

Effect of early childhood development interventions delivered by healthcare providers to improve cognitive outcomes in children at 0–36 months: a systematic review and meta-analysis

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ABSTRACT

Objective To determine the effect of early childhood development interventions delivered by healthcare providers (HCP-ECD) on child cognition and maternal mental health.

Design Systematic review, meta-analysis.

Setting Healthcare setting or home.

Participants Infants under 1 month of age.

Interventions HCP-ECD interventions that supported responsive caregiving, early learning and motor stimulation. MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, Health Technology Assessment Database, Database of Abstracts of Reviews of Effects and Cochrane Database of Systematic Reviews were searched until 15 November 2021. Studies reporting prespecified outcomes were pooled using standard meta-analytical methods.

Main outcome measures Cognitive development in children at 0–36 months.

Results Forty-two randomised controlled trials with 15 557 infants were included in the narrative synthesis. Twenty-seven trials were included in the meta-analyses. Pooled data from 13 trials suggest that HCP-ECD interventions may improve cognitive outcomes in children between 0 and 36 months (Bayley Scales of Infant Development version III (BSID-III) mean difference (MD) 2.65; 95% CI 0.61 to 4.70; 2482 participants; low certainty of evidence). Pooled data from nine trials suggest improvements in motor development (BSID-III MD 4.01; 95% CI 1.54 to 6.48; 1437 participants; low certainty of evidence). There was no evidence of improvement in maternal mental health (standardised MD –0.13; 95% CI –0.28 to 0.03; 2806 participants; 11 trials; low certainty of evidence).

Conclusions We report promising evidence, particularly for cognitive and motor outcomes, of the effect of HCP-ECD interventions. However, effect sizes were small, and the certainty of evidence ranged from very low to moderate. Additional high-quality research is required.

PROSPERO registration number CRD42019122021.

INTRODUCTION

Globally, more than 40% of disadvantaged children under 5 years have neurodevelopmental problems resulting in social, emotional and educational functioning deficits into adulthood.^{1–3} The WHO defines early childhood development (ECD)

interventions as physical, socioemotional, cognitive and motor development interventions implemented between birth and 8 years of age.^{4–10} The importance of the family and social environment in influencing children's neurodevelopment is well-known. However, the impact of health services on the neurodevelopment of children, particularly primary care (the first level of the health system), is less well understood.^{11 12} Healthcare providers (HCPs) working in primary care, including community health workers, generalist nurses, health visitors, midwives, child health nurses and general practitioners, are uniquely positioned to augment early child development. However, many lack skills and confidence in neurodevelopmental care and few receive appropriate training, education and resources.^{13 14} HCP-delivered ECD interventions (HCP-ECD) include: WHO's Care for Child Development package, family partnership working and motivational interviewing.^{15–20}

Four systematic reviews have examined the effectiveness of ECD interventions to improve early child development.^{21–24} Most recently, a systematic review of 102 studies reported that parenting interventions improved a range of ECD outcomes at 3 years.²⁴ However, these reviews had various individuals delivering the ECD interventions such as peer counsellors, family support workers, HCPs and researchers. To our knowledge, there have been no systematic reviews that have examined the effect of ECD interventions delivered solely by an HCP (HCP-ECD) to families in high-income country (HIC) and low/middle-income country (LMIC) settings.

There is a growing body of evidence that babies develop important communication and social behaviours within the first days and weeks of life, especially eye contact, visual locking, auditory responses, responsiveness and self-quietening behaviour.^{4 25–29} Systematic reviews have assessed the effect of interventions delivered in the antenatal period.^{23 24} However, to our knowledge, there have been no reviews of the effects of ECD interventions in a subgroup of babies who received ECD interventions in the neonatal period from 0 to 28 days ('neonatal ECD').^{23 24} The optimal number of visits or contacts ('dose') and types of ECD interventions delivered in the neonatal and infant periods is also not known.

Table 1 Intervention definitions used in included studies

| Interventions | Definitions* | Example of ECD programmes delivered by healthcare providers |
|------------------------------|--|---|
| Responsive caregiving | Interventions that promote responsive caregiving and interactions, and strengthen the parent–child relationship. These interventions aim to support and encourage sensitivity and responsiveness or secure attachment | WHO-UNICEF Care for Child Development Programme, ¹⁵ Philani Plus (+) ⁵¹ |
| Early learning support | Interventions that enhance parent and/or caregivers' access, attitudes, knowledge, skills or practices to support early learning and development of children. This could be through providing direct support to parents and/or caregivers which enable them to provide new early learning opportunities to their children. Other interventions may include providing education, information or guidance of early child development | Healthy steps, ⁷⁰ Family Nurse Partnership ⁵⁹ |
| Motor stimulation | Interventions that target fine and gross motor development of children including interventions such as goals-activity-motor enrichment or constraint-induced movement therapy | BRAIN-HIT Programme ³⁷ |
| Any responsive caregiving | Any trial with an intervention that includes responsive caregiving (even in low dose) regardless of the provision of other ECD or non-ECD interventions | WHO-UNICEF Care for Child Development Programme, ¹⁵ Philani Plus (+) ⁵¹ |
| ECD-predominant intervention | Any trial where ECD interventions (responsive caregiving, early learning support or motor stimulation as defined above) were implemented for more than 50% of contact time between healthcare provider and family | WHO-UNICEF Care for Child Development Programme, ¹⁵ Philani Plus (+), ⁵¹ Healthy steps, ⁷⁰ Family Nurse Partnership, ⁵⁹ BRAIN-HIT Programme ³⁷ |

*Definitions from: WHO. Early childhood development (https://www.who.int/maternal_child_adolescent/topics/child/development/en/)¹⁰. ECD, early childhood development.

The primary objective of this review was to assess effects of HCP-ECD on cognitive outcomes in children at 0–36 months. Secondary objectives were to assess effects on (1) childhood neurodevelopmental domains (speech, language, fine motor, gross motor, social emotional, behaviour) at 0–36 months; (2) maternal mental health at 0–36 months and (3) in prespecified subgroups (number and timing of infant and neonatal contacts, type of intervention, income level of country).

METHODS

The protocol was registered in PROSPERO (CRD42019122021), and the detailed protocol is published separately.³⁰ Preferred Reporting Items for Systematic Reviews and Meta-Analyses-Protocol (PRISMA-P) guidance was followed.³¹ Modifications made from the original protocol are provided in online supplemental appendix 1.

Search strategy

We searched the following databases with no restrictions to time periods and language: Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, the Cochrane Database of Systematic Reviews, Health Technology Assessment Database and the Database of Abstracts of Reviews of Effects. We also searched clinical trial registries. Reference lists from included studies and relevant systematic reviews were inspected for additional citations. The search was completed on 15 November 2021. The search strategy is presented in online supplemental appendix 2.

Eligibility criteria

The HCP-ECD interventions had to be delivered by primary-level HCPs (eg, generalist nurses, health visitors, midwives, child health nurses, general practitioners, primary care doctors, community health workers). The interventions could commence in the hospital but had to include community-based post-discharge follow-up.³² Interventions were required to be face to face in nature, for example, delivered through home visiting, mobile health team visits, clinic visits, child health checks or group programmes. The comparator group was 'no HCP-ECD interventions', that is, any other care, standard care that did not include ECD or no care. Only individual, cluster and quasi-randomised controlled trials (RCTs) were eligible for inclusion.

Interventions

We used WHO definitions and classified the ECD interventions into three categories: responsive caregiving, early learning support and motor stimulation.¹⁰ We also classified interventions as: any responsive caregiving, no responsive caregiving, and ECD predominant and ECD non-predominant. ECD predominance was defined as ECD implemented for more than 50% of the contact time (table 1).

Outcomes

The primary outcome measure was cognitive development in children at 0–36 months of follow-up. Secondary outcomes were: (1) speech, language, fine motor, gross motor, social, emotional, behaviour, executive functioning and adaptive functioning; and (2) maternal mental health. Studies were included in the systematic review regardless of the type of outcomes. However, only standardised measures, for example, the Bayley Scales of Infant and Toddler Development or the Griffiths Mental Development Scales for cognitive development, were used in the meta-analyses.

Our a priori primary analysis was the period between 0 and 36 months where an infant received assessment for outcomes 'at latest follow-up'. We did this to ensure that the maximum amount of data could contribute to the primary outcome, that is, that all studies with follow-up could be included regardless of the duration of follow-up. We expected that the duration of follow-up would vary across studies so we reported the mean (SD) and median (IQR) duration of follow-up for each outcome and presented this in each forest plot. For completeness, we also assessed effects at 12, 24 and 36 months of follow-up. However, these time points were not prespecified as primary or secondary outcomes. A priori, we expected that these results would be underpowered and imprecise with wide CIs.

Subgroups

We assessed effects on cognitive development in children at 0–36 months in seven prespecified subgroups: (1) number of contacts in the neonatal period (one contact, two contacts, three or more contacts); (2) timing of contact (first week, second week or later); (3) antenatal period exposure (intervention delivered in the antenatal period, intervention not delivered in the antenatal

Table 2 Participant characteristics in included studies of early childhood development interventions delivered by healthcare providers

| Study author, year | Country | No of infants* | Description of caregiver/infant | Sex of child (male (%)) | Primary caregiver | Age of mother |
|--|----------------------|----------------|---|-------------------------------|-------------------------|--|
| Ara <i>et al</i> , 2019 ¹²³ | Bangladesh LMIC | 378 | Married pregnant women aged 16–49 years | Not recorded | All mothers | Mean age in years (SD) intervention: 23.38 (4.0), control: 23.54 (4.32) |
| Aracena <i>et al</i> , 2009 ¹²² | Chile HIC | 90 | Primiparous adolescent mothers living in an extremely poor neighbourhood | Intervention 61%, control 45% | All mothers | Mean age in years (SD) intervention: 17.3 (0.23), control: 17.15 (0.22) |
| Armstrong <i>et al</i> , 1999 ¹²¹ | Australia HIC | 181 | High-risk mothers with at least one liveborn infant | Not recorded | All mothers | Mean age in years (SD) intervention: 25.72 (5.61), control: 26.67 (6.08) |
| Barlow <i>et al</i> , 2003 ¹¹⁷ | England HIC | 131 | Vulnerable/high-risk women | Intervention 52%, control 48% | All mothers | <17 years n (%) intervention: 12 (17.9), control: 14 (22.2) |
| Barnes <i>et al</i> , 2013 ¹¹⁶ | England HIC | 166 | Expectant mothers with low educational qualifications and/or less than 20 years of age | Intervention 54%, control 63% | All mothers | Mean age in years (SD) intervention: 21.7 (1.9), control: 21.9 (1.6) |
| Black <i>et al</i> , 1994 ¹¹³ | USA HIC | 60 | Low-income, inner-city, multiparous, polydrug misusers | Intervention 45%, control 59% | All mothers | Mean age in years (SE) intervention: 26.4 (0.9), control: 27.9 (0.7) |
| Brooten <i>et al</i> , 1986 ¹¹² | USA HIC | 79 | Infants with birth weights of 1500 g or less | Not recorded | All mothers | Mean age in years (SD) intervention: 24 (7), control: 23 (6) |
| Butz <i>et al</i> , 2001 ¹¹¹ | USA HIC | 117 | Mothers who used cocaine and/or opiates | Intervention 41%, control 59% | Mother 69%, other 31% | Mean age in years at infant birth (SD) intervention: 28.9 (4.5), control: 28.0 (4.6) |
| Cooper <i>et al</i> , 2009 ¹⁰⁴ | South Africa LMIC | 449 | Women in the last trimester of their pregnancy | Intervention 48%, control 48% | All mothers | Mean age in years (SD) intervention: 25.5 (5.23), control: 26.2 (5.84) |
| Cooper <i>et al</i> , 2015 ¹⁰⁵ | England HIC | 301 | Primiparous women at risk of postnatal depression | Intervention 38%, control 46% | All mothers | Mean age in years (SD) intervention: 27.94 (5.4), control: 28.66 (6.0) |
| Cremer <i>et al</i> , 1977 ¹⁰¹ | Colombia LMIC | 148 | Mothers in the first/second trimester of pregnancy with at least 50% of their other children classified as malnourished | Not recorded | Not recorded | Not recorded |
| El-Mohandes <i>et al</i> , 2003 ¹⁰⁰ | USA HIC | 286 | Mothers receiving no or inadequate prenatal care | Not recorded | All mothers | Mean age in years intervention: 24.8, control: 25.2 |
| Fatori <i>et al</i> , 2019 ⁹⁹ | Brazil LMIC | 80 | Low-income pregnant youth aged 14–19 years | Not recorded | All mothers | Mean age in years (SD) intervention: 16.9 (1.3), control: 17.3 (1.2) |
| Gardner <i>et al</i> , 2003 ⁹⁶ | Jamaica LMIC | 140 | Low-income women with infants with birth weight <2500 g | Intervention 41%, control 46% | All mothers | Mean age in years (SD) intervention: 23.0 (6.6), control: 24.6 (7.3) |
| Goldfeld <i>et al</i> , 2017 ⁹⁵ | Australia HIC | 722 | Pregnant mothers <37 weeks' gestation with 2 or more of 10 risk factors | Intervention 46%, control 44% | All mothers | Mean age in years (SD) intervention: 27.5 (6.1), control: 27.8 (6.4) |
| Gray <i>et al</i> , 1979 ⁹² | USA HIC | 100 | Women who had their first or second child at the Colorado General Hospital | Not recorded | Not recorded | Not recorded |
| Guteilus <i>et al</i> , 1977 ⁹¹ | USA HIC | 95 | Primiparous mothers who were black, unmarried and between 15 and 18 years of age | Not recorded | Mothers or grandmothers | Not recorded |
| Infante-Rivard <i>et al</i> , 1989 ⁹⁰ | Canada HIC | 47 | Mothers from low socioeconomic background | Not recorded | All mothers | Mean age in years (SD) intervention: 25.3 (5.7), control: 23.5 (3.8) |
| Jack <i>et al</i> , 2015 ⁸⁹ | Canada HIC | 739 | Primiparous pregnant women (<24 years) with <28 weeks' gestation experiencing socioeconomic disadvantage | Not recorded | All mothers | Mean age in years for total sample (SD) 19.76 (2.36) |
| Jungmann <i>et al</i> , 2010 ⁸⁸ | Germany HIC | 755 | Primiparous low-income mothers between their 12th and 28th week of pregnancy | Not recorded | All mothers | Mean age in years (SD) intervention: 21.27 (4.2), control: 21.53 (4.4) |

Continued

Table 2 Continued

| Study author, year | Country | No of infants* | Description of caregiver/ infant | Sex of child (male (%)) | Primary caregiver | Age of mother |
|--|---|----------------|---|-------------------------------|-------------------|---|
| Kemp <i>et al</i> , 2008 ⁸⁴ | Australia HIC | 208 | At-risk mothers from a disadvantaged community | Not recorded | All mothers | Mean age in years (SD) intervention: 27.6 (6.7), control: 27.7 (5.9) |
| Kitzman <i>et al</i> , 1997 ⁸¹ | USA HIC | 1139 | Primiparous women less than 29 weeks pregnant with sociodemographic risks | Not recorded | All mothers | Mean age in years (SD) intervention: 18.1 (3.2), control: 18.1 (3.3) |
| Korfmacher <i>et al</i> , 1999—RCT 1 ⁷⁹ | USA HIC | 490 | Primiparous women | Not recorded | All mothers | Mean age in years (SD) intervention: 20.24 (4.17), control: 19.70 (4.13) |
| Korfmacher <i>et al</i> , 1999—RCT 2 ⁷⁹ | USA HIC | 500 | Primiparous women | Not recorded | All mothers | Mean age in years (SD) intervention: 19.44 (3.69), control: 19.70 (4.13) |
| Letourneau, 2001a ⁷⁶ | Canada HIC | 24 | Primiparous inexperienced adolescent mothers aged between 13 and 19 years | Not recorded | All mothers | Mean age in years at time of infant birth (SD) for total sample 18.06 (1.01) |
| Mejdoubi <i>et al</i> , 2011 ⁷⁴ | The Netherlands HIC | 460 | High-risk primiparous women | Not recorded | All mothers | Mean age in years (SD) intervention: 19.5 (2.8), control: 19.2 (2.6) |
| Minkovitz <i>et al</i> , 2001 ⁷⁰ | USA HIC | 2235 | Not recorded | Not recorded | All mothers | <20 years (%) intervention: 15.2, control: 14.9 20–29 years (%) intervention: 53.0, control: 51.5 ≥30 years (%) intervention: 31.8, control: 33.5 |
| Norr <i>et al</i> , 2003 ⁶⁷ | USA HIC | 477 | Low-income, inner-city women in neighbourhoods with high infant mortality | Not recorded | All mothers | Under the age of 20 (%) intervention: 105 (40.7), control 85 (38.8) |
| Olds <i>et al</i> , 1986 ⁶² | USA HIC | 400 | Primiparous women | Not recorded | All mothers | Mean age in years intervention: 19.53, control: 19.57 |
| Owen-Jones <i>et al</i> , 2013 ⁵⁶ | England HIC | 1645 | Nulliparous pregnant women aged 19 years or under | Not recorded | All mothers | Mean age in years (range) intervention: 17.9 (17.0–18.8), control: 17.9 (16.9–18.8) |
| Resnick <i>et al</i> , 1988 ⁵⁵ | USA HIC | 41 | Premature infants weighing <1800 g at birth | Intervention 52%, control 40% | Not recorded | Mean age in years (SD) intervention: 24.0 (5.8), control: 24.9 (7.8) |
| Rotheram-Borus <i>et al</i> , 2014 ⁵⁰ | South Africa LMIC | 1190 | Pregnant women at least 18 years old | Not recorded | All mothers | Mean age in years (SD) intervention: 26.5 (5.5), control: 26.3 (5.6) |
| Sadler <i>et al</i> , 2013 ⁴⁹ | USA HIC | 105 | Primiparous women aged 14–25 years | Intervention 51%, control 52% | All mothers | Mean age in years (SD) intervention: 19.5 (2.6), control: 19.7 (2.8) |
| Salo <i>et al</i> , 2019 ⁴⁷ | Finland HIC | 45 | Mothers with depressive symptoms | Not recorded | All mothers | Not recorded |
| Siegel <i>et al</i> , 1980—RCT 1 ⁴⁶ | USA HIC | 99 | Low-income women in their third trimester | Not recorded | All mothers | Mean age in years intervention: 21.3, control: 19.8 |
| Siegel <i>et al</i> , 1980—RCT 2 ⁴⁶ | USA HIC | 105 | Low-income women in their third trimester | Not recorded | All mothers | Mean age in years intervention: 20.6, control: 19.8 |
| Siegel <i>et al</i> , 1980—RCT 3 ⁴⁶ | USA HIC | 112 | Low-income women in their third trimester | Not recorded | All mothers | Mean age in years intervention: 20.7, control: 21.0 |
| Slade <i>et al</i> , 2020 ⁴⁴ | USA HIC | 164 | Primiparous mothers aged between 14 and 25 years | Intervention 52%, control 53% | All mothers | Mean age in years (SD) intervention: 20.1 (2.8), control: 20.0 (2.5) |
| Tsiantis <i>et al</i> , 1996 ⁴⁰ | Cyprus, Greece, Yugoslavia, Portugal HIC | Not recorded | Not recorded | Not recorded | All mothers | Not recorded |

Continued

Table 2 Continued

| Study author, year | Country | No of infants* | Description of caregiver/ infant | Sex of child (male (%)) | Primary caregiver | Age of mother |
|--|---------------------------------|----------------|---|-------------------------------|-------------------|--|
| Wallander <i>et al</i> , 2010—RCT ¹³⁷ | India, Pakistan, Zambia LMIC | 164 | Infants with birth asphyxia who were unresponsive to bag and mask ventilation | Intervention 59%, control 61% | All mothers | Mean age in years (SD) intervention: 24.6 (5.5), control: 24.2 (4.0) |
| Wallander <i>et al</i> , 2010—RCT ²³⁷ | India, Pakistan, Zambia LMIC | 243 | Infants without birth asphyxia who did not require any resuscitation | Intervention 54%, control 58% | All mothers | Mean age in years (SD) intervention: 25.5 (5.1), control: 25.6 (5.7) |
| Yousafzai <i>et al</i> , 2014 ¹⁵ | Pakistan LMIC | 751 | Mothers from a predominantly rural and impoverished community | Intervention 55%, control 55% | All mothers | Not recorded |

*Number of infants randomised.
HIC, high-income country; LMIC, low/middle-income country; RCT, randomised controlled trial.

period); (4) type of intervention (responsive caregiving, early learning support and motor stimulation) (any responsive caregiving, no responsive caregiving) (intervention predominantly ECD, intervention not predominantly ECD); (5) type of HCP (child health workers, nurse (including general nurse and child health nurse), child health workers and others); (6) income level of the country (HIC, LMIC); and (7) risk of bias (high risk of bias, some concerns of bias).

Study selection and data collection process

All titles, abstracts and full-text articles were reviewed and extracted independently by two review authors. Discussions with a third author were used to resolve any disagreement. Standardised pretested data collection forms were used. Data collected were: study design, study setting, intervention components, participant demographics and outcomes.

Risk of bias assessment

Two independent review authors used the Cochrane risk-of-bias assessment tool to assess the risk of bias.³³ We also assessed meta-biases, including publication bias and selective reporting. No studies were excluded based on risk of bias assessment.

Data management and statistical analysis

We searched for both continuous and dichotomous data for all outcomes (online supplemental appendix 3 and 4). In the meta-analyses, we reported mean differences (MDs) for continuous data if they were measured on the same scales and standardised MDs (SMDs) for outcomes that were reported on different scales. Relative risks were reported for dichotomous data. We contacted authors where possible to request data.

Random-effects models were used with restricted maximum likelihood estimates and Knapp-Hartung SEs. Where possible, we imputed data using standard methods. We used the I^2 statistic to measure heterogeneity among the primary and secondary outcomes of all included trials. An I^2 value of $>50\%$ was considered to represent substantial heterogeneity. For outcomes with at least 10 studies, funnel plots and Egger's test were used to assess publication bias and small study effects, respectively. We completed an unadjusted random-effects meta-regression with Knapp-Hartung SEs on the primary outcome for the number of expected visits ('doses'). Statistical analyses were performed using STATA V.16.1 statistical software (Stata, College Station, Texas, USA).

Grading of evidence

We used the principles of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system to assess the quality of the body of evidence associated with specific outcomes which included assessment of risk of bias, consistency of effect, imprecision, indirectness and publication bias.³⁴

Role of funding source

No funding.

RESULTS

Study characteristics

After the removal of duplicates, 9401 papers were eligible for inclusion (PRISMA flow diagram, online supplemental appendix 5). After assessing inclusion and exclusion criteria, 97 papers reporting on 42 trials were included in the narrative synthesis, of which 27 trials were included in the meta-analyses (online supplemental appendix 5).^{15 35–130} Online supplemental appendix 3 displays the outcomes and scales reported by each study and those included in the meta-analyses. Online supplemental appendix 6 shows the ongoing studies.

Of the 42 trials, 38 were individual RCTs,^{37 38 44–49 54–77 79–122 124–129} and 4 were cluster RCTs.^{15 35 36 39–43 50–53 78 123 130} (table 2). Thirty-three trials were conducted in HICs^{44–49 54–67 69–77 79–97 100 103 105–108 111–119 121 122 125 126 128} and eight were conducted in LMICs (Pakistan, Bangladesh, South Africa, Columbia, Jamaica, Brazil, India and Zambia).^{15 35–38 41–43 50–53 68 78 96 98 99 101 102 104 109 110 120 123 124 127 129 130}

A total of 15 661 infants participated in the 41 trials; 7857 intervention and 7804 comparison. There were 12 118 infants from HICs, 3136 from MICs and 407 from LMICs. All infants were from families experiencing some level of adversity such as low socioeconomic status, maternal drug abuse, adolescent mothers or were premature (table 2).

Thirty-six trials used a single HCP to implement the intervention (4 trials used child health nurses; 17 used generalist nurses; 4 used health visitors; 17 used community health workers; and 6 used multidisciplinary healthcare teams including child health nurses, general practitioners and generalist nurses) (online supplemental appendix 4). Forty trials used home visits and two used community clinics to implement their ECD intervention. The number of contacts in the trials varied from 6 to 312 (median 25, IQR 9–52), with the interventions lasting between 6 weeks and 36 months (mean 19.7, SD 3.21). The number of contacts in the neonatal period ranged from one to four. Twelve

Table 3 Meta-analyses of effects of early childhood development interventions delivered by healthcare providers (HCP-ECD) on primary and secondary outcomes and in subgroups at 0–36 months

| | No of studies | No of participants | Pooled effect (95% CI) |
|--|---------------|--------------------|--------------------------|
| Primary analyses | | | |
| Cognitive development at 0–36 months | 13 | 2482 | 2.65 (0.61 to 4.70) |
| Cognitive development at 12 months | 7 | 1192 | |
| Cognitive development at 24 months | 2 | 873 | 5.14 (–59.57 to 69.84) |
| Cognitive development at 36 months | 2 | 293 | 3.15 (–10.09 to 16.38) |
| Expected number of visits (dose) | 12 | 1811 | 0.02 (–0.07 to 0.11)* |
| Secondary analyses at 0–36 months | | | |
| Maternal mental health | 11 | 2806 | –0.13 (–0.28 to 0.03)† |
| Motor development | 9 | 1437 | 4.01 (1.54 to 6.48) |
| Speech and language development | 2 | 354 | –0.31 (–12.65 to 12.02)† |
| Social emotional development | 2 | 369 | –0.91 (–27.72 to 25.89) |
| Behavioural development | 3 | 1769 | 8.34 (–31.20 to 47.88)† |
| Child's home environment | 8 | 1534 | 1.37 (0.29 to 2.45) |
| Subgroup analyses at 0–36 months for primary outcome | | | |
| Number of contacts | | | |
| At least one contact in the neonatal period | 4 | 1391 | 4.63 (–4.68 to 13.94) |
| Two contacts in the neonatal period | 4 | 383 | 1.92 (–1.10 to 4.94) |
| Three or more contacts in the neonatal period | 5 | 708 | 2.28 (0.33 to 4.23) |
| Timing of contact | | | |
| First week | 6 | 755 | 1.94 (0.30 to 3.58) |
| Second week or later | 7 | 1727 | 3.48 (–0.70 to 7.66) |
| Antenatal contact | | | |
| Intervention delivered in the antenatal period | 3 | 353 | 1.55 (–1.17 to 4.26) |
| Intervention not delivered in the antenatal period | 8 | 1248 | 4.03 (0.51 to 7.56) |
| Type of intervention | | | |
| Responsive caregiving alone | 3 | 321 | 2.29 (–2.45 to 7.03) |
| Early learning support alone | 6 | 1625 | 0.77 (–0.40 to 1.94) |
| Motor stimulation alone | 0 | 0 | – |
| Any responsive caregiving | 4 | 523 | 5.02 (–3.23 to 13.28) |
| No responsive caregiving | 9 | 1959 | 1.36 (–0.08 to 2.79) |
| ECD predominant | 10 | 1672 | 3.31 (0.74 to 5.88) |
| Non-ECD predominant | 3 | 810 | 0.27 (–1.62 to 2.16) |
| Type of HCP | | | |
| Community health worker (CHW) only | 5 | 801 | 4.03 (–1.00 to 9.06) |
| Mixed (CHW or nurse or other health workers) | 4 | 852 | 1.68 (–2.91 to 6.26) |

Continued

Table 3 Continued

| | No of studies | No of participants | Pooled effect (95% CI) |
|-------------------------|---------------|--------------------|------------------------|
| Nurse only | 4 | 829 | 0.78 (–2.11 to 3.67) |
| Income level of country | | | |
| High income | 9 | 1724 | 1.06 (–0.53 to 2.64) |
| Low and middle income | 4 | 758 | 4.61 (–1.40 to 10.63) |
| Risk of bias | | | |
| High risk of bias | 10 | 2141 | 1.64 (0.32 to 2.96) |
| Some concerns of bias | 3 | 341 | 4.21 (–11.54 to 19.96) |

*Beta coefficient for meta-regression.
†Standardised mean difference.

trials included contact in the antenatal period. Most interventions were classified as responsive caregiving only (15 trials) or early learning support only (18 trials). Nineteen trials provided responsive caregiving along with other interventions and 19 were classified as predominantly ECD (online supplemental appendix 4).

Risk of bias

For assessor-reported outcomes, 5 trials^{15 74 113 119 121} had moderate risk of bias and the remaining 20 trials had high risk of bias (online supplemental appendix 7). For patient-reported outcomes, 2 trials^{15 119} had moderate risk of bias and 27 had high risk of bias (online supplemental appendix 7). There was no evidence of publication bias or small study effects shown for any outcome including the cognitive development outcome (Egger's test $p=0.17$) and maternal mental health outcome (Egger's test $p=0.10$) (funnel plots, online supplemental appendix 7).

Primary analysis

Data for the primary analysis are presented in table 3 and figure 1. The GRADE summary of findings is presented in online supplemental appendix 8. Pooled data from 13 trials suggest that HCP-ECD compared with usual care improved cognitive outcomes in infants at follow-up of 0–36 months (Bayley Scales of Infant Development version III (BSID-III) MD 2.65; 95% CI 0.61 to 4.70; 2482 participants; low certainty of evidence). We downgraded one level for heterogeneity ($I^2=63%$) and one level for risk of bias (six trials had a high risk of bias in the selection of the reported result and two trials had a high risk of bias in outcome measurement). No publication bias was reported. There was little to no evidence of an effect of HCP-ECD interventions at 12 months, 24 months and 36 months of follow-up (table 3 and online supplemental appendix 9). However, these analyses had small sample sizes and wide CIs and were downgraded for imprecision and risk of bias.

Secondary analyses

Data from the secondary analyses are presented in table 3 and online supplemental appendix 10. Pooled data from nine trials suggest that HCP-ECD improves motor outcomes in infants aged 0–36 months (BSID-III MD 4.01; 95% CI 1.54 to 6.48; 1437 participants; moderate certainty of evidence). Pooled data from eight trials suggest that HCP-ECD improves home environments for children at 0–36 months (HOME inventory scales¹³¹ MD 1.37; 95% CI 0.29 to 2.45; 1534 participants; low certainty of evidence).

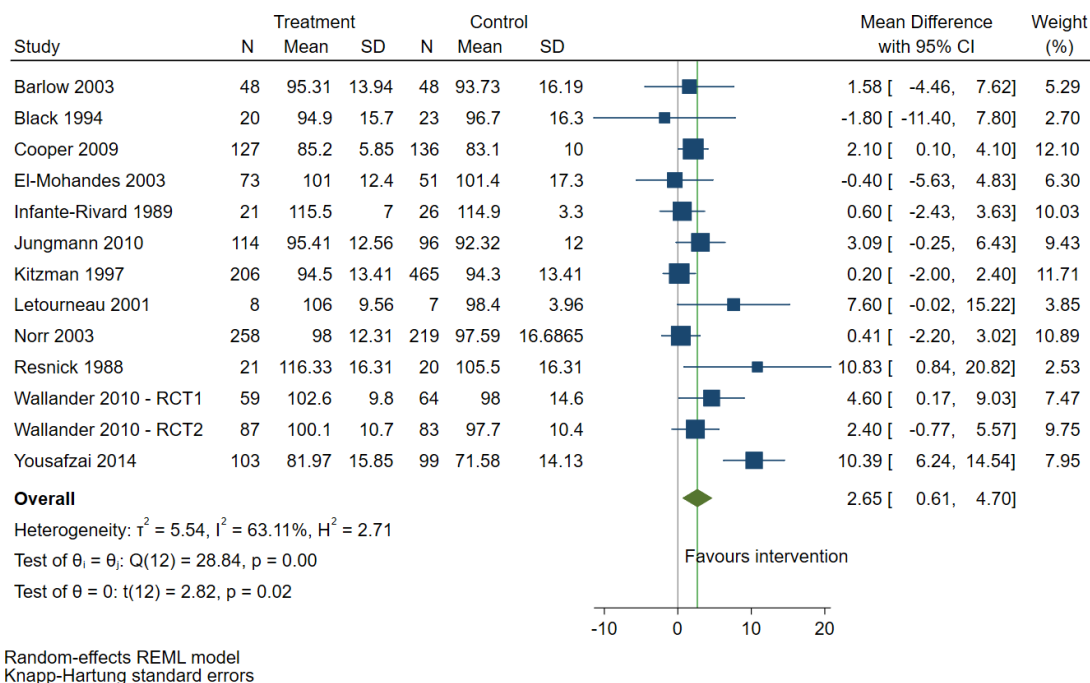


Figure 1 Effect of ECD interventions delivered by healthcare providers on cognitive development at 0–36 months: mean (SD) 18±10 months; median (IQR) 18 (12–25). N, number of children in study; RCT, randomised controlled trial; REML, restricted maximum likelihood.

There was little to no effect on maternal health (SMD -0.13 ; 95% CI -0.29 to 0.03 ; 2806 participants; 11 trials; low certainty of evidence); speech and language (SMD 0.30 ; 95% CI -0.53 to 1.13 ; 1551 participants; 3 trials; very low certainty of evidence); socioemotional (Ages and Stages Questionnaire-Social Emotional scales MD -0.91 ; 95% CI -27.72 to 25.89 ; 369 participants; 2 trials; very low certainty of evidence) or infant behaviour outcomes (SMD 8.34 ; 95% CI -31.20 to 47.88 ; 1769 participants; 3 trials; very low certainty of evidence). No studies reported on executive or adaptive functioning.

Subgroup analyses

There was no evidence of differences in the effect of HCP-ECD on the primary outcome (cognitive development) in any subgroup (number of contacts, timing, type of intervention, type of HCP, income level of country, risk of bias) except for ECD predominance (ie, ECD implemented for more than 50% of the contact time between HCP and family) (table 3 and online supplemental appendix 11). The effect of ECD-predominant interventions (BSID-III MD 3.31 ; 95% CI 0.74 to 5.88 ; 1672 participants; 10 trials) was greater than the effect of interventions that were not ECD predominant (BSID-III MD 0.27 ; 95% CI -1.62 to 2.16 ; 810 participants; 3 trials) (X^2 statistic 4.16 , $p = 0.04$). No other differentials in effect were found for any other subgroup analysis. In particular, there was no evidence of a ‘dose–response’, that is, an effect of HCP-ECD by number of expected HCP visits (β coefficient 0.018 ; 95% CI -0.07 to 0.11 , 1811 participants; 12 trials; table 3).

Few studies reported dichotomous outcomes. These analyses had wide CIs and were limited by imprecision. Results are presented in online supplemental appendices 9 and 10.

DISCUSSION

Our systematic review of 15 557 infants aged 0–36 months in 42 trials showed that HCP-ECD interventions may improve cognitive and motor outcomes and the quality of the home

environment for infants aged 0–36 months across HICs and LMICs. No effect was seen on speech, language, socioemotional, behaviour or maternal mental health outcomes.

Our effects on cognitive outcomes (MD 2.65 ; 95% CI 0.61 to 4.70) at 36 months appeared greater than the four recent parenting reviews which reported SMD scores ranging from 0.25 to 0.42 .^{23 24 132 133} We prespecified the combined period of follow-up of 0–36 months as our primary outcome to ensure that the maximum amount of data could contribute to the primary outcome, that is, all studies could be included regardless of the duration of follow up. The other analyses at 12 months, 24 months and 36 months were downgraded for imprecision due to small sample sizes and wide CIs and showed little to no evidence of an effect of HCP-ECD interventions at 12 months, 24 months and 36 months of follow-up.

Effects on motor development were similar to other reviews.^{22 23} No effects were seen on language, behaviour and socioemotional development domains. However, few trials assessed these outcomes (speech (two trials, 354 infants), language (two trials, 369 infants) and social and emotional development (three trials, 1769 infants)). The trials also had wide CIs and we downgraded the certainty of the evidence two levels for imprecision. We found no impact of HCP-ECD on maternal mental health. This is similar to most other reviews of ECD interventions,^{22–24 134} and could be because ECD interventions do not include techniques that directly address parental mental health, such as behavioural activation and cognitive–behavioural therapy. However, we did show that HCP-ECD interventions improved home environment scores. Forty of the 42 studies used home visits as the main delivery channel which may be an important mechanism, though further research is needed.

Trials that fulfilled the definition of ‘ECD predominance’ (ECD implemented for more than 50% of contact time) had a greater effect on child neurodevelopment than trials with

ECD implemented for less than 50% contact time. However, caution is needed in interpreting these results due to unexplained heterogeneity, especially in the ECD-predominant group ($I^2=68\%$). There was no differential effect by type of intervention (responsive caregiving, learning support or other), antenatal contact or timing of neonatal interventions. However, these subgroup analyses had small sample sizes and limited power to detect effects.

There were a number of methodological limitations in the trials included in our meta-analysis. Using the GRADE system,³⁴ we judged that the evidence for our primary outcome was low certainty due to risk of bias and heterogeneity. Many different scales were also used for measurement of child neurodevelopment and maternal mental health. However, we found sufficient data for pooling using SMDs or MDs for the follow-up period of 0–36 months. We also did not find publication bias or small study effects for our primary and secondary outcomes. All the ECD interventions in our systematic review were delivered to infants facing adversity including: poverty, maternal drug abuse and preterm birth. However, these situations are unfortunately not uncommon, and children facing these types of adversities are most in need of ECD interventions. Our study also had a number of other strengths. We included 12 013 infants and 27 trials in our meta-analyses. Our search was intentionally broad to capture all relevant studies, and we did not limit our search geographically, by language or by intervention approach. The interventions were delivered by a range of healthcare workers, including community health workers, generalist nurses, general practitioners and health visitors, making the findings relevant across many settings.

To our knowledge, this is the first systematic review and meta-analysis that has examined the impact of HCP-ECD interventions across HICs and LMICs. We report evidence of impacts on child neurodevelopment. Importantly, our review shows ‘what the health system can do’ to improve neurodevelopmental outcomes in the first 3 years of a child’s life. This is especially important as HCPs (such as midwives and child health nurses) have multiple contacts with the mother and child in the first 3 years of life and are well placed to integrate and support maternal health as well as ECD.

We believe a sustained long-term commitment to ECD from governments and donors that focuses on three core ECD interventions (responsive caregiving, early learning support and motor stimulation) could quickly accelerate the gains we reported in our meta-analysis. More investment is also needed to train and build the skills and confidence of HCPs in neurodevelopmental care.^{13 14} Many countries have committed to reaching the 2030 United Nations Sustainable Development Goal for ECD.⁵ Our findings suggest that the health system has a potentially important role to play in achieving this goal, especially in the early years.

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