay-At-Home (1) Employed (2)	Some College (1) Bachelor's Degree (1) Doctorate (1)
Buckley et al. (2014)	1	NR	0:1	NR	Married (1)	NR	NR
Cain (2017)	4	35, 37, 39, 41	0:4	English (4)	NR	Stay-At-Home (2) Stay-At-Home/Part-Time (1) Full-Time (1)	College Degree (2) Graduate Degree (1) NR (1)
Gevarter et al. (2022)	3	20, 26, 28	2:1	English (3) Spanish (1)	NR	Employed (2) Stay At Home (1)	High School Degree (2) Some College (1)
Hong et al. (2018)	3	NR	0:3	NR	NR	NR	NR
Keough (2016)	3	NR	1:2	NR	NR	Part-Time (1) Stay-At-Home (2)	Undergraduate (1) Bachelor's Degree (1) Doctorate (1)
Ma (2022)	4	31, 31, 32, 35	0:4	NR	Two parent household (3)	NR	College (4)
Ousley (2022)	5	42.8 (30–60)	3:2	NR	NR	Full Time (2) Stay At Home (1) NR (2)	NR
Penney and Schwartz (2019)	3	NR	1:2	NR	Married (3)	Stay-At-Home (2) Employed (1)	NR
Popovic et al. (2020)	3	35–44 (2) 45–54 (1)	0:3	English (3)	NR	NR	2-Year College Degree (2) 4-Year Undergraduate Degree (1)
Rooks-Ellis et al. (2020)	10	25–34 (6) 35–44 (3) 55+(1)	1:9	NR	NR	Stay-At-Home (3) Employed (6)	High School (1) Some College (5) College Degree (3) Graduate Degree (1)
Shire et al. (2021)	6	NR	1:5	English (5) Inuktitut (1) Innu (1)	Two parent household (5) NR (1)	Part Time (3) Full Time (2) NR (1)	Some High School (1) Some College (1) College Degree (2) Graduate Degree (1) NR (1)
Taylor (2014)	4	34, 37, 41, 41	0:4	NR	Married (3) Single (1)	Employed (2) Stay-At-Home (2)	Graduate Degree (2) Some College (1) Associates Degree (1)
van Noorden et al. (2022)	7	NR	2:5	English (6) Samoan (1) Cantonese (1) Māori (1)	Married (4) De facto (2) Single (1)	Full-Time (2) Part-Time (3) Stay-At-Home (1)	High School (2) Trade Certified (2) Bachelor's Degree (1) Master's Degree (1) Doctorate (1)
Waddington et al. (2020)	5	NR	0:5	English (5) Cambodian (1) Tamil (1)	Married (4) Long term relationship (1)	Unemployed (3) Part-Time (1) Full Time (1)	High School (3) Bachelor's Degree (1) Master's Degree (1)
Zaghlawan and Ostrosky (2016)	2	NR	1:1	English (2)	NR	Stay-At-Home (2)	NR

initial self-guided web-based training component. When reported, the RIT studies involved one to two sessions per week, with a minimum of 5 and maximum of 27 sessions per participant.

Supplementary Table 3 outlines the characteristics of the coaches who worked with parents, and the coaching approach that was used in each study. When reported, coaches were frequently masters or doctoral students ( $n = 7$ ), had 5 or more years of experience in the autism field, and

**Table 3** Program location and characteristics

Study	Country	NDBI model	Program characteristics								
			Study design	Teaching focus	Delivery method	Delivery setting	Number of sessions	Duration of each session (minutes)	Sessions per week	Total support hours	Duration of Coaching (weeks)
Hong et al. (2018)	Japan	IT	MB across participant design	Specific (communication)	Self-guided + 1–1	Web-based + in-person (setting NR)	Self-paced: NR VF: 19–20	Self-paced; NR VF: 5 min	Self-paced: NR VF: 2–3	NC	Self-paced: 2 weeks VF: 20 weeks
Ma (2022) <sup>1</sup>	China	IT	MP across participants design	Specific (Requesting)	Self-guided + 1–1	Web-based + asynchronous delayed VF	Self-paced web module: 5 VF: 9–14	Self-paced web-module: 10 min VF: 10.9 min (average), 3.7–24.2 min (range)	3–5	2.5–3.4 h	Self-paced web-module: 2 days VF: NR
Shire et al. (2021)	Canada (rural)	JASPER	Concurrent MB across participants	Specific (social communication)	1–1	Telehealth + 3 in-home	24	40 min	2	16 h	12 weeks
Gevarter et al. (2022)	USA	NDBI	Non-concurrent MP across participants	Specific (Expressive communication)	1–1	In-home + Telehealth (COVID)	7–9	60–90 min training session + 10 min coaching sessions	2	2.5–2.8 h	3–5 weeks
Ousley (2022) <sup>1</sup>	USA	NDBI	Concurrent MB across participants	Specific (Expressive communication)	1–1	Telehealth with delayed VF	7–11	60 min intro session + 30 min coaching sessions	1	4–6 h	4+ weeks
Cain (2017) <sup>2</sup>	USA	P-ESDM	MB component analysis	Comprehensive	1–1	In-clinic	12	60–90 min	3	12–18 h	4 weeks
Rooks-Ellis et al. (2020)	USA (rural)	P-ESDM	Concurrent MB across participants	Comprehensive	1–1	Telehealth	12	90 min	1	18 h	12 weeks
van Noorden et al. (2022)	NZ	P-ESDM	Non-concurrent MB across groups	Comprehensive	Group + 1–1	In-clinic	19–20	50–90 min	1	21.8–23.3 h	19–22 weeks
Waddington et al. (2020)	NZ	P-ESDM	Non-concurrent MP across participants	Comprehensive	1–1	In-home	12	60 min	1	12 h	12 weeks



**Table 3** (continued)

Study	Country	NDBI model	Program characteristics								
			Study design	Teaching focus	Delivery method	Delivery setting	Number of sessions	Duration of each session (minutes)	Sessions per week	Total support hours	Duration of Coaching (weeks)
Abda (2021) <sup>1</sup>	USA	PRT	MB across participants	Specific (communication)	1–1	Telehealth	6	60 min	3	6 h	2 weeks
Bradshaw et al. (2017)	USA <sup>3</sup>	PRT	Non-concurrent MB across participants	Specific (expressive communication)	1–1	In-home	7–12	60 min	1	7–12h	12 weeks
Buckley et al. (2014)	USA <sup>3</sup>	PRT	MB design	Specific (child “compliance”)	1–1	In-home	NR	NR	NR	NC	NR
Popovic et al. (2020)	Canada <sup>3</sup>	PRT	Concurrent MB across participants	Specific (Question asking)	1–1	In-home	6	120 min	2	12 h	3 weeks
Keough (2016) <sup>2</sup>	USA <sup>3</sup>	RIT	MB across participants and behaviors	Specific (Imitation)	1–1	In-home	15–27	30 min	NR	7.5–13.5 h	NR
Penney and Schwartz (2019)	USA <sup>3</sup>	RIT	MB design (after an initial group training session)	Specific (Imitation)	Group training + 1–1	Preschool initial training + in-home coaching	7–8	90 min intro, + 30–40 min coaching	1	5.5–6.2 h	6–7 weeks
Taylor (2014) <sup>1</sup>	USA	RIT	Concurrent MP across participants	Specific (Imitation)	Self-guided + 1–1	Web-based + in-home	4 online modules + 5–7 training/GEN sessions	NR	1–2	NC	3.7–4.9 weeks
Zaghawan and Ostrosky (2016)	USA <sup>3</sup>	RIT	MB across strategies	Specific (Imitation)	1–1	In-home	11–16	NR	2	NC	NR

*Note*<sup>1</sup> doctoral thesis<sup>2</sup> master’s thesis

<sup>3</sup> the authors did not specifically report which country the study occurred in, so the country of the author’s institution is included as a proxy  
 USA = United States of America; NZ = New Zealand; NR = Not reported; NC = not calculable; MB = multiple baseline; MP = multiple probe; IT = Incidental Teaching; JASPER = Joint attention symbolic play emotion regulation; NDBI = naturalistic developmental behavioral intervention (generic program); P-ESDM = parent-mediated early start Denver model; PRT = Pivotal response treatment; RIT = Reciprocal imitation training

had professional or model specific accreditation. Most studies used coaching methods that aligned more with a clinician directed protocol ( $n=13$ ), compared to a collaborative coaching approach ( $n=4$ ).

## Outcomes

All parent and child outcomes included in this review were measured through analysis of video recordings of parent-child interactions, except Buckley et al. (2014) who did not report how their data were collected. Table 4 reports the key findings for changes in child and parent outcomes during or after program implementation compared to baseline levels, as either positive effects (+), null effects (O), or negative effects (-).

### Child Outcomes

Five studies evaluated changes in parent-child engagement. Shire et al. (2021) was the only study that found positive

effects across all participants, three studies found positive effects for some but not all participants, and Taylor (2014) found null effects for parent-child engagement. Cain (2017) evaluated child joint attention and found mixed effects, with positive or null effects for each child. Child communication was the most common child outcome measure. Of the 10 studies evaluating child communication, four studies found positive effects across all children, five studies found positive effects across some communication measures for some but not all children, Ousley (2022) found a null effect on child communication. Seven studies evaluated changes in child imitation. Keough (2016) found positive effects on both object and gesture imitation across all child participants. All other studies reported a mixture of positive, null, and negative effects across various imitation measures. Buckley et al. (2014) reported positive effects for child 'compliance', the only outcome measure included in their study. Cain (2017) reported that there was no effect of the intervention on child avoidance for any participant.

**Table 4** Program effects for child and parent dependent variables

Study	Child outcomes				Parent Outcomes		
	Parent-child engagement	Joint attention	Child language/communication	Child imitation	Child "compliance" / "avoidance"	Fidelity change <sup>1</sup>	Proportion of parents achieving fidelity (threshold % accuracy/frequency)
Hong et al. (2018)			+ / O			+	2/2 ( $\geq 80\%^2$ )
Ma (2022)			+ / O			+	4/4 ( $\geq 80\%^2$ )
Shire et al. (2021)	+					+	1/5 ( $\geq 75\%$ )
Gevarter et al. (2022)			+			+	3/3 ( $\geq 80\%^2$ )
Ousley (2022)			O			+ / O	3/5 ( $\geq 65\%$ )
Cain (2017)	+ / O	+ / O	+ / O	Obj Im: + / O Gest Im: O	O	O	0/3 ( $\geq 90\%$ )
Rooks-Ellis et al. (2020)						+	8/10 ( $\geq 80\%$ )
van Noorden et al. (2022)	+ / O		+ / O	Vocal Im: + / O / - Obj & Gest Im: + / O		+	5/7 ( $\geq 80\%$ )
Waddington et al. (2020)	+ / O		+ / O	+ / O		+	3/5 ( $\geq 80\%$ )
Abda (2021)			+			+	NR
Bradshaw et al. (2017)			+			+	NR
Buckley et al. (2014)					+	NR	NR
Popovic et al. (2020)			+			+	3/3 ( $\geq 80\%$ )
Keough (2016)				Object Im: + Gest Im: +		+ / O	NR
Penney and Schwartz (2019)				+ / O		+	3/3 ( $\geq 80\%$ )
Taylor (2014)	O			+ / O		+	4/4 ( $\geq 80\%$ )
Zaghlawan and Ostrosky (2016)				Obj Im: + / O Gest Im: + / O		+	NR

Note + = positive effect, O = null effect, - = negative effect

Obj. Im. = Object imitation. Gest. Im. = Gestural imitation. Vocal Im. = vocal imitation. NR = not reported

<sup>1</sup> When multiple parent behaviors/strategies were measured separately, the results were combined and summarized for this table

<sup>2</sup> If a specific threshold was not reported by the study, 80% accuracy was used as a proxy threshold

## Parent Outcomes

Parent fidelity (i.e., use of the NDBI strategies as intended) was reported in 16 out of 17 studies. Thirteen studies found a positive effect on fidelity across all parents, two studies found a positive effect for some but not all parents, one study found a null effect on parent fidelity. Some studies found that when parents were taught a new strategy (e.g., how to teach gestural imitation), their use of previously learned strategies (e.g., teaching object imitation) decreased (Cain, 2017; Keough, 2016; Taylor, 2014; Zaghawan & Ostrosky, 2016).

Regarding the proportion of parents who met a predetermined fidelity threshold in each study, nine studies explicitly stated or referred to manuals that specify a fidelity threshold. Fidelity thresholds ranged from 75 to 90%. The proportion of parents who met the fidelity threshold in each study ranged from 0 to 100%. By NDBI model, the average percentage of parents reaching fidelity thresholds was 20% (JASPER), 52% (P-ESDM), 75% (NDBI), 100% (PRT, 3 NR), 100% (IT), and 100% (RIT, 2 NR).

## Study Quality

The quality indicators outlined in Cook et al. (2015) were used to assess the quality of each study. Supplementary Table 4 summarizes the results across studies. The number of quality indicators that were met ranged from 5 (Buckley et al., 2014), to 22 out of 22 (Gevarter et al., 2022; Shire et al., 2021; Waddington et al., 2019). Two quality indicators were met by all studies: demonstrations of experimental effect at three different times (Item 6.5), and socially important outcomes (Item 7.1). Only eight studies described the training and qualifications of the clinician coaching the parents (Item 3.2; see Supplementary Table 3) and reported on implementation fidelity for each interventionist (i.e., both the parent and clinician) across each setting and throughout implementation of the program (Item 5.3; Cook et al., 2015, p. 224). The mean number (and range) of quality indicators met by thesis studies and peer-reviewed studies were 17.3 (13–21), and 17.5 (5–22) respectively.

## Discussion

We synthesized evidence from single-case studies for the effects of parent-mediated NDBIs on individual child and parent outcomes. Reviewing single-case research designs allowed for evaluation of individual parent and child outcomes, as well as insights into the effects of programs across time for the participants. The 17 studies included within this review generally reported positive effects for at least

some of their participating children on at least one measure of engagement, joint attention, communication, imitation, or ‘compliance’. Most of the included studies also reported positive effects on parent fidelity, for most but not all parents. There were mixed results across studies for whether parents reached a specified fidelity criterion.

The findings of this review of parent-mediated NDBIs align with previously published research. Child communication was the most common child outcome across studies in this review and is also a frequently reported outcome across both NDBI studies generally (Fuller et al., 2020; Ona et al., 2020; Tiede & Walton, 2019; Waddington et al., 2021), and autism parent coaching programs (Nevill et al., 2018; Oono et al., 2013). Similar to Tiede and Walton (2019), the current review found improvements in child communication across different NDBI models, cautiously suggesting that “NDBI models as a class may positively affect language development” (p. 10). It is, however, important to note that only 4 out of 12 studies that included a measure of child communication found a positive effect across every child in that study. This could stem from the heterogeneity of autistic children in presentation, developmental trajectories, and response to supports (Masi et al., 2017).

It is promising that there were positive effects on parent-child engagement for many children in this review, as increasing duration and quality of engagement is a foundational goal in NDBIs (Schreibman et al., 2015). It has been suggested that establishing joint engagement is a prerequisite to other developmental outcomes (Tiede & Walton, 2019). Therefore, improvements in this area might promote learning in many other areas (Dawson & Bernier, 2013). However, parent-child engagement is a very proximal program outcome, and it is possible that changes in this outcome were due to changes in parent behavior rather than, or as well as, changes in child behavior (Tiede & Walton, 2019). Indeed, studies have found associations between child engagement and higher parent fidelity (van Noorden et al., 2022), including higher parental use of attentional strategies (Cain et al., 2017).

Findings for changes in child imitation skills were mixed across the included studies. Even when parents reached the fidelity threshold in specific imitation focused programs, not all children showed improvements in their imitation skills (e.g., Taylor, 2014; Zaghawan & Ostrosky, 2016). There are several potential explanations for this. First, only spontaneous instances of imitation were included, that is, instances where the child copied an adult’s action, gesture, or vocalization without any prompting. Only measuring spontaneous imitation could potentially obscure changes in child imitation skills as this is a core challenge for many autistic children, and they may need structured supports while this skill is emerging. Conversely, parents may

over-prompt their children and therefore prevent their children from responding independently (Keough, 2016). Second, teaching imitation requires parents to initiate teaching episodes, which may be a harder skill for parents to learn, compared to strategies that require responding to child behaviors (Stahmer et al., 2017; Waddington et al., 2020).

It may be useful to consider how the measures in this study align with a neurodiversity affirming approach to support (Dawson et al., 2022). A survey conducted by Waddington et al. (2023) found that goals targeting play skills and autism characteristics -including imitation and eye contact- were ranked lowest priority and were most likely to be considered inappropriate by autistic adults, parents, and professionals supporting autistic children. Goals related to upskilling the individuals around the child and increasing child quality of life were the highest priorities across groups. This aligns with a neurodiversity perspective that emphasises changing the environment around the child, rather than requiring an autistic child to change (Gillespie-Lynch et al., 2017; Pellicano & den Houting, 2022). Several measures that were used by studies in this review including imitation, compliance, and measuring engagement and joint attention in ways that require a ‘non-autistic’ performance of these skills (e.g., requiring eye contact), may be deemed inappropriate or undesirable by the increasing number of people in the autistic and autism communities who align with a neurodiversity affirming approach (ASAN, 2021; Waddington et al., 2023). It is important that researchers select measures which are appropriate and meaningful to their participants and the community more broadly.

Most parents showed improvements in fidelity across these NDBI programs. However, not all parents reached fidelity threshold criteria. Supporting parents to reach an effective level of fidelity is an important aim of support programs, as higher implementation fidelity has been linked to greater child skill acquisition (Waddington et al., 2020; Zitter et al., 2021). Multi-tiered approaches to parent coaching can be a flexible way to provide appropriate supports and meet family needs (Frost et al., 2020; Green, 2019; Phaneuf & McIntyre, 2011). Several reviewed studies included additional individualized program tiers. Many, but not all parents showed further increases in fidelity during these additional tiers (Ousley, 2012; Penney & Schwartz, 2019; van Noorden et al., 2022). Studies where all parents did reach fidelity thresholds, often involved a focused NDBI such as RIT, Incidental Teaching, or PRT.

Parents in the reviewed studies often demonstrated variability in their use of NDBI strategies from one session to another. Several reasons were suggested for this, including child characteristics, interests, and temperaments across sessions (Gevarter et al., 2022; Shire et al., 2021), and parent difficulties applying strategies over the wide range of

child goals and activities (Ousley, 2022; van Noorden et al., 2022). Another explanation could be that in programs where parents are frequently learning new techniques, the introduction of a new strategy could have an inhibitory effect on previously learned strategies; as suggested by the results of Cain (2017), Keough (2016), Taylor (2014), and Zaghawan and Ostrosky (2016). This highlights the fact that single-case research can reveal effects that would not be readily identifiable in a group designs.

There was wide variability in the amount of parent support delivered, ranging from a total of 2.5 to 23.3 h, and program duration ranged from 1 week to 22 weeks. There was no clear pattern of amount or duration of support within specific NDBI models either. This is similar to findings from other parent coaching reviews (Nevill et al., 2018). This variability makes comparing the programs to one another difficult. However, the variation also points towards the flexibility of parent-mediated NDBIs in that some very short and low-intensity programs (e.g., Gevarter et al., 2022) as well as longer (van Noorden et al., 2022), and higher intensity programs (Abda, 2021) reported positive outcomes for many participants. According to Tiede and Walton (2019), even small effects on outcomes from relatively short and low-intensity programs “may be promising and meaningful” (p. 10). It is also important to consider however, that there is no agreement on what amount of support is optimal for autistic child learning, and it is likely to depend on child and family characteristics (Trembath et al., 2021). Additionally, parameters other than total hours and weeks of support are relevant to the question of the effects of different levels of intensity, such as the number of learning opportunities that are provided and responses that are reinforced within a session (Warren et al., 2007). For example, Zitter et al. (2021) found that the NDBI strategy of providing clear teaching episodes every 10-30 s was associated with child acquisition of targeted skills.

There was also flexibility across included studies regarding delivery setting and method, with most programs using a 1–1 coaching approach within the families’ homes, or in-clinic. However, group coaching components were also included in several studies, as initial one-off sessions, or multi-week coaching phases. Several recent studies also utilized technology in their delivery, through telehealth, video modelling or feedback, or web-based modules. Group and telehealth coaching approaches could help to increase access to supports by reducing barriers associated with funding, logistical or location constraints, pandemics, and shortages of service providers.

There were also discrepancies between studies as to the coaching approaches that were used. The findings of this review align with Kemp and Turnbull (2014) who identified that the term “parent coaching” was used to describe

a continuum of practices from a more clinician-directed training approach, to a more relationship focused and collaborative coaching approach. Similarly to Tomeny et al., (2020), this review found that very few studies reported using coaching strategies such as collaborative planning, parent reflection, and collaborative decision making. This suggests that many of the reviewed studies may have been using more directive “teaching” or “training” approaches, which have been critiqued as potentially limited for adult learning as such approaches might not as effectively meet the needs of participating families (Rush & Shelden, 2011; Tomeny et al., 2020).

Regarding study quality, more methodologically sound research needs to be conducted to determine whether parent-mediated NDBIs can be considered an evidence-based practice according to Cook et al.’s (2015) guidelines. However, three very recent studies met all quality indicators (QIs; Cook et al., 2015), and all six studies that met over 20 QIs were published since 2020. This suggests that there is a trend towards higher quality single-case research in this area. Areas that were under-reported across studies included descriptions of parent and child characteristics, the coach and their qualifications, the program procedures, and the inclusion of fidelity measures for both the coach’s implementation and the parents’ implementation regularly across the program (Cook et al., 2015). Across the included studies there was also a lack of diversity in parent and child participants, as most children were male and white, and most parents were female, white, and highly educated. Most children also came from two-parent households where at least one parent was not working full time, this may limit the replicability of these studies’ findings regarding solo parents, or families where both parents are employed full time.

There are several clinical implications of this review. First, despite some methodological concerns, the collective results of these studies suggest that many parents could learn to implement NDBI strategies with their own autistic child. Furthermore, many children might show increases in target behaviors including joint engagement, communication, and imitation during parent-mediated NDBIs. Thus, parent-implemented NDBI may represent a promising approach for enabling children to receive an effective form of support from their natural caregivers and thus this could help reduce barriers to accessing early supports.

This review is subject to several limitations. First, no ancestral searches of reference lists were conducted, and so relevant studies may not have been identified. Second, this review did not screen for NDBI characteristics of the included studies, instead relying on Schreibman et al.’s (2015) list of models that can be considered NDBIs. Therefore, some of the included studies may not have met the criteria for NDBI classification as outlined in other research

(e.g., Tiede & Walton, 2019). Finally, this review included grey literature in the form of master’s and doctoral thesis, which can help to reduce the risk of inflated positive results through publication bias (Paez, 2017), but may also pose a threat to the internal validity of systematic literature reviews given the potential for lower quality methodology and experimental control (Walsh et al., 2023).

Several aspects of parent-mediated NDBIs require further research. Increasing congruence in the field of parent-mediated NDBIs is important for evaluating the effectiveness of these approaches collectively, as well as ensuring families and clinicians can make informed decisions about appropriate supports for autistic children. Therefore, researchers should specifically identify when they are evaluating a model that fits within the category of NDBIs (D’Agostino et al., 2023; Schreibman et al., 2015), and use comparable, valid, and reliable measures of parent fidelity such as the NDBI-Fi tool (Frost et al., 2020). Additionally, future single-case research could explore active ingredients of parent-mediated NDBIs through analyzing each component separately (D’Agostino et al., 2023), and conducting statistical analysis of the relation between parent fidelity changes and child outcomes (van Noorden et al., 2022; Waddington et al., 2020). This might help to identify the strategies that are necessary for successful use of parent-implemented programs. Only one study (Gevarter et al., 2022) involved community practitioners, future research should evaluate community implementation of parent-mediated NDBIs to improve dissemination efforts. Research that compares the outcomes of specific versus comprehensive parent-mediated NDBIs would also help to identify which approaches are best suited to which individual parents and children (Waddington et al., 2021). Improving the quality of studies in this area is imperative, future studies should aim to consider how the QIs outlined in Cook et al. (2015) could be included. In line with this, the use of outcome measures that do not rely on parents who have participated in the program might help to elucidate whether observed positive effects are due to changes in parent or child behavior, or both. Finally, future research should include a consideration of neurodiversity affirming practices and outcomes (D’Agostino et al., 2023; Schuck et al., 2021; Waddington et al., 2023). For example, the social and ecological validity of research might be improved by adopting a more participatory research design with input from and consultation with the autistic community. This may also help to ensure that acceptable goals are being targeted within the program, including evaluating effects of the program on the social and physical environment around the child, and outcomes that improve the child’s quality of life.

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## Declarations

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