The Impact of Early Childhood Development Interventions on Children's Health in Developing Countries: A Systematic Review and Meta-analysis

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The Impact of Early Childhood Development Interventions on Children's Health in Developing Countries: A Systematic Review and Meta-analysis†

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Abstract

Investing in a child's early years reduces incidences of stunting, wasting, worm infections, and anemia among young children. Yet, 250 million children are at risk of not reaching their full development potential in low-and-middle income countries (LMIC) due to inadequate nutrition and lack of early stimulation. Multiple early childhood health interventions such as growth monitoring, nutrition supplementation, cash transfers, handwashing, and deworming have been tested to evaluate their impact on improving child health outcomes in LMIC. However, there is limited evidence assessing the relative benefits of implementing one type of intervention over another. This review is among the first to identify the interventions which have comparatively outperformed others in improving children's physical health since the year 2000 and the gaps in the quality of existing evidence. Upon a comprehensive review of the impact from 39 early childhood interventions, we find that interventions including nutrition or cash based assistance outperform interventions offering information based support or growth monitoring. Further examination of the long term impacts, cost-effectiveness, and extended exposure of these interventions is needed to understand what works in improving child health during early years.

JEL Classification: I15, J13, I31

Keywords: Early Childhood Development (ECD), Systematic Review, Meta-analysis, Health, Lower-and-Middle Income Countries (LMIC)

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1 Introduction

Impaired linear growth in early childhood caused by malnutrition, recurrent infections, and lack of care for development has adverse consequences for a child's development. Children suffering from stunting may never develop their brains to full cognitive potential. Wasted children suffer from long term development delays due to reduced immunity levels and face increased risk of morbidity and mortality. Further, anemia and infections during early years exacerbate the risk of learning difficulties, work capabilities, and participation in communities. Enteric parasite infection resulting from improper sanitation facilities among children from 0–8 years old also has severe impact on child growth and development. Despite an 11 percentage point decline in the percentage of under–5 children affected by stunting, wasting, and overweight globally, accelerated progress is required to reach the United Nation's 2030 target (UNICEF, 2021). The Joint Malnutrition Estimates published in 2021, by UNICEF, WHO, and The World Bank found that 22% of children under the age of five (150 million) are estimated to be stunted (Silwal et al., 2020) and 7% (45.4 million) to be wasted. Moreover, the onset of the COVID-19 pandemic has undone considerable progress in improved childhood health by disrupting health care access and affordability. COVID-19–related disruptions could result in an additional 9.3 million wasted children and 2.6 million stunted children, 168,000 additional child deaths, and $29.7 billion USD in future productivity losses due to excess stunting and child mortality (Osendarp et al., 2021).

Since more than 90% of all under–5 stunted and wasted children live in Low and Middle Income Countries (LMICs), evidence on what works in this context is required to achieve the SDG Target of 2030. Scholarship has proven that Early Childhood Development (ECD) interventions such as nutrition supplementation of zinc, iron and folic acids, micronutrient powders, and proper feeding practices can improve child growth outcome (Hess et al., 2015). Sanitation programs to curb open defecation can also achieve significant impacts of child's growth, intestinal infections, and anemia prevalence.[1] Such investments in early child health can have long lasting impacts on poverty alleviation, generation of sound human capital, and labor market outcomes in the long run (Baird et al., 2016). However, these need to be designed and implemented effectively to be beneficial. Combining different components such as cash, information, and nutrition interventions with one another can have larger impacts than single component interventions. Hossain et al. (2017) emphasize that a combination of nutrition-specific and nutrition-sensitive interventions is necessary in order to optimise programs to reduce stunting. They found that single interventions reduced stunting only in countries with specific disease burden. Similarly, the appropriate intensity of the interventions affect the level of impact one can achieve for the long term. Further, impacts on child growth outcomes may vary by the intensity of intervention and time-period for which

[1] This is mediated by contributing towards lower amounts of feces polluting groundwater and cause enteric pathogen transmission.

it was delivered. In a systematic review assessing the long term impacts of early childhood interventions, Tanner et al. (2015) find that nutrition interventions may need to be in place throughout and beyond the first 1,000 days of a child's life. This would enable children in LMICs to leverage the window of opportunity from conception to age 2 to achieve sustained effects beyond early childhood. They emphasize that if not implemented and designed properly, ECD interventions might not always lead to lasting impacts in physical development and adulthood health.

A number of systematic reviews have evaluated the impacts of either a single type of intervention (e.g., daycare, nutrition supplements, etc.) (Prado et al., 2019; Leroy et al., 2012; Aboud and Yousafzai, 2015; Olusanya et al., 2018; Miller et al., 2015) or on single child growth outcomes (Hossain et al., 2017). However, a comprehensive review of all interventions types in LMICs across the main child growth outcomes – stunting, wasting, underweight and anemia – is lacking. Through this study, we aim to shed light on the types of interventions which have been tested so far, and highlight which interventions have considerable impacts in improving children's growth outcomes. We also aim to evaluate why some studies find insignificant impacts and point towards gaps in the current literature.

Similar to previous systematic reviews and meta-analyses examining the health outcomes of ECD interventions (Aboud and Yousafzai, 2015; Olusanya et al., 2018; Miller et al., 2015; English and Uler, 2016; Murphy et al., 2018; Magnuson et al., 2016), our study is limited to Randomized Controlled Trials (RCTs). We review 39 articles published since the turn of the century evaluating ECD interventions on children aged 0–8 years in 22 LMICs. We focus on 6 primary outcomes affecting child health – anemia prevalence, stunting, wasting, underweight, mid upper arm circumference (MUAC), and worm infections. We complement this by examining 5 secondary related outcomes – height, height-for-age, weight, weight-for-age, and head circumference. We analyze these outcomes using a random effects meta-analysis. The random effects estimation allows for variation across studies using sampling variability in treatment effects. Analyzed through a meta-analysis, this estimates the average treatment effect reported across multiple studies.

Our findings suggest that standalone interventions on information for caregivers; water, sanitation, and hygiene; and growth monitoring have achieved limited impact on boosting child growth. Nutritional supplementation appears to be an effective method in boosting child development outcomes. Pyschosocial stimulation programs and deworming campaigns are still under-evaluated for children between 0–8 years of age and their role in boosting child growth outcomes requires further examination. Considering the difficulty in achieving the SDG goals by 2030, reconsidering investments in ECD programs aligned with the expansion of dualy integrated nutrient supplements and cash incentive programs may accelerate progress to overcome the damages incurred by the COVID-19 pandemic. Further, we call for more studies measuring child growth outcomes over longer intervention periods, the use of cost-effectiveness analysis of interventions, and tackling measurement issues in evaluating outcomes such as anemia (i.e., self-reports vs. haemoglobin levels), height, weight, and MUAC.

2 Methods

This review follows the guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions[2] (Higgins et al., 2021). Below, we summarize the key elements of the methodology followed in this review. For a detailed explanation of the methods used in this study, please refer to Appendix Section A.

2.1 Exclusion Criteria

We included studies using Randomised Controlled Trials (RCTs) in LMICs to evaluate the impact of the ECD interventions on children's health outcomes. Since this study performs a meta-analysis, RCTs were included to avoid the unit of analysis error in the meta estimates and maintain the consistency in type of evidence[3]. Countries which were not classified as LMIC prior to the onset of the Millenium Development Goals (MDG)[4] in 2000 (United Nations, 2020) were excluded from the review. We also excluded interventions aimed at children older than 8 years old at the start of the experiment.[5] Other meta-analyses or systematic reviews, and studies not published in English were also excluded from this review. We focused on evidence evaluating key health outcomes in children – anthropometric measures (e.g., stunting, underweight, wasting, and MUAC), anemia prevalence, and worm infections. Subsequently, we excluded studies which were not focused on ECD interventions. The selected outcomes focus on growth and development, rather than morbidity and mortality. In addition, we examine a series of related complementary secondary outcomes[6] whose analysis is provided in Appendix Section C. The exclusion of articles by exclusion criteria at each stage of the systematic review is shown in Figure 1. These criteria were assessed sequentially, e.g., we examined criteria 1 before examining criteria 2 in assessing inclusion.

[2]This systematic review follows the PICO model (Miller and Forrest, 2001) and PRISMA design (Moher et al., 2015). PRISMA and PICO are standard guidelines for conducting systematic reviews in clinical and health settings.

[3]We expand upon our exclusion of longitudinal study designs in Appendix Section A.3.

[4]The MDG goals preceded the SDG goals established in 2015. For further information, refer to Appendix Section B.

[5]This age limit is consistent with the WHO defined age range for ECD interventions (World Health Organization, 2020).

[6]These outcomes are height, height-for-age, weight, weight-for-age, and head circumference.

2.2 Search Strategy

During Dec. 2019 – Dec. 2020, we screened 20 databases to source our articles in the initial search. The combination of search terms were as follows: "("early childhood development" OR "early development" OR "early child care" OR "ecd") AND ("health*" OR "nutr*" OR OR "special needs" OR "food")."[7]

The review process was undertaken in two stages. First, studies were excluded based on the review of titles and abstracts by two independent reviewers. Second, a full reading of the included studies further screened the articles per the exclusion criteria. Once the final list of articles was obtained, all authors reviewed all the selected articles' citations following the title, abstract, and full review process as mentioned previously. The search process was concluded by December 2020.

2.3 ECD Interventions

We define an ECD intervention as "The process of cognitive, physical, language, temperament, socio-emotional, and motor development of children that starts at the time of conception until 8 years of age" (World Health Organization, 2020). For this study, these interventions are targeted at improving child health outcomes by providing a product or service as opposed to general phenomenon (e.g., a good harvest resulting from plentiful rain).

While each intervention was uniquely crafted for its specific context, we broadly categorize these interventions into six categories. These categories are nutrition supplements; childcare at home, preschool, and play groups; water, sanitation, and hygiene; cash transfers; psychosocial stimulation; and deworming pills. For explicit details on the activities pertaining to each intervention category by study, please refer to Appendix Table A.6.

2.4 Data and Analysis

Data on impact estimates, confidence intervals, standard errors, sample sizes, and p-values were extracted from individual studies. For each study, the impact estimates took into account the effect of clustering and were corrected for control characteristics. We present the effect sizes of discrete outcomes (i.e., anemia prevalence, worms infection, stunting, wasting, and underweight) in terms of probability, and of continuous outcomes (i.e., mid-upper arm circumference) in terms of normalized z-scores.

If a study reported multiple effect size estimates for different treatment arms, we constructed one estimate per study for each intervention in each outcome. In case of only 2 intervention arms in a study, we evaluated the combined effect estimate and confidence

[7] The article selection process for this systematic review is documented through a Search Tracker available at https://mcwayrm.github.io/files/McWay_et_al_2022_ECD_Search_Tracker.xlsx.

intervals using a meta regression. For 3 or more intervention arms in a study, we made use of standard formulas for combining effect sizes of continuous and discrete outcomes (See details in Appendix Section A.3 following Cochrane guidelines (Higgins et al., 2021)).

Our analysis examined the impact of each intervention by outcome measure and identified types of interventions which were able to achieve the largest impact for children's health. We addressed considerable heterogeneity between studies by using a random effects model and assessed the quality of evidence through GRADE and risk of bias (ROB) of the published studies. The criterion used to rank studies included an assessment of the importance of the problem, feasibility of the recommendations, precision of the estimates, reporting bias, rigor of the methodology, and overall quality.[8]

2.5 Publication Bias

Given the small number of studies found by this review, we inspected our search for publication bias through an Egger Test and funnel plots. Details on the analysis of publication bias are reported in Appendix Section D.

A funnel plot for studies assessing the primary outcomes, presented in Figure 2, shows no visual representation of publication bias. This suggests that the primary outcomes are largely unaffected by small-study bias. Examining the influence of publication formally using the Egger test in Appendix Table A.1 echoes the visual evidence presented through the funnel plots. The primary outcomes do not show any presence of small-study bias (p-value 0.2167) with the exception of Anemia which has a positive small-study bias (p-value 0.0439). As a result, we can confidently assert that it is unlikely that the findings presented in this review are generally driven by publication bias.

3 Results

3.1 Article Characteristics

Figure 1 depicts the search results of the review from 20 databases. We found 24,762 articles from our initial search and were left with 13 articles after removing duplicates and screening titles, abstracts, and full articles based on the exclusion criteria. The majority of articles were not accepted because they did not conduct an ECD intervention. In addition to the 13 articles, 31 snowball articles were added to the final list after reviewing the bibliographies of the initially selected articles[9].

Table 1 outlines the characteristics of articles included in this study. 71% of studies were limited to Sub-Saharan Africa (41%) and South Asia (30%). Notably, the search did not

[8]For more details on GRADE and ROB classifications, please refer to the Appendix Section A.2.

[9]We speculate that this high ratio of of snowballs to primary search articles could be the result of our search terms being too broadly defined.

find studies from some large developing nations such as China, Brazil, and Indonesia. It also lacks representation from Middle Eastern countries, the Balkans, and the Caribbean. Due to this, it is ambiguous if findings in this review are externally valid for all LMICs.

80% of the studies measured anthropometric outcomes on stunting, wasting, and underweight. However, only 16% of the studies measured outcomes for anemia prevalence, MUAC, and worm infections; indicating an under-examination of these outcomes.

46% of the ECD interventions in this review comprised of nutrition supplements and information. Interventions on deworming pills, caregiver/parental education, and psychosocial stimulation programs each made up of less than 5% of the evidence. Most of these interventions targeted children under age 5, and representation of studies targeting children from ages 5–8 remains low. Only 10% of the studies in our review included children who were greater than 2 years old.

Around 56% of the identified studies had a considerably low ROB and a high GRADE score. Further details on the sample composition of this review is given in Appendix Section E.

3.2 Child Anthropometric Measures

We combine the findings on child anthropometric outcomes covering stunting, underweight, wasting, and MUAC. We find that interventions including a nutrition supplement have achieved the most significant impact on child growth outcomes, amongst others.

Results presented in Figures 3 and 4 depict a pooled likelihood of 5 percentage point (pp) (CI -0.10, -0.01) reduction in stunted children and 7pp (CI -0.13, -0.01) reduction in underweight children through provision of nutrient supplements. The pooled impact on stunting prevalence appears to be driven by Hess et al. (2015), who find a 10pp reduction (CI -0.12, -0.08) in stunting and 5pp reduction (CI -0.05, -0.05) in wasting prevalence in Burkina Faso. The high I2 statistic confirms that the pooled effect is driven by considerable heterogeneity among studies. Other studies which achieved significant impacts on height-for-age Z-Score (HAZ) include Yousafzai et al. (2014) and Christian et al. (2015) (Refer to Figure A.2). A considerable number of studies evaluating nutrition based interventions also observed improvement in weight-for-age Z-Score (WAZ) (Vermeersch and Kremer, 2004; Hess et al., 2015; Yousafzai et al., 2014; Iannotti et al., 2013; Null et al., 2018; Christian et al., 2015). Overall, findings suggest that providing SQ-LNS with or without zinc, malaria, and diarrhoea treatment (Hess et al., 2015); enhanced nutrition in the form of micronutrient powders (Yousafzai et al., 2014); daily lipid-based nutrient supplements including Vitamin A, Vitamin B-12, iron, and zinc (Iannotti et al., 2013); and folic acid supplementation (Gardner et al., 2005; Hamadani et al., 2002; Olney et al., 2006) for young children and infants leads to positive and statistically significant child health outcomes. Though some studies like Berry et al. (2017) did not find a significant impact of provision of micronutrient mix and iron and folic acid supplements in the meals of school going children.

Although the pooled effect of cash transfer interventions is insignificant, we find that cumulative cash transfers have potential to significantly improve HAZ by 0.03 SD (Fernald et al., 2009). Conditional cash transfer programs were found to improve child anthropometric outcomes in the Philippines, where grants provided conditional on health behavior of children from age 0–5, lead to a 10.2pp reduction in severe stunting and minor gains in HAZ (0.28, $p < 0.01$) (Kandpal et al., 2016). Attanasio et al. (2015) also shows that cash transfers, conditional on attending preventative care visits, contributed to better child health outcomes and a reduction in the probability of a child being underweight by 12pp. However, Gertler (2004) found no significant impact of the PROGRESA program on stunting outcomes for children.

Other interventions aiming to educate parents or caregivers at home or at community forums, had statistically insignificant impacts on child anthropometric outcomes (Martinez et al., 2018; Rockers et al., 2016; Null et al., 2018). For example, Fink et al. (2017) did not find significant impacts of home/community-based growth monitoring and nutritional supplementation on the prevalence of underweight, stunted children, and HAZ. They did find slight improvements in WAZ for all children and HAZ for children with stunted growth at baseline. Similarly, Attanasio et al. (2018) did not find a significant change in HAZ for all children, but a statistically significant 6pp reduction in the fraction of children whose HAZ was below -1 standard deviation at baseline. Low heterogeneity demonstrated by our pooled results indicates that delivering standalone information on nutrition, parenting techniques, stimulation activities at home, community, and preschool levels may not achieve significant effects on child anthropometric outcomes for children between 0–5 years of age (Bouguen et al., 2013).

Although, informational interventions bundled with other components have shown stronger impacts. Attanasio et al. (2015) found a statistically significant reduction in stunting by 6pp because of a unique intervention (FAMI) integrating parent support services with a nutritional supplement corresponding to 22% – 27% of the monthly recommended nutritional intake for children under 12 months in Colombia. Similarly, Levere et al. (2016) found significant and sizable impacts of the information plus cash intervention on maternal knowledge, behavior, child development, and nutrition.

Insignificant pooled meta estimates suggest that programs providing psychosocial support and sanitation have had limited impacts in boosting child anthropometric outcomes. Rahman et al. (2008) evaluated the impact of delivering psychological support to mothers with perinatal depression on their infant's health in rural Pakistan. No significant impacts were found on HAZ or WAZ for infants at 6 and 12 months of age. Additionally, evaluations of India's Total Sanitation Campaign (TSC), aiming to promote latrine access and curb open defecation by Patil et al. (2014) and Clasen et al. (2014) produced no significant impact on children's growth outcomes. Null et al. (2018) also found that behavior change messaging combined with technologically simple interventions such as water treatment, sanitation upgrades from unimproved to improved latrines and handwashing stations did not reduce childhood diarrhoea or improve growth, even when program take up was at least as high as has been achieved by other programs. Counseling and nutrition supplementation led to small growth benefits, but there was no advantage to integrating water, sanitation, and handwashing with nutrition.

However, all efforts were not in vain. Pickering et al. (2015) found considerable positive impact of access to toilets on children's HAZ, WAZ, stunting, and underweight outcomes in Mali. Younger children (<2 years) also showed comparative improvements to older children. This is consistent with a priori expectations. A null meta estimate on WASH interventions indicates that even though increased latrine coverage can be effective for reducing exposure to faecal pathogens and preventing disease, consistent uptake and reduced exposure are required to achieve significant gains in health outcomes for children.

3.3 Anaemia Prevalence

Our findings in Figure 7 indicate a 9pp pooled reduction in anemia prevalence among children. However, it is not statistically significant (CI -0.22, 0.04). A high value I2 statistic (96.96%) confirms that the pooled effect is driven by a high degree of heterogeneity among studies. With 4 studies evaluating the impact on anaemia prevalence among children, only 2 achieve a significant reduction (Gertler, 2004; Hess et al., 2015).

In evaluating a conditional cash transfer intervention (PROGRESA) in Mexico, Gertler (2004) found that children (12–48 months of age) in the treatment group were 26% less likely to be anaemic as compared to those in control group ($p < 0.05$). PROGRESA households received conditional cash worth 20–30 percent of their household income, every 2 months. Transfers were provided conditional on a range of requirements: immunization of children between 0–23 months of age, effective nutrition intake by children and mothers, health monitoring of all family members, pre/post-natal care of pregnant women, etc. Thus, PROGRESA was a unique cash transfer intervention which has shown significant effects on anemia reduction. It should also be noted that the effects pertain to a self-reported measure of anemia prevalence and not a clinical examination in this study.

Direct nutrition-based interventions also reduced anemia prevalence. Hess et al. (2015) evaluated the impact of small quantity lipid-based nutrient supplements (SQ-LNS) on 9 month old infants and found a 13pp (CI -0.19, -0.08) reduction in anemia prevalence among treated children. However, they also found that despite the provision of 6 mg iron, 400 µg retinol, and B-vitamins in SQ-LNS, along with treatment for malaria and diarrhea, 76% of children in the intervention groups still had anemia. The authors highlight the need for additional interventions to reduce the anemia burden among these children. Since the authors clinically measure anemia prevalence through Haemoglobin concentration levels, their effect sizes have higher reliability and reduced likelihood of measurement error. To the contrary, Martinez et al. (2018) found no significant impact of community based behavioural change monthly/bi-monthly visits by health workers on anemia among children. The visits were directed to caregivers and family members of children younger than 12 months and educated them on key messages on nutrition, exclusive breastfeeding, complementary feeding, responsive behavior, and hygiene. The information was delivered in the form of play-based education such as songs and poems. Interventions aiming to improve sanitation practices did not have a significant impact on anemia prevalence as well. Patil et al. (2014) found no impact of a mass rural sanitation program in India, aimed at construction of more latrines and reducing open defecation among children of 0–24 months of age.

3.4 Worm Infections

A number of water and sanitation interventions have shown positive impacts on worm infections in children. In a clinical clustered RCT, Lin et al. (2018) found that individual handwashing and hygienic sanitation interventions significantly reduced childhood Giardia infections by 19pp (CI -0.33, -0.04) as shown in Figure 8. Even though they test 7 different types of interventions including chlorinated water, sanitation, handwashing, and nutrition, maximum reduction in worm infections was achieved by sanitation and nutrition + WASH interventions. In a similar evaluation, Pickering et al. (2015) find a 22pp reduction in Ascaris infections among children because of an integrated wash, sanitation, hygiene, and nutrition intervention. Patil et al. (2014) did not find significant impacts of a latrine construction program in India, possibly because of poor implementation of the sanitation program and inadequate access to sanitation.

In summary, ECD interventions have successfully been found to reduce anemia in some cases and generally reduce worms infections. There is mixed evidence to whether current ECD program designs are effective at improving childhood growth, as measured through anthropometrics. We find only a few studies assessing the impact of WASH and psychosocial support interventions on child health outcomes. The number of evaluations on MUAC, head circumference, and anemia as an outcome measure also remains limited. Further, we find mixed evidence on the effectiveness of interventions like cash transfers in boosting child health outcomes.

4 Discussion

We assess our results in two steps. First, we analyze the results and determine the reasons why we observe statistically insignificant effects across individual and pooled estimates. Second, we highlight the stark gap in evidence across contexts, types of interventions tested, duration of the projects, and the mechanisms through which these impacts can be explained.

We observe that combining two or more types of interventions in a comprehensive package can lead to considerable and statistically significant impacts on child growth outcomes (e.g., conditional cash transfers + nutrition supplementation in the case of PROGRESA by Gertler (2004) and Pantawid by Kandpal et al. (2016); cash + maternal education by Levere et al. (2016); and early stimulation curriculum + nutrition supplementation by Attanasio et al. (2018)). Studies also showed that growth impacts were most effective for populations with worse baseline child growth outcomes (e.g., severely stunted children) (Attanasio et al., 2018). Hess et al. (2015) similarly finds significant growth impacts on children with limited initial growth. *These results point towards delivering interventions as a comprehensive package with multiple components rather than a tailored standalone program.* They also reflect on the role of targeting selection amongst the pool of study participants. Since already stunted children at baseline were shown to have significant impacts even with limited intervention exposure, targeting the neediest children can be more cost-effective in accelerating child growth.

Our findings suggest that standalone interventions have limited impact in improving children's growth. Interventions aiming to solely educate caregivers in following better sanitation, deworming, and nutrition practices for children lead to insignificant impacts on child growth; even when significant change was observed in caregiver knowledge and behaviors (Muhoozi et al., 2017; Martinez et al., 2018). Such lack of impact from informational interventions could be explained by insufficient intervention uptake or lack of finances for respondents to buy nutrient rich food (Muhoozi et al., 2017). Similarly, improved access to the facilities without including caregiver education also lead to insignificant effects on child health. Patil et al. (2014) did not find improvement in anemia and child growth outcomes due to inadequate change in behavior and absorption of information.

The majority of our pooled meta estimates reported statistically insignificant impacts of interventions on child anthropometric outcomes. *We argue that an insignificant pooled effect can partially be explained by considerable variation in the duration and intensity of exposure of interventions among studies.* Patil et al. (2014) emphasize that short-term follow up could have influenced the estimates reported in their study because the impacts on enteric parasite infections, anemia, and growth accrue relatively slowly. Similarly, Muhoozi et al. (2017) only had 6 months and Fink et al. (2017) only had 10 months of intervention exposure with study subjects which is a relatively shorter duration to observe impacts on child growth outcomes. Similarly, Berry et al. (2017) could have found no significant impacts because they had restricted intensity of treatment. The dosage of micronutrient package evaluated in their study was below the recommended daily amounts and intervention exposure was only one year. *We also find evidence that longer exposure to treatment might lead to positive impact on child growth.* Kandpal et al. (2016) found positive impacts on child anthropometric outcomes since they studied the program impact 31 months after the intervention, which was likely beyond the age riskiest for stunting.

A variation in the effect size of similar intervention categories could also arise by the way these estimates were measured in each study. A few studies included in the review were clinical trials (Hess et al., 2015), and hence were better able to measure child health outcomes as compared to the ones which relied on self reported measures (Gertler, 2004; Patil et al., 2014). This point is most relevant for measuring anemia prevalence in our review. Self reported measures of anemia prevalence are less reliable compared to the clinical tests measuring haemoglobin levels. Future trials could avoid this measurement error by using more robust ways to measure health outcomes. Besides, measurement error pertaining to age, weight, and height could also have contributed to varied impacts amongst studies testing similar interventions (Attanasio et al., 2018). Parents in developing countries are likely to not know the exact age of their children and enumerators are likely to make mistakes while measuring child health and weight during data collection. One way to control for such bias is to control for enumerator specific errors in study specifications. Additional reasons for different effects from similar interventions could be seasonality of the study period (e.g., intervention during lean agricultural season), risk of bias among studies, different contexts, low statistical power, environmental constraints in linear growth not addressed by the intervention, respondent's inability to adhere to program practices, and ineffective intervention implementation (Martinez et al., 2018).

These findings are consistent with other systematic reviews and meta analysis. A review of child care interventions by Prado et al. (2019) found that nurturing and stimulation interventions had significant effects on child development but no effects on child growth. Leroy et al. (2012) also found no impact of daycare interventions on child nutrition outcomes. Zhang et al. (2021) and Jeong et al. (2021) find that parenting interventions which encourage nurturing care are effective in improving the cognitive, motor and language development of children, but they do not test impacts on child anthropometric outcomes. Additionally, in a review of studies that examined the effect of interventions combining a child development component with nutrition, Grantham-McGregor et al. (2014) found that nutritional interventions usually benefited nutritional status and sometimes benefited child development. They also found little evidence of synergistic interaction between nutrition and stimulation on child development.

We are limited to comment on heterogeneity of findings by participant characteristics and mechanisms in this review. Notably, only 12% of the studies in our sample undertook a heterogeneity analysis by gender, socioeconomic status, religion, or other differential factors. Furthermore, no study tested the causal mechanisms at play for explaining the observed impacts on child's growth. The number of studies testing MUAC and head circumference also remains low. Since MUAC serves as a quick measure to identify wasted children,a greater number of studies aiming to test children's nutrition status should include MUAC in their evaluations. Our findings also highlight the scarcity of studies undertaking a cost effectiveness analysis of ECD interventions for child health outcomes. Except for Fink et al. (2017), Ozier (2018) and Attanasio et al. (2018), the remaining studies did not elaborate on cost-effectiveness of the interventions.

Our results point towards the necessity for a broader scope from developing countries in Latin America, Southeast Asia, the Middle East, and Central Asian regions. Further, this review calls for increased examination to understand the impact of nutrition, WASH, psychosocial stimulation, and cash transfer interventions on children between ages 2–5 and 5–8. Studies have shown that 70% of stunting predominantly occurs during the first 1,000 days of life. However, this linear growth deficit further deteriorates till the age of 5 due to sustained exposure to unpleasant environmentally modifiable factors related to feeding, infections, and psychosocial care (Akombi et al., 2015). The continued decline in linear growth observed in the first 5 years of life may cause severe irreversible physical and neurocognitive damage that accompanies stunted growth and pose a major threat to child development. Greater knowledge on the differential benefit of undertaking interventions during the first 2 years of a child's life compared to later years can benefit policymakers in structuring child health programs at the right time, know the potential impacts in targeting children during 3–5 years and identify the relative benefits of intervening during early years.

We stress the need for measuring sustained impacts. A systematic review on the later impact of ECD interventions has emphasized the need for nutrition interventions to be in place beyond the first 1,000 days in order to leverage the window of opportunity from conception to age 2 and achieve sustained effects beyond early childhood (Tanner et al., 2015). The review also emphasizes that sizeable knowledge gaps persist in assessing the long term effects of child health interventions but can be closed with careful planning and design. *Only 10% of the studies in our review measured sustained impacts of the initial intervention, indicating a scarcity of evidence on long-term child health outcomes.*

There are several limitations to our study. Since we only reviewed evidence on RCT studies, our review excludes evidence from the quasi-experimental and observational studies. Additionally, due to the scope of our review, we exclude important interventions targeting pregnant women during the prenatal stage. However, we recognize that several prenatal interventions could have long lasting impact on early child health. We found too few studies to have convincing and precise pooled meta-estimates from this analysis; restricting our ability for conclusive pooled effects broadly over all interventions. Thus, we only rely on sub-group meta estimates while discussing our results. We also recognize that our review is not an exhaustive representation of all the existing studies on child health outcomes, but it is consistent with the systematic search process as discussed in the methodology.

Due to our strict exclusion criteria, we also miss out on important studies like Miguel and Kremer (2004) and Baird et al. (2016), emphasizing the substantial gains on childhood health as a result of a school-based deworming intervention in Kenya. Miguel and Kremer (2004) report small, but significant reductions in anemia prevalence ($p < 0.05$) after a deworming treatment given to school attending children of less than 13 years old. In an evaluation of a unconditional cash transfer program for adolescent girls, Baird et al. (2016) found that children of recipients receiving the transfer, who were born during the two-year program, were substantially taller for their age than children in both the control and the conditional cash transfer group. They also affirmed that effects of cash interventions phase out in the long term if significant capital gains are not achieved from the transfers. The findings of Baird et al. (2016) indicate the potential benefit of cash transfer programs on children health, even when the transfers are not targeted towards children. Mahmud et al. (2015) also found that handwashing with soap and weekly nail clipping demonstrated a significant reduction in intestinal parasite reinfection rates. Children between 6–15 years, who received handwashing with soap at critical times were 68% less likely to be reinfected by intestinal parasites than children left to continue with existing habits and practices.

5 Conclusion

We conducted a meta-analysis of RCTs evaluating early childhood interventions focused on improving child growth and development. We find that amongst the 6 predominant interventions categories – cash transfers, nutrition supplements, WASH, childcare and caregiver education, psychosocial stimulation, and deworming pills – nutrition based interventions have been the most successful. We also find that standalone interventions aiming to train caregivers on child health and nutrition, sanitation practices, and promote parenting relations have limited impact on child growth indicators. Integrating nutrient supplements and cash incentives while delivering these interventions can lead to long lasting impacts in child development. Thus, policymakers should emphasize the delivery of nutrition and cash incentives while delivering behavioral change interventions to improve child growth and development.

We find several gaps in existing literature. First, a majority of the evidence is focused on developing countries in Sub-Saharan Africa and South Asia. An increased diversity from other regions of the world is necessary, particularly following the COVID-19 pandemic which adversely affected child growth globally. Second, inadequately few studies test the differential impact of interventions on older cohorts of children (between ages 3 – 8). Third, insufficient scholarship has studied if these interventions have long term impacts on child growth outcomes. Fourth, more than 50% of articles in our study report statistically insignificant impacts on child health outcomes. We hypothesize that the tight timelines of these studies and limited intervention exposure/take-up could be a reason that most interventions report insignificant impacts. Fifth, few studies analyzed heterogeneity with respect to gender, socio-economic status, religion, etc. Sixth, there is a lack of examination assessing the causal mechanisms facilitating the achieved effects. Lastly, we find only 5% of studies undertook a cost-effectiveness analysis of the intervention in question. Clarity on cost-effectiveness and scalability of these interventions supports the dialogue about avenues for achieving the SDGs considering financial constraints.

Future research could focus on identifying the determinants of malnutrition which are unrelated to diets in the population, evaluating long term impacts of the interventions which significantly improve child health outcomes in the short run, and including a cost effectiveness analysis of the evaluated intervention. Policymakers with limited budgets should focus on targeting interventions towards the neediest populations, and design multifaceted intervention packages including the components we discuss as most effective at improving children's health and development.

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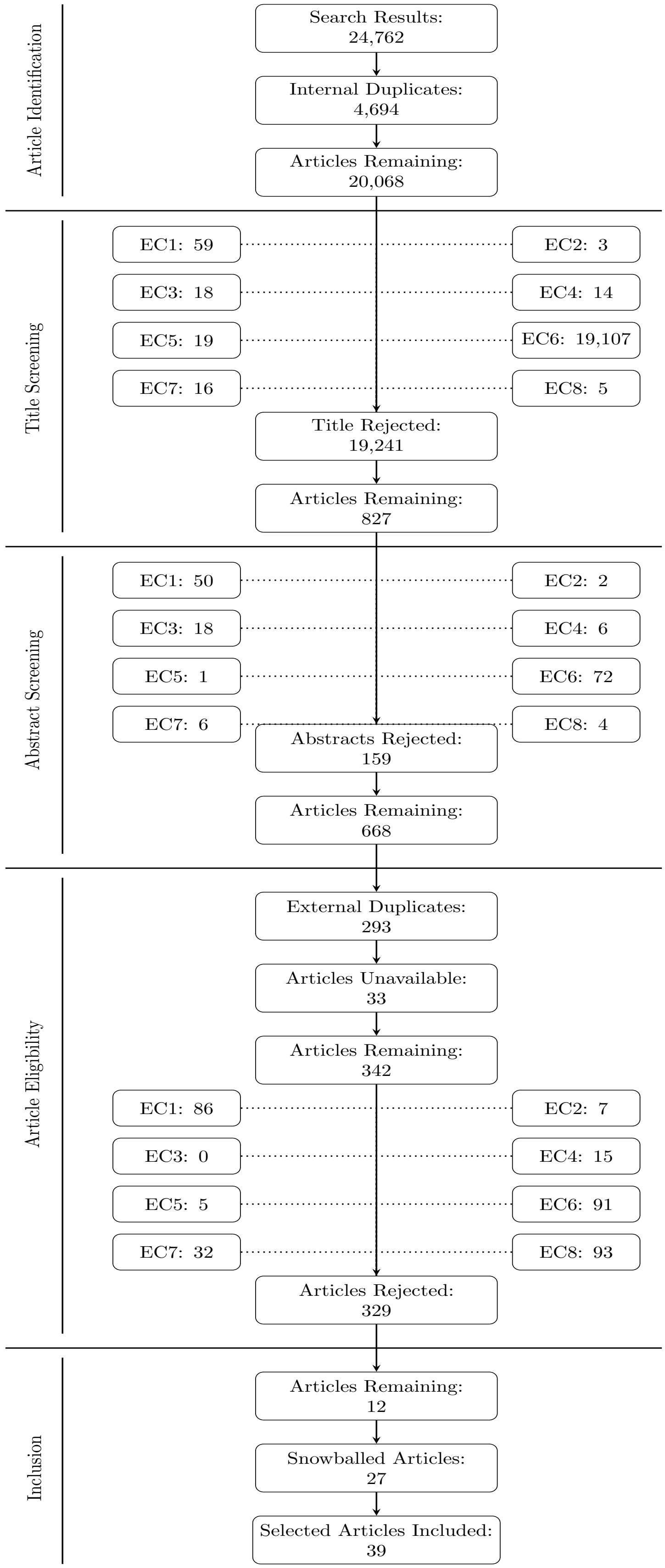
Figure 1: **Search Process Flowchart**



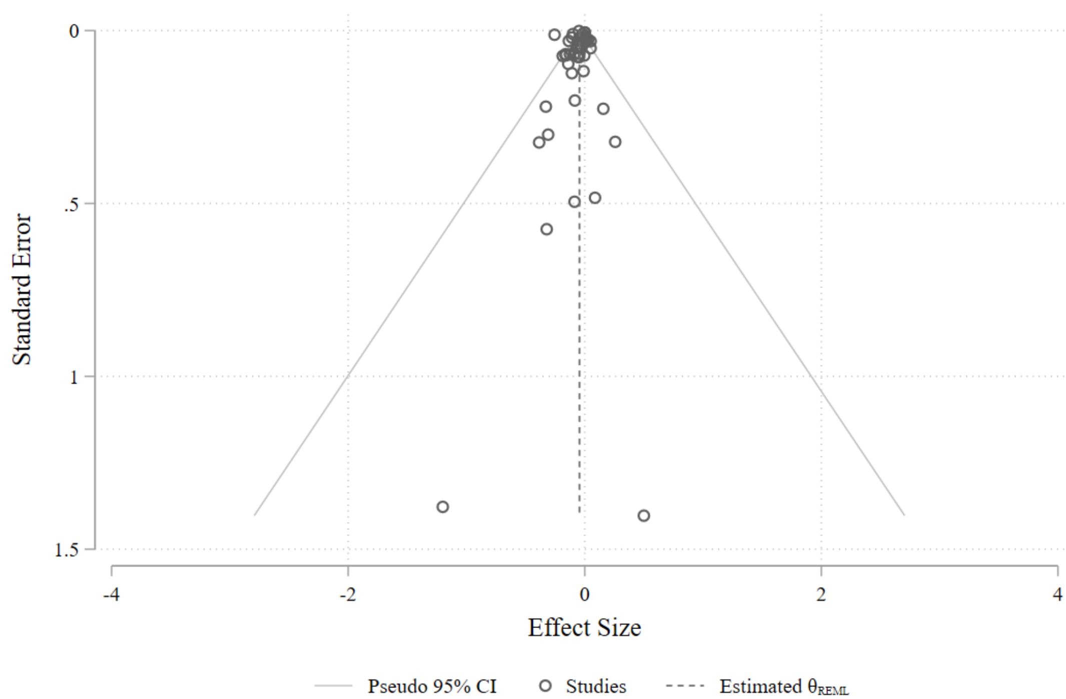
Notes: The search process shown in this figure follows a standard PRISMA design (Moher et al., 2015). The articles found through the main search engine results come from twenty article databases - further information can be found in Appendix A. For shorthand, exclusion criteria for omitting articles from the systematic review at the title review, abstract review, and article review are represented by the acronym 'EC'. The following is the list of reasons for exclusion in the systematic review: EC1 - Not a developing country context as of 1999, EC2 - Subject participants older than the age of 8, EC3 - Publication or intervention occurring prior to 2000, EC4 - Another literature review or meta-analysis, EC5 - Article not in English, EC6 - Does not study an ECD intervention, EC7 - Does not measure results on examined outcomes, EC8 - Study is not an RCT. Further explanation of the rationale for these eight exclusion criteria are expanded in Appendix A.

Table 1: **Description of Systematically Selected Articles**

(1) ID	(2) Article	(3) Search Source	(4) Country	(5) Age Range	(6) Program	(7) Interventions	(8) Outcomes	(9) Sample Size	(10) GRADE	(11) Risk of Bias
1	(Behrman and Hoddinott, 2001)*	AgEcon Search	Mexico	1 – 3	PROGRESA	CT	H	693	Moderate	Low
2	(Attanasio et al., 2018)*	EconLit	Colombia	0 – 1	FAMI	CC	HA, S	1,456	Moderate	Low
3	(Levere et al., 2016)*	EconPapers	Nepal	0 – 2	Attencion a Crisis	NS, CT	HA, WA, UW, S, WT	1,953	High	Unclear
4	(Pickering et al., 2019)	IPA	Kenya	2 – 2	Integrated WASH and Child Parasite Infections Study	NS, WS	WI	9,077	High	Low
5	(Null et al., 2018)	IPA	Kenya	0 – 2	Kenya WASH Benefits Study	NS, WS	HC, WA, UW, S, WT	6,583	Moderate	Low
6	(Fink et al., 2017)	IPA	Zambia	0 – 2	National Food and Nutrition Strategic Plan for Zambia	CC, NS	HA, WA, UW, S	497	Moderate	Low
7	(Ozier, 2018)	IPA	Kenya	8 – 8	Primary School Deworming Project	DW	H, HA, S	15,158	Moderate	Low
8	(Berry et al., 2017)*	J-PAL	India	3 – 5	The Mid-day Meal Program & Weekly Iron Folic Acid Program	NS	H, W, WA, UC	1,947	High	Medium
9	(Attanasio et al., 2014)	ProQuest	Colombia	1 – 2	Independent RCT	NS, PS	H, W	1,231	High	Low
10	(Martinez et al., 2018)	Scopus	Bolivia	1 – 1	Community Child Nutrition Project	CC	A, HC, HA, WA, S	1,513	Moderate	Low
11	(Muhoozi et al., 2017)	Web of Science	Uganda	0.5 – 2	Independent RCT	CC	HC, UC, HA, WA	511	High	Low
12	(Rockers et al., 2016)	Web of Science	Zambia	0.5 – 1	Independent RCT	NS	HA, WA	540	Moderate	Low
13	(Yousafzai et al., 2014)	Snowball	Pakistan	1 – 2	Lady Health Worker Programme	NS, PS	HA, WA	1,489	High	Low
14	(Fernald et al., 2009)	Snowball	Mexico	8 – 8	Oportunidades	CT	HA	1,710	Moderate	Low
15	(Attanasio et al., 2015)	Snowball	Colombia	1 – 7	Familias en Accion	CT	UW, S, WT	3,591	High	Low
16	(Powell et al., 2004)	Snowball	Jamaica	0.75 – 2.5	Independent RCT	CC	H, W	139	High	Low
17	(Clasen et al., 2014)	Snowball	India	0 – 4	Total Sanitation Campaign Offshoot	WS	HA, WA	2,952	High	Low
18	(Lin et al., 2018)	Snowball	Bangladesh	2 – 3	WASH Benefits Bangladesh	NS, WS	WI	5,551	High	Low
19	(Patil et al., 2014)	Snowball	India	1.75 – 5	Total Sanitation Campaign	WS	UC, H, HA, W, WA, S	5,209	Moderate	Low
20	(Pickering et al., 2015)	Snowball	India	0 – 5	Community-led Total Sanitation	WS	HA, WA, UW, S	2,365	Moderate	Low
21	(Christian et al., 2015)	Snowball	Bangladesh	0.5 – 1.5	JiVitA Project	NS	H, HA, W, WA	5,319	High	Low
22	(Iannotti et al., 2013)	Snowball	Haiti	0.5 – 1	Lipid-based Nutrient Supplements Program	NS	HA, WA	589	Moderate	Low
23	(Maleta et al., 2015)	Snowball	Malawi	0.5 – 0.5	Independent RCT	NS	H, HA, W, WA, UW, S, WT	1,932	Moderate	Low
24	(Hess et al., 2015)	Snowball	Burkina Faso	0.75 – 1.5	iLiNS Project	NS	A, H, HA, W, WA, UW, S, WT	3,220	High	Low
25	(Hammer and Spears, 2013)*	Snowball	India	0 – 5	Total Sanitation Campaign	WS	HA	3,432	High	Low
26	(Kirwan et al., 2010)	Snowball	Nigeria	1 – 5	Independent RCT	NS	WI	1,228	High	Low
27	(Kandpal et al., 2016)	Snowball	The Philippines	0.5 – 5	Pantawid Program	CT	HA, WA, UW, S	485	High	Low
28	(Gertler, 2004)	Snowball	Mexico	2 – 4	PROGRESA	CT	A, H, S	2,010	High	Low
29	(Vermeersch and Kremer, 2004)*	Snowball	Kenya	4 – 6	The Meals Program	NS	HA, WA	1,184	High	Low
30	(Bhandari et al., 2004)	Snowball	India	0 – 2	The Integrated Child Development Services Scheme	NS	H, W, UW, S	1,025	High	Low
31	(Vazir et al., 2013)	Snowball	India	0.75 – 1.25	The Integrated Child Development Services Programme	CC, NS	W, H	511	High	Low
32	(Penny et al., 2005)	Snowball	Peru	0.5 – 1.5	Growth and Development Monitoring Programme	NS	H, W, S	187	Moderate	Low
33	(Olney et al., 2006)	Snowball	Tanzania	0 – 1	International Nutritio	NS	HA, WA	354	High	Low
34	(Faber et al., 2005)	Snowball	South Africa	0.5 – 1	The Valley Trust	NS	H, HA, W, WA	361	High	Low
35	(Gardner et al., 2005)	Snowball	Jamaica	0.75 – 2.5	Independent RCT	NS	H, HA, W, WA	114	High	Low
36	(Hamadani et al., 2002)	Snowball	Bangladesh	0.5 – 1	Independent RCT	NS	HA, WA	168	High	Medium
37	(Blimpo et al., 2018)*	Snowball	The Gambia	1 – 2	Baby Friendly Community Initiative	NS	HA, WA	1,228	High	Low
38	(Rahman et al., 2008)	Snowball	Pakistan	0.5 – 1	Thinking Healthy Program	PS	HA, WA	903	High	Low
39	(Bouguen et al., 2013)*	Snowball	Cambodia	3 – 5	Education Fast Track Initiative Catalytic Fund	CC	HA, WA	1,541	High	Medium

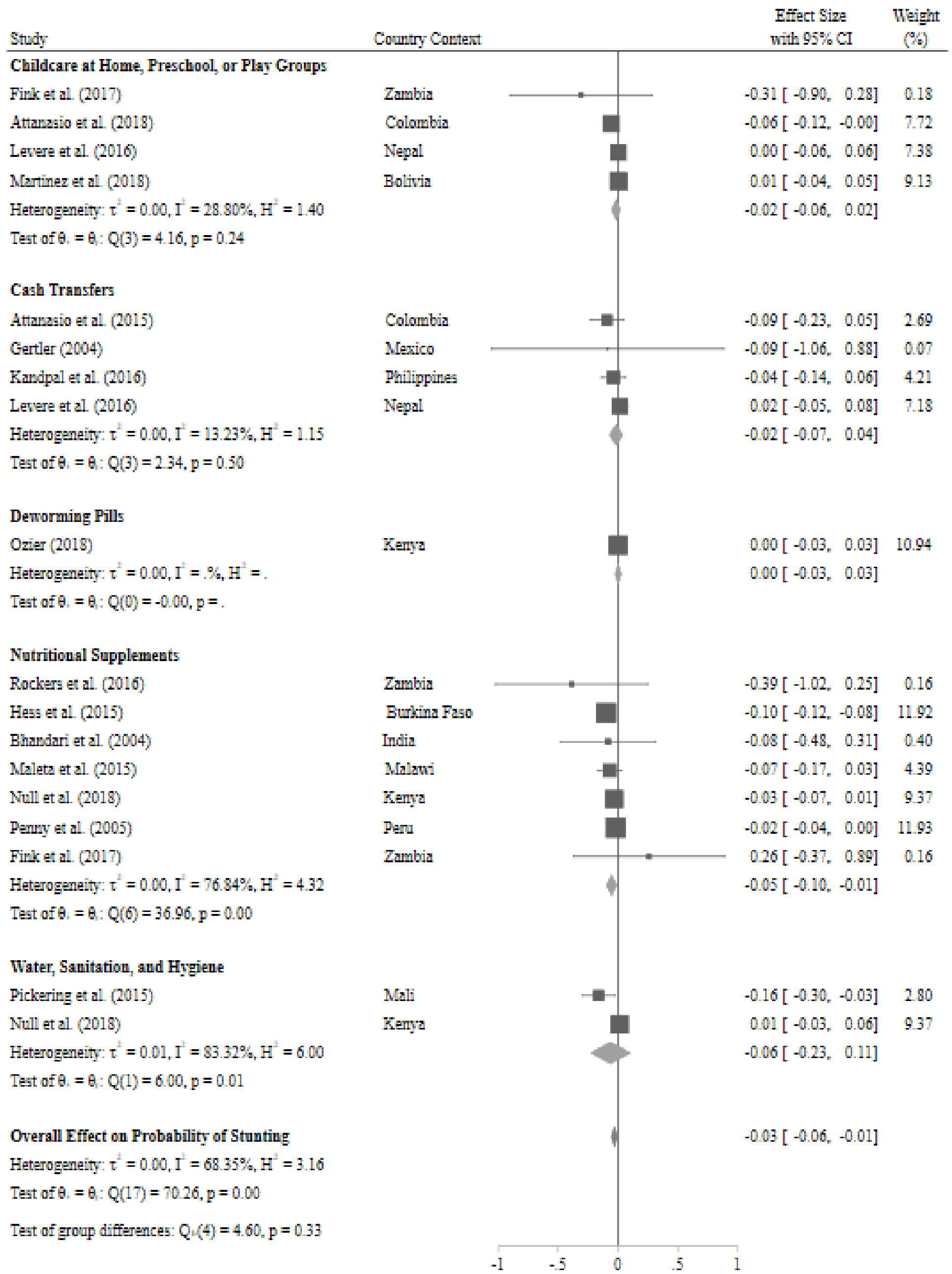
Notes: Each line in this table represents a study included in the systematic review and meta-analysis. Article names denoted with * are not yet peer-reviewed working papers. Column 3 displays the search engine that sourced the find for this article in the search process. Reference Appendix A for details on the search process. Snowballed articles are labelled as 'Snowball'. Column 4 is the country-context of the study. Column 5 is the range of ages in years covered in the article's sample. Column 6 is the program or study intervention conducted in the study. Column 7 and 8 are treatment intervention classifications tested, and the outcome measured in the study, respectively; refer to Appendix A for details intervention classifications and list of outcomes. Shorthand for intervention categories is as follows: Attend Childcare - CC, Cash Transfers - CT, Deworming - DW, Nutritional Supplements and Information - NS, Psycho-social Stimulation - PS, Water and Sanitation - WS. Shorthand for outcomes is as follows: Anemia - A, Worms Infection - WI, Head Circumference - HC, Upper-arm Circumference - UC, Height - H, Height for Age - HA, Stunting - S, Weight - W, Weight for Age - WA, Underweight - UW, Wasting - WT. Column 9 is the overall sample size of the study. Column 10 and 11 are the GRADE of quality and Risk of Bias of the study; refer to Appendix A for details on the construction of the GRADE and Risk of Bias scales.

Figure 2: **Funnel Plot of Publication Bias for Primary Outcomes**



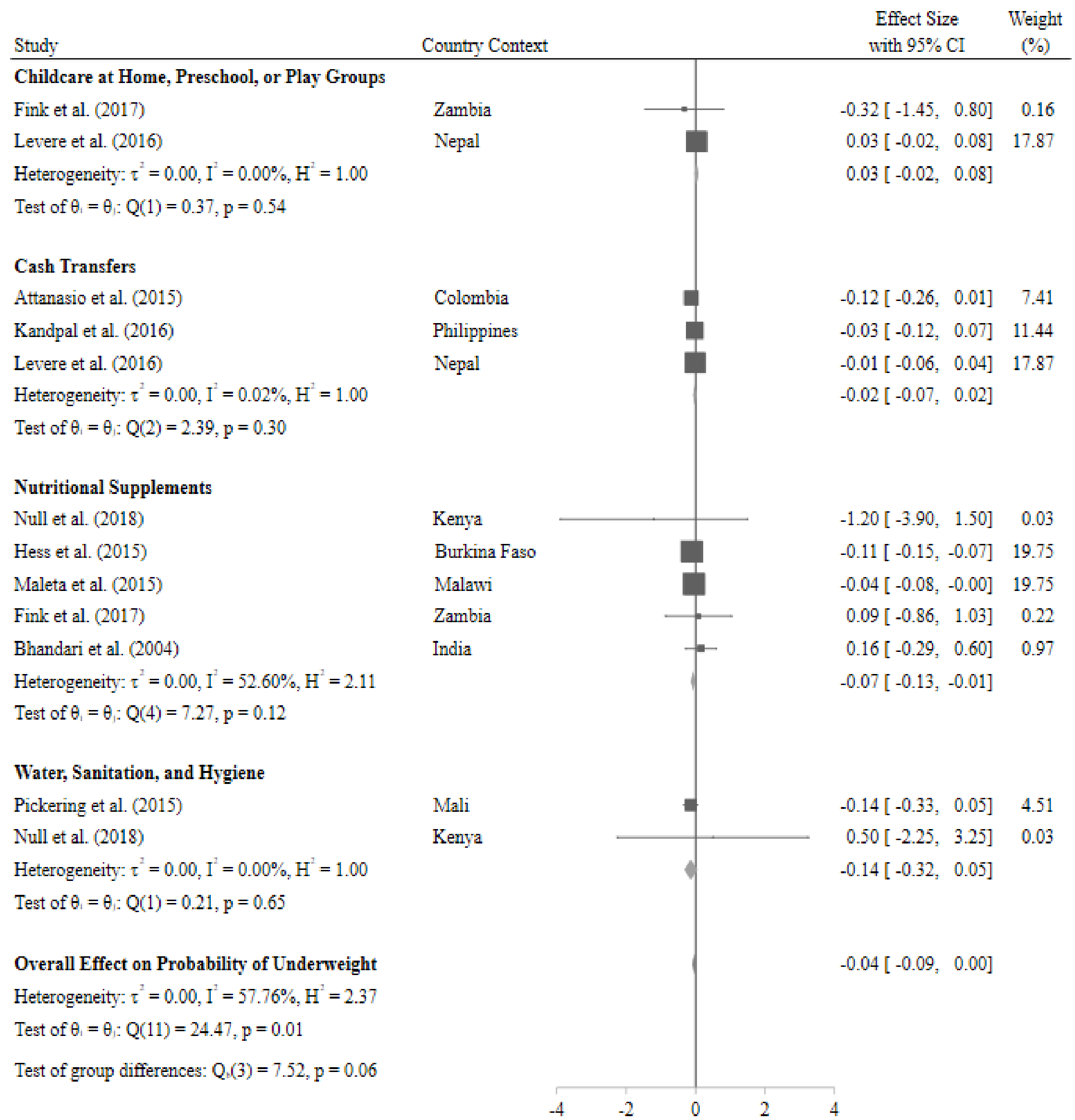
Notes: This funnel plot shows the point estimate and pseudo 95% confidence interval using a restricted maximum likelihood random effects model following a frequentest approach. Observations are plotted relative to the point estimate reported and their standard error. This plot limits observations to the primary outcomes: anemia, stunting, underweight, wasting, mid-upper arm circumference, and worms infections.

Figure 3: **Evidence Summary on Probability of Stunting**



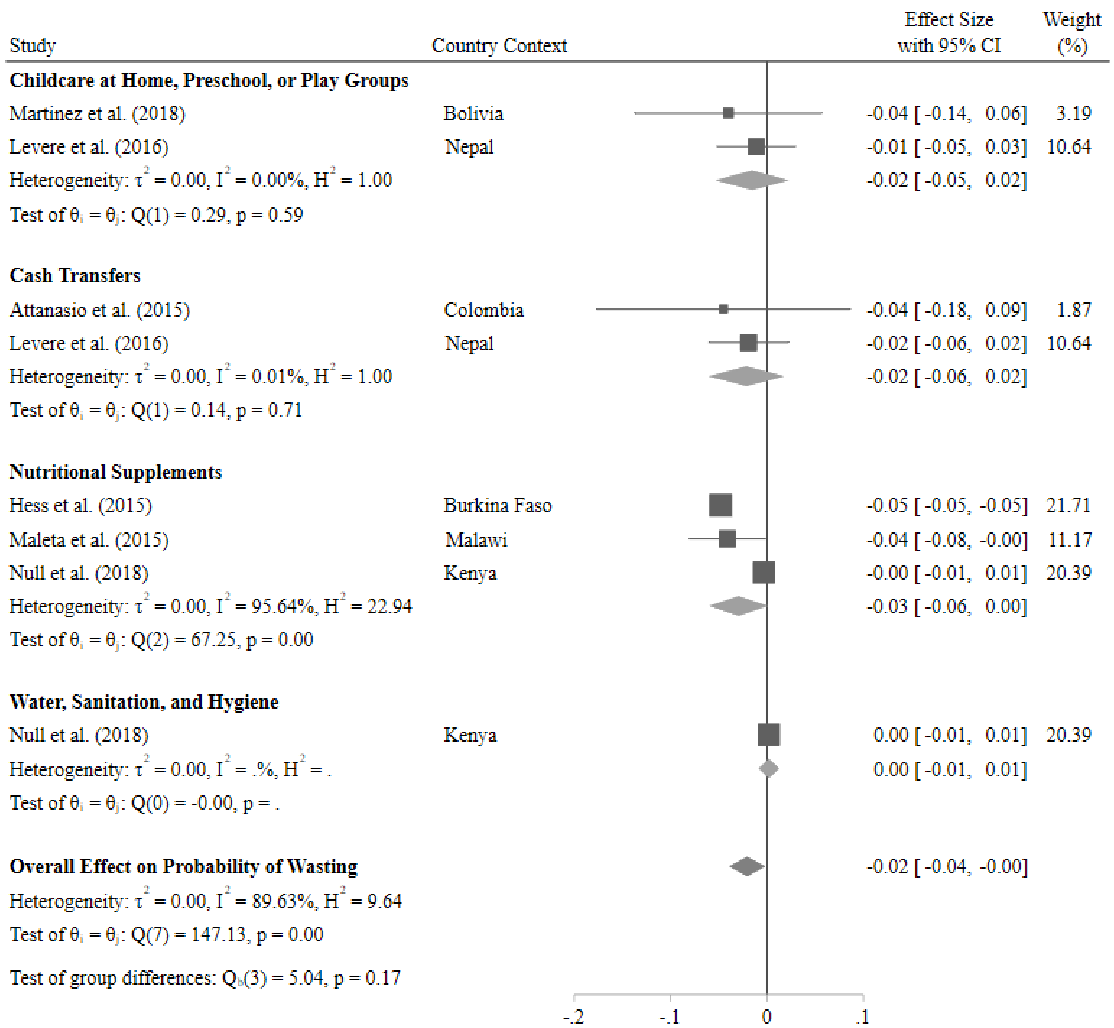
Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported stunting (<2 SD from mean for height for age z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

Figure 4: **Evidence Summary on Probability of Underweight**



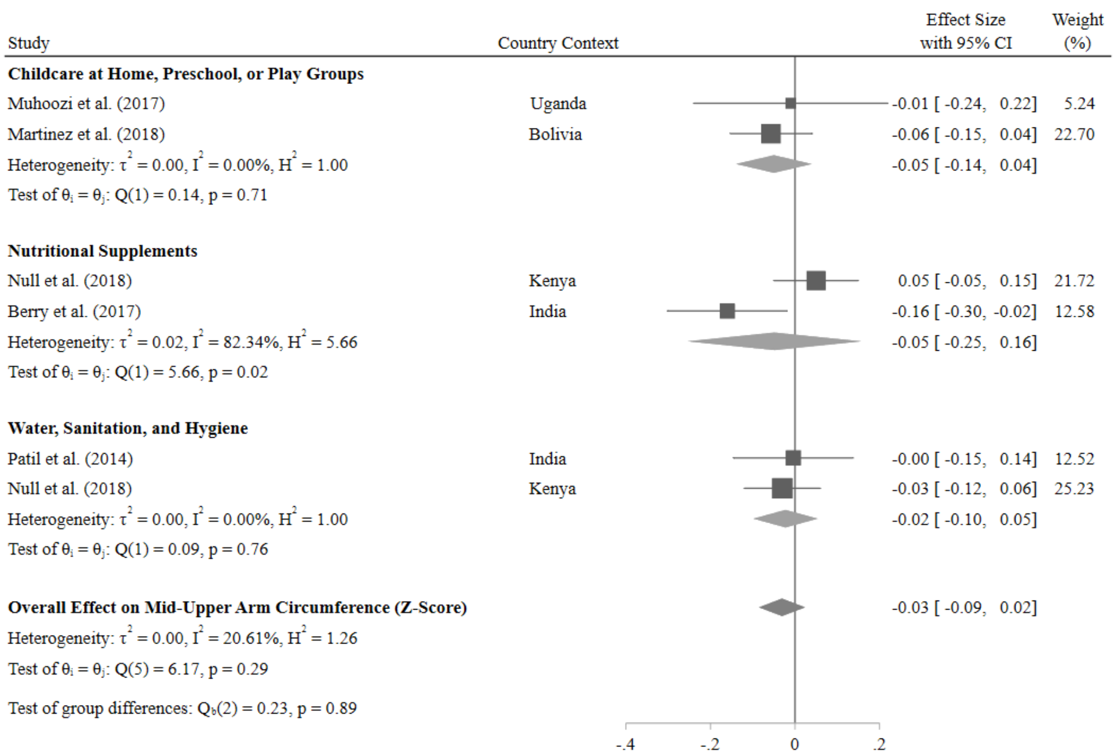
Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported underweight (<2 SD from mean for weight for age z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

Figure 5: **Evidence Summary on Probability of Wasting**



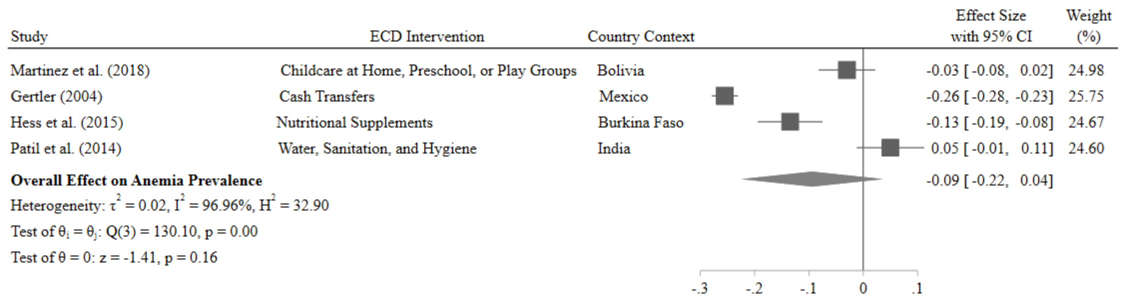
Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported wasting (<2 SD from mean for weight to height z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

Figure 6: **Evidence Summary of Mid Upper Arm Circumference (Z-Score)**



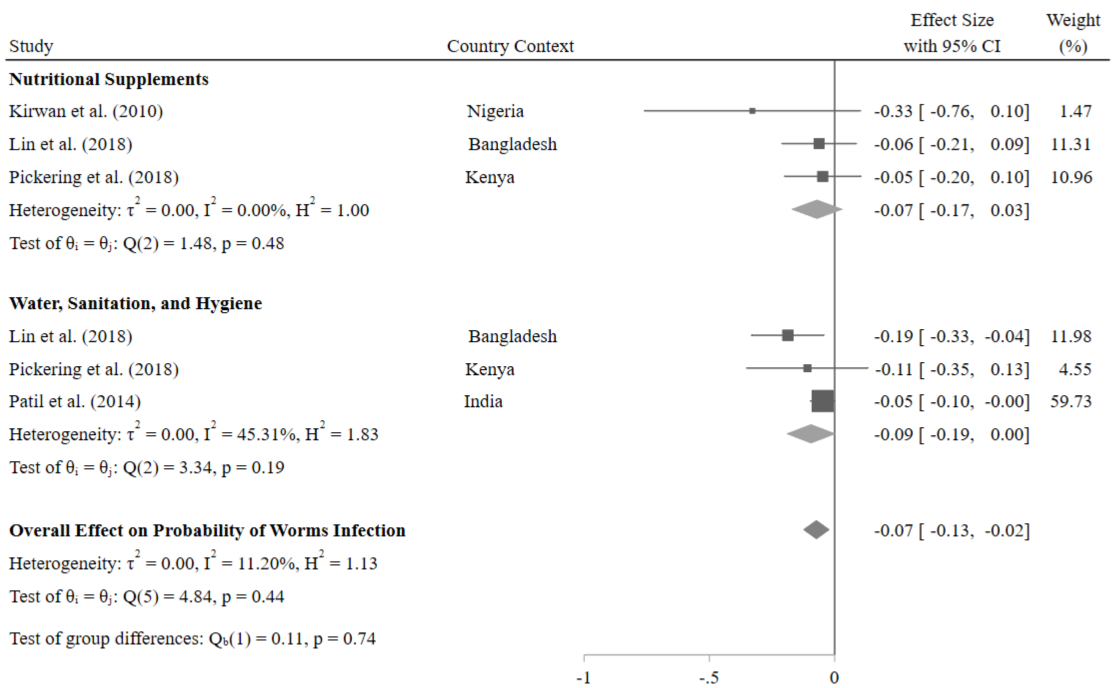
Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported mid-upper arm circumference (z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

Figure 7: **Evidence Summary on Anemia Prevalence**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported anemia prevalence in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. The overall meta estimation effect is displayed at the bottom of the figure.

Figure 8: **Evidence Summary on Probability of Worms Infection**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported any form of worms infection in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

For Online Publication: Appendix

A Study Protocols

A.1 Search Methodology

This systematic review and meta-analysis follows best practices using a PICO model (Miller and Forrest, 2001) and PRISMA design (Moher et al., 2015). PICO stands for Patient, Intervention, Comparison, and Outcome. The PICO model is used to define the research question and criteria prior to a systematic review. Our PICO model is:

- **Patient:** Children ages 0–8 in developing countries as of the year 2000.
- **Intervention:** Broadly early childhood development interventions and programs.
- **Comparison:** Randomized controlled trials.
- **Outcome:** Health outcomes, specifically Anemia, Worms Infection, Head Circumference, Upper-arm Circumference, Height, Height for Age, Stunting, Weight, Weight for Age, Underweight, and Wasting.

We defined our research question as "What causal effects from ECD interventions exist related to health outcomes in children from LMIC?" We then followed the 27 point checklist from the PRISMA 2009 method to complete the structure of our systematic review. This checklist goes as follows:

Title

1. **Title:** The Impact of Early Childhood Development Interventions on Children's Health in Developing Countries: A Systematic Review and Meta-analysis

Abstract

2. **Structured Summary:** Refer to the Abstract.

Introduction

3. **Rationale:** The impacts of ECD interventions is well studied within the context of advanced economies. What is less known is what ECD interventions have been effective in improving childhood health in developing countries. Specifically, in light of the SDG goals of ending childhood hunger by 2030, what interventions are scalable in achieving this goal.
4. **Objectives:** (1) Which ECD interventions are improving childhood health? (2) Is there important heterogeneity in these results?, and (3) How can this synthesis of results inform policymakers with respect to the SDG goals?

Methods

5. **Protocol:** We provide a Search Tracker to document our decision making throughout this search process. This Search Tracker can be found here:
    - https://mcwayrm.github.io/files/McWay_et_al_2022_ECD_Search_Tracker.xlsx

Including the authors of this study, we involve a cohort of research assistants to ensure that there is at least two teams of reviewers at each stage of selection in order to remove bias. When conflicts arrive, selection by majority rule from the committee of authors resolved these conflicts.

6. **Eligibility Criteria:** We used eight exclusion criteria to filter articles for inclusion in this study. They are as follows:
   (a) Not considered a Lower- and Middle-Income country (developing country) prior to the start of the MDG goals in 2000 (United Nations, 2020).
   (b) Subject participants are older than 8 years old at the start of treatment or the measure of outcomes.[1]
   (c) Publication of the study or time frame of the study was conducted prior to the start of the MDG goals in 2000.
   (d) The article is another systematic review or meta-analysis of ECD interventions.
   (e) Study not written in English, (6) Study does not examine an ECD intervention.
   (f) Study does not measure one of the pre-specified selected health outcomes.
   (g) The study does not utilize a randomized controlled trial methodology to produce causal estimations.
7. **Information Sources:** We look broadly at twenty databases to source our articles from the initial search. These databases include: African Development Bank, Asian Development Bank, BRAC Repository, EconLit, EconPapers, EconStor, Education Source, Ideas/RePEc, Innovation Poverty Action, J-PAL Publications, OpenGrey, Oxfam Repository, ProQuest, PubMed, Save the Children, Scopus, USAID Development, Web of Science, and World Bank Open Repository.
8. **Search:** The search was done by two of the authors on this study at the start of the year 2020. The search dates are documented in the aforementioned Search Tracker. Where possible date limitations where placed upon the search to articles after January 1st, 2000. In the search process, we used two groupings of search terms; those relating to early childhood development and those related to health. We then combined these two groups of search terms into a single statement. The combination of search terms were as follows: "("early childhood development" OR "early development" OR "early child care" OR "ecd") AND ("health*" OR "nutr*" OR "special needs" OR "food")."
9. **Study Selection:** The studies selected in this article are those that are not excluded by the eight aforementioned exclusion criteria from the twenty search engines listed above. The articles included in the systematic review and meta-analysis are a strict set of one another.

[1] This age range is supported by the WHO standard definition for ECD interventions on children. As the WHO states, "ECD refers to the process of cognitive, physical, language, temperament, socioemotional and motor development of children that starts at the time of conception until 8 years of age." (World Health Organization, 2020).

10. **Data Collection Process:** Following the final selection of the articles included in this study, we recorded the intervention, outcome, point estimation, standard deviation or confidence interval, and the reference of the figure or table that that information came from for each estimate included in the meta-regression.

11. **Data Items:** The variables included in the data collection are: Article ID: Article identification, Country: Country context of study, Intervention: Intervention measured in the result, Outcome: Outcome of interest in the result, Table or Figure: Reference of table or figure where the results come from in each study, Estimate: Point estimate of the causal effect of treatment status, Standard Error: Reported standard error of the point estimate (When standard errors or confidence intervals are not reported, the other is estimated from the other given the point estimate.), Bound Lower: Lower bound of 95% confidence interval of point estimate, Bound Upper: Upper bound of 95% confidence interval of point estimate, Sample Size: Number of study participants included in the sample, Power: Estimated power of the result calculated from the point estimate provided given a null hypothesis of no effect (a precise zero). Imputation and standardization of data is explained further in Appendix Section A.2.

12. **Risk of Bias in Individual Studies:** We determine a GRADE (Guyatt et al., 2008) and Risk of Bias (ROB) (NHMRC, 2019) classification for each article. These methods are elaborated further below.

13. **Summary Measures:** We summarize our results using forest plots of the meta-regressions and a table of the descriptives of the articles include in this study. Descriptions of the sample can be found in Appendix Section E.

14. **Synthesis of Results:** The results are synthesized in the Results section with conclusions by intervention and outcome groupings.

15. **Risk of Bias Across Studies:** We look at publication bias using a funnel plot as well as an Egger Test. This is explored in Appendix Section D.

16. **Additional Analyses:** We conduct a meta-regression whose details can be found in Section **??**. Additionally, we perform a Bayesian version of the meta-regressions as summarized in Appendix Section **??**.

Results

17. **Study Selection:** Reported in Figure 1.

18. **Study Characteristics:** Reported in Table 1.

19. **Risk of Bias within Studies:** Reported in Table 1 and in Table Appendix A.6.

20. **Results of Individual Studies:** These are reported via the forest plots discussed in Section 3.

21. **Synthesis of Results:** Reported in Results Section.

22. **Risk of Bias Across Studies:** Findings on publication bias can be found in Appendix Section D.

23. **Additional Analyses:** All analyzes are stated above.

Discussion

24. **Summary of Evidence:** This can be found in Section 4.
25. **Limitations:** This can be found in Section 5.
26. **Conclusions:** This can be found in Section 5

Funding

27. **Funding:** None of the researchers received any funding to support this research. Institutional access to journals provided access to search engine access and the PDF versions of published articles. Previous institutional relationships with BRAC provided access to the private BRAC repository for reported interventions.

This review process occurred from December 2019 through December 2020. At the end of 2019 and the beginning of 2020, we performed the searches and collected the potential articles from our selected databases. Throughout the year 2020, we conducted our two teamed review process using our exclusion criteria to select articles at the title, abstract, and article stages. At the end of 2020, with our final selection of articles, we began the snowball process of identifying citations from the selected articles which are within the scope of our review. At the start of 2021, we had the 39 articles we intended to analyze for this review. Through the year 2021, we conducted our meta-analysis and qualitative review of the selected articles in preparation for this manuscript.

A.2 Review Process

For transparency in our process, we have made publicly available our search tracker which can be found at: https://mcwayrm.github.io/files/McWay_et_al_2022_ECD_Search_Tracker.xlsx. This document records the information on decisions that we made for each article that we reviewed for the systematic review process at each stage. This expands on the process that produced Table 1 and Figure 1. To mitigate bias in selection, we had two separate teams make selections in the title review, abstract review, and article review stages. When each team conflicted in their selection of an articles, a majority vote was conducted to determine the inclusion of the article. This is documented within the search tracker. Note that none of the articles selected to be included in this review were subject to such a decision. Selection for each article was decided upon a 'yes'/'no' method.

For GRADE (Guyatt et al., 2008), each article is subjectively rated on the credibility of the article to present the evidence. The rating system is as follows with the former performing better than the latter: High, Moderate, Low, Very Low, Unclear. The final determination of GRADE for each study is comprised of an assessment for each of the following considerations:

- Importance and frequency of the problem
- Variability and uncertainty about the values and preferences recommended in the article
- Overall quality of the evidence presented
- Net benefits and net harms of the recommendations for study participants

- How resource intensive or cost-effective are the recommendations
- How equitable are the recommendations
- How acceptable are the recommendations for stakeholders
- How feasible is it to implement the recommendations in the article.

For Risk of Bias (ROB) (NHMRC, 2019), each article is rated by how prone the study is to being biased. The rating system is as follows with the former performing better than the latter: Low, Medium, High, Unclear. The final determination of ROB for each study is comprised of an assessment for each of the following considerations:

- Funding
- Applicability
- Precision
- Reporting Biases
- Methodology

A.3 Data Collection

The level of observation is at the child level. This is because this review focuses on the intervention benefits for children's health. While the majority of the interventions are targeted towards the children (e.g., nutritional supplements or deworming pills, etc.) some of the interventions are facilitated via the parents (e.g., cash transfers or nutritional information, etc.). We do not examine the impact on the parents or caregivers as these are extenalities to the targeted effects of the ECD programs examined.

This review focuses solely on RCTs. We do not include quasi-experimental studies that may be arguably equally worthy of inclusion (e.g. RDDs, DID, IV, or longitudinal). The reason for this exclusion is that we wish to avoid unit of analysis error while performing the meta-analysis with panel study designs. RCTs are known to have internal validity and are considered the "gold standard" amongst field-based empiricists. Limiting our selection to only RCTs ensures the highest quality of scientific evidence on the topic. The assumptions required for these other methodologies introduces further potential for risk of bias.

For the outcomes covered in this study, some of the articles reported these outcomes in different units of measurement. For consistency of the unit of measure used for the meta regressions, we standardized outcomes to have the following measurements:

- **Anemia**: Probability
- **Stunting**: Probability
- **Underweight**: Probability
- **Wasting**: Probability
- **Worms Infection**: Probability
- **Mid Upper Arm Circumference**: Z-Score

- **Head Circumference**: Z-Score
- **Height for Age**: Z-Score
- **Weight for Age**: Z-Score
- **Height**: Centimeters
- **Weight**: Kilograms

For studies that did not report the unit of measure in these terms, we converted those reported estimates to conform with the above list. For conversion of odds ratios to probabilities, we used the following formula: $estimate = \ln(estimate)$. And for conversions of centimeters to a standardized z-score, we used the following formula: $estimate = \frac{estimate-CM}{SE}$ where CM stands for the control mean, and SE represents the standard error.

In collecting information on treatment effects, some studies reported the uncertainty of their estimations through standard errors while other reported confidence intervals. When one was reported, the other form was often not reported as well. We impute this information with the standard understanding of the relationship between standard errors and confidence intervals. When standard errors were missing, we used the following formula to calculate the lower and upper 95% confidence interval bounds of the treatment estimation:

$$Bound = E \pm 1.959964 \times SE$$

where $Bound$ is the upper or lower 95% confidence interval bound, E is the point estimate, and SE is the standard error. To calculate the standard error from the 95% confidence intervals, we followed the following formula:

$$SE = |\frac{Bound_{High} - Bound_{Low}}{3.92}|$$

where SE is the standard error, $Bound_{High}$ is the upper bound, and $Bound_{Low}$ is the lower bound. To determine the power of each treatment effect, we performed a post-hoc calculation using the "power" command in Stata 16 to calculate the power of the study's reported estimate against a null hypothesis of no effect (point estimate of zero) considering the article's reported sample size.

When a study reported more than two related treatment arm in a study for the outcome measure, we made use of standard formulas for combining effect sizes of continuous and discrete outcomes as determined by the Cochrane Handbook (Higgins et al., 2021). For the new sample size: $N = N_1 + N_2$. For the new mean: $M = \frac{N_1M_1+N_2M_2}{N_1+N_2}$. For the new standard deviation:

$$SD = \sqrt{\frac{(N_1-1)SD_1^2 + (N_2-1)SD_2^2 + \frac{N_1N_2}{N_1+N_2}(M_1^2 + M_2^2 - 2M_1M_2)}{N_1+N_2-1}}$$

Prior to doing the meta-regressions, the data was processed in Stata using the "meta set" command using Stata 16. Meta regressions and meta-analysis operations used the Stata 16 meta-analysis suite of commands to perform these operations.

B Sustainable Development Goals

The United Nations (UN) adopted the Millennium Declaration at the Millennium Summit in September of 2000, producing the Millennium Development Goals (MDG) for eliminating poverty by 2015. Of particular interest are the achievement of the MDG goals within LMICs. For this reason, both targeted and recorded progress on these fronts have been particularly centered about LMIC contexts. The eight goals of the MDGs were to:

1. Eradicate poverty and hunger
2. Reach universal primary education
3. Empower women and promote gender equality
4. Lower childhood mortality rates
5. Boost positive maternal health outcomes
6. Combat HIV/AIDs, malaria, and other diseases
7. Promote environmental sustainability
8. And establish a global partnership for development

These targets were not reached by 2015. Rather the MDGs had significant blind spots such as social justice, the rule of law, and security. Building on lessons of the MDGs and expanding the breadth of the goals, the General Assembly established the 17 Sustainable Development Goals (SDG) known as the 2030 Agenda for Sustainable Development. By 2015, the General Assembly set the Post-2015 Development Agenda, ultimately leading to the 2030 Agenda for Sustainable Development by September of that year.

The United Nations universally adopted the Agenda for sustainable development in 2015, providing a framework for ending impoverishment and destitution globally by 2030. The Agenda consists of 17 goals that serve as an urgent call to action to reduce inequality, generate growth, provide sufficient health infrastructure, eliminate poverty, combat climate change, and better education. Decades of research and monitoring by the UN, member countries, and the UN Department of Economic and Social Affairs have developed the SDGs. The 17 SDGs are as listed:

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation, and Infrastructure
10. Reduced Inequality

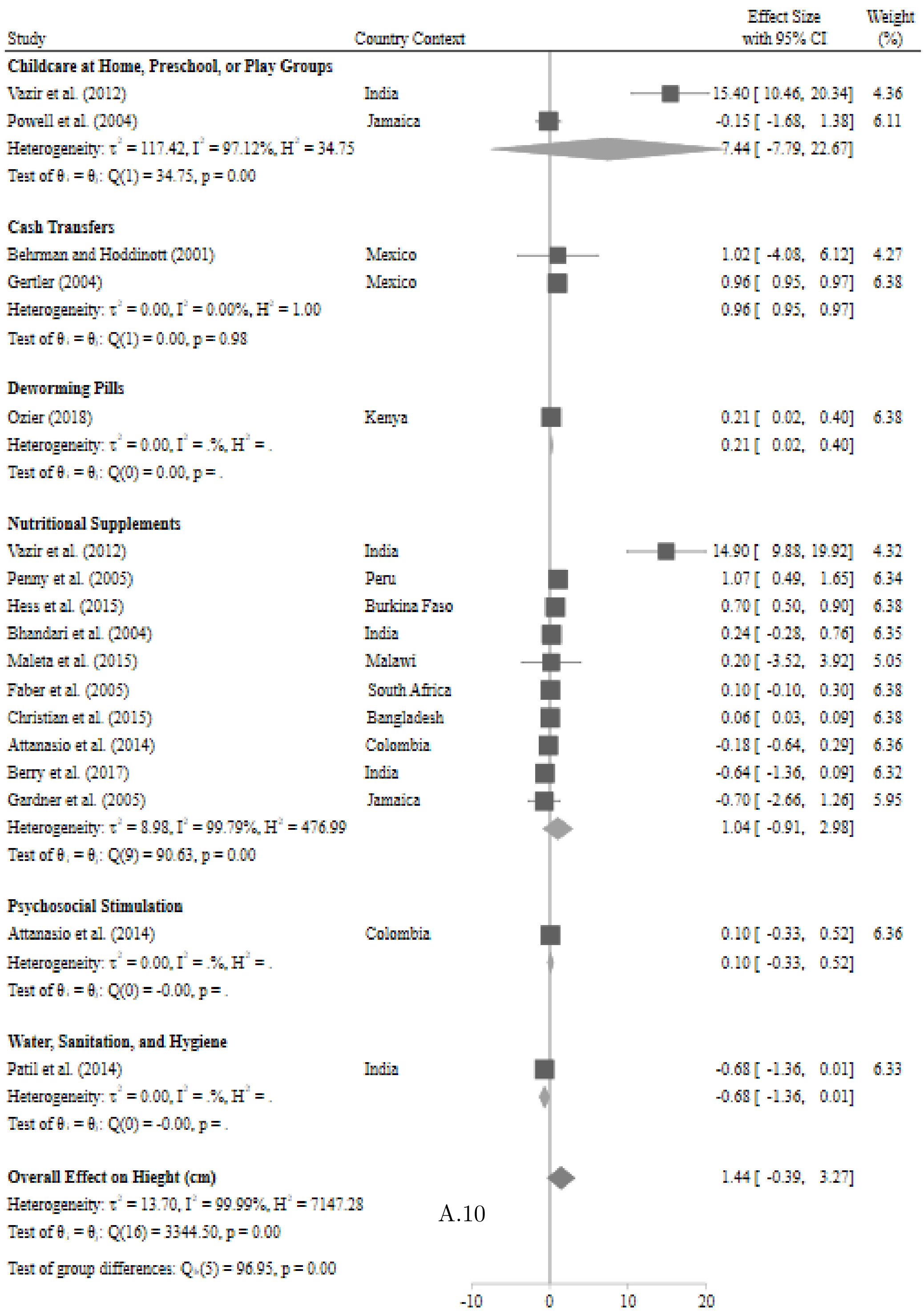
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace and Justice Strong Institutions
17. Partnerships to Achieve the Goal

For the purpose of this review, we examine childhood health outcomes. With respect to the current SDG goals, this research focuses on goals: (2) eradicating hunger, (3) promoting good health and well-being, and (6) clean water and sanitation. These three guiding targets are the impetuous for scholars, NGOs, and governments to act during the 21st century to find scalable and successful ECD programs achievable by 2030.

C Secondary Outcomes

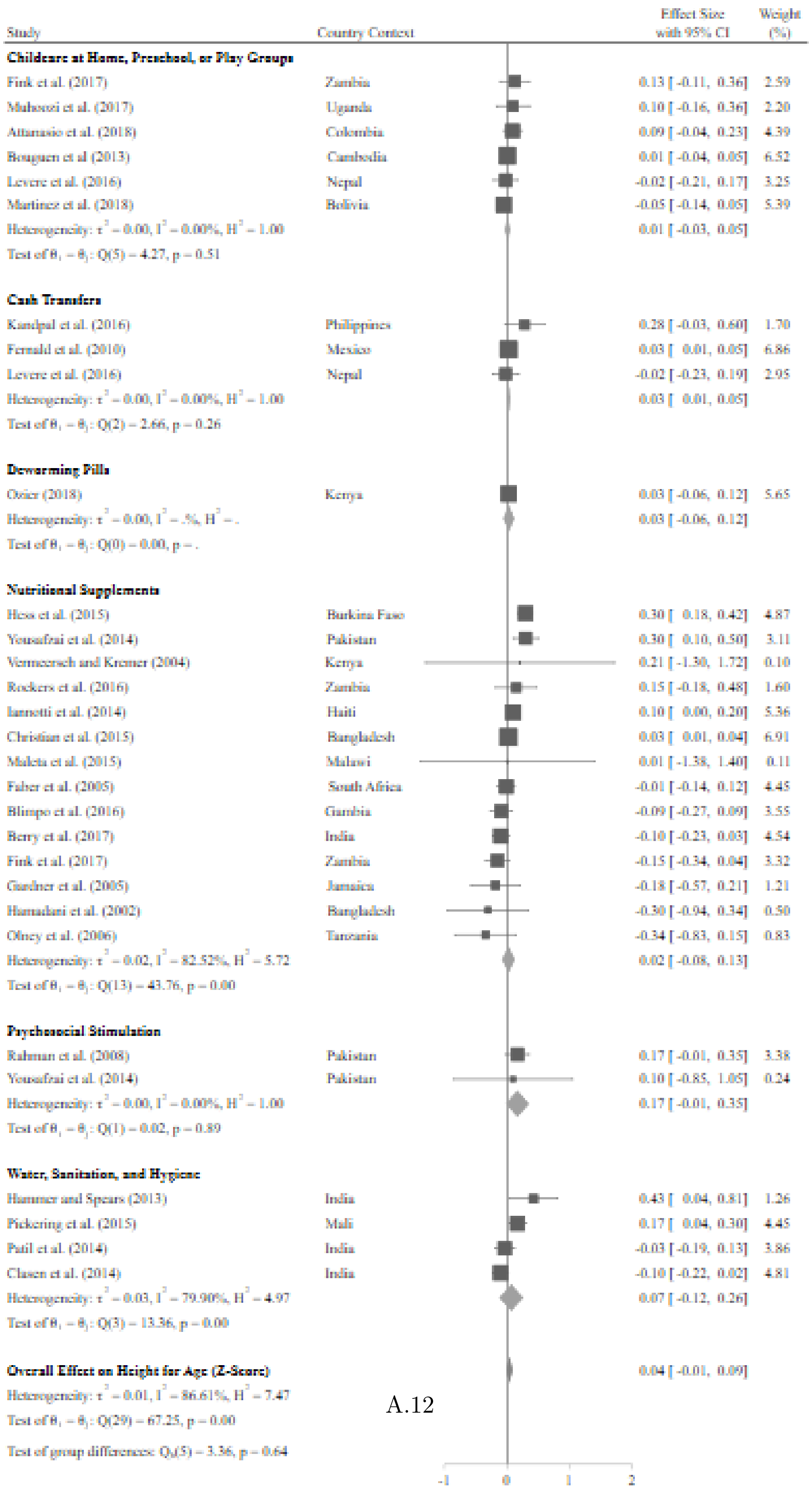
C.1 Height and Height for Age

Figure A.1: **Evidence Summary on Height (cm)**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported height (in centimeters) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

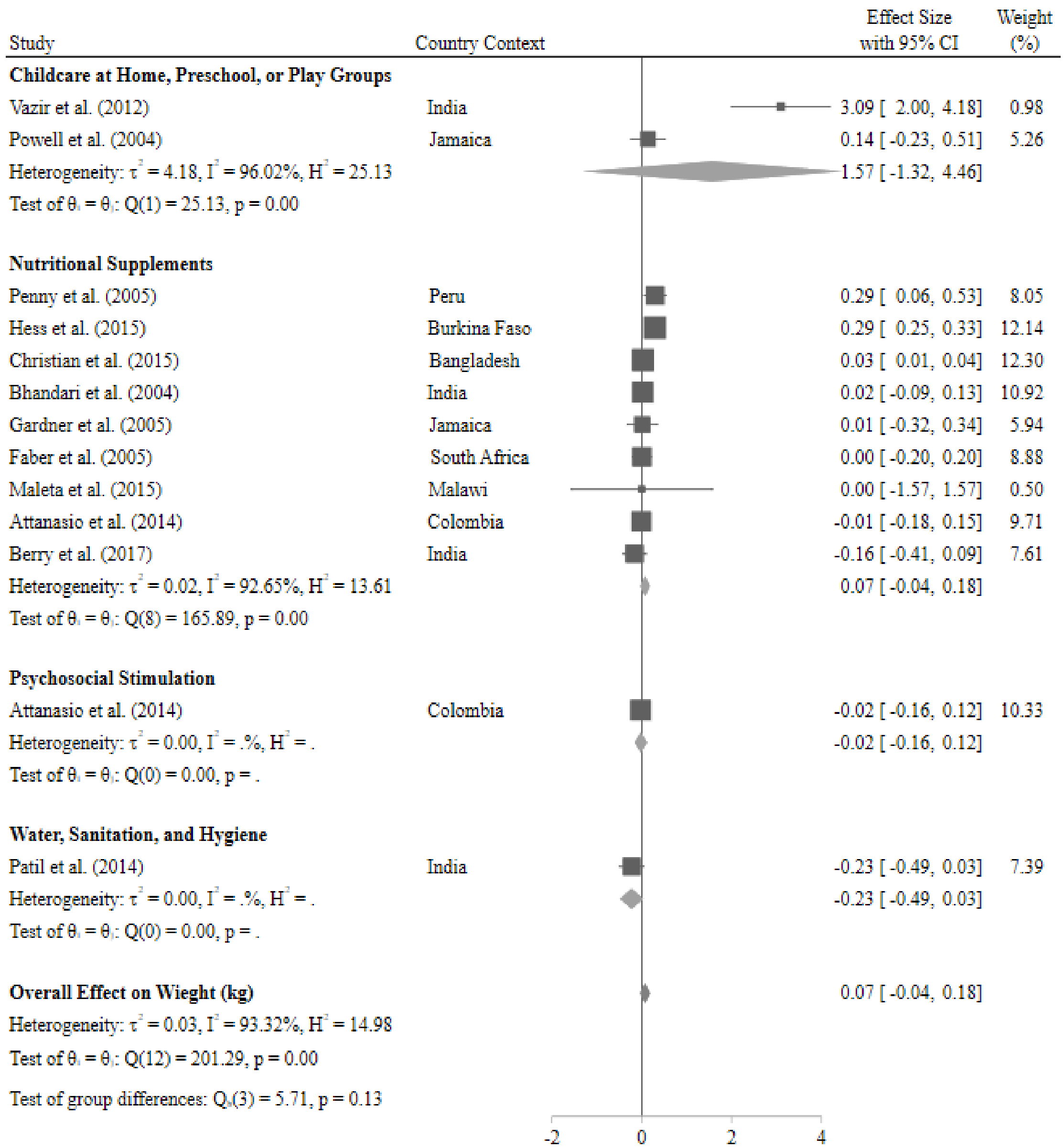
Figure A.2: **Evidence Summary on Height for Age (Z-Score)**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported height for age (z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

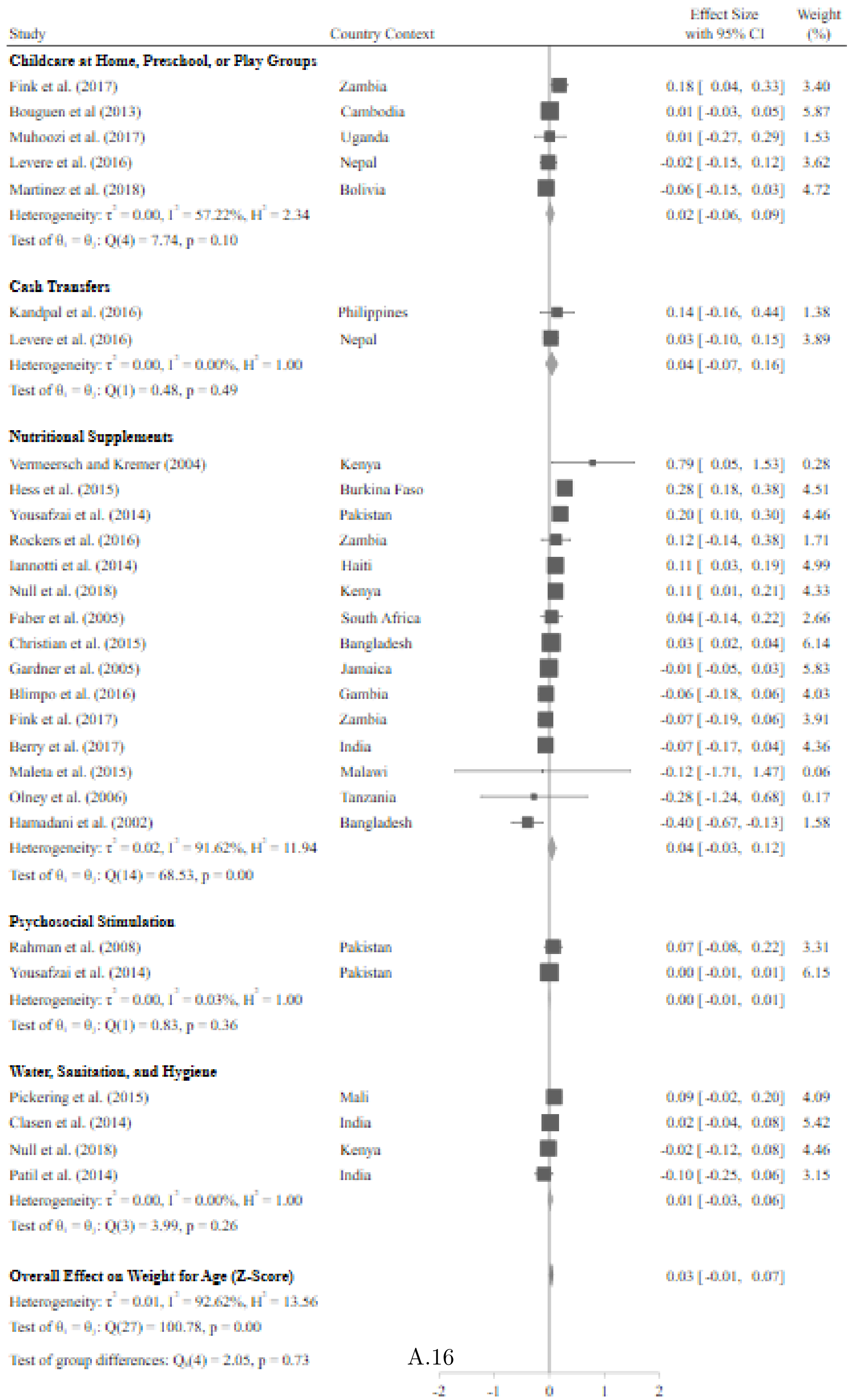
C.2 Weight and Weight for Age

Figure A.3: **Evidence Summary on Weight (kg)**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported weight (in kilograms) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

Figure A.4: **Evidence Summary on Weight for Age (Z-Score)**

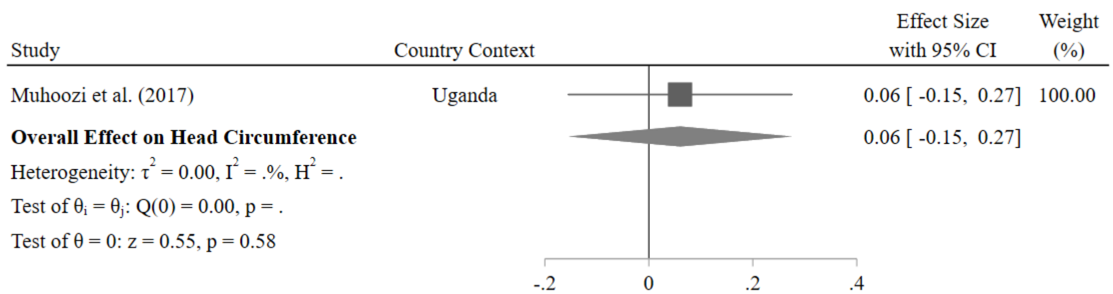


Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported weight for age (z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by

C.3 Head Circumference

Here is a placeholder for discussion on Head Circumference. Primary just focus with respect to main text. Discuss how it is surprising that there is such little evidence for this outcome. Potential difficulty obtaining this information, or selectively under-reported.

Figure A.5: **Evidence Summary on Head Circumference (Z-Score)**



Notes: This figure shows the point estimate and 95% confidence interval for regression estimations of studies that reported head circumference (z-score) in children. Meta regressions is restricted maximum likelihood random effects model following a frequentest approach. Studies are grouped by intervention type, with a meta estimate for each subgroup displayed at the end of each group. The overall meta estimation effect is displayed at the bottom of the figure.

D Publication Bias

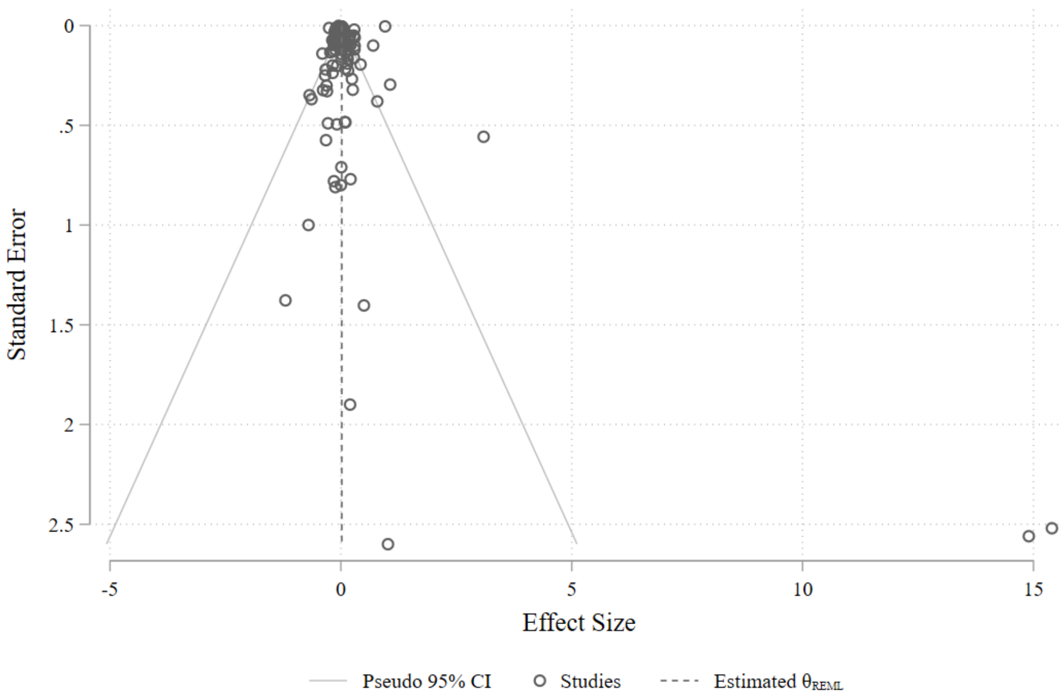
Due to the incentive by authors and journals to publish significant results rather than null results, we examine the presence of publication bias within our sample. To do so, we employ a visual examination of the influence of publication bias from small study samples using a Funnel plot. Additionally, we formally test for the influence of small study bias using the Egger's test (Egger et al., 1997). The Egger test is conducted using a random effects meta-analysis model. These measures show if any asymmetry is exhibited between the reported effect size and standard errors reported by the studies in this review. Publication bias is detectable if a small-study (i.e., a small sample size) has a disproportionately significant effect, suggesting that there may be some publication bias overestimating the presence of statistically significant results in this review.

Examining the the funnel plot for all observations in this review as shown in Figure A.6, most estimations are within the bounds of a pseudo 95% confidence interval of expected standard error given the effect size reported. Although, there appears to be a upward bias of publication for small studies with large effect sizes in some of the observations. But upon further examination, this is primarily driven by two observations in particular on ECD effects for height. Removing the two of observations from Vazir et al. (2013) of the 143 total observations results in Figure A.7. While there remains some visual representation of a bias for publications of statistically significant positive results, this bias is less pronounced.

Separating the observations between the primary outcomes presented in the main text compared to the secondary outcomes covered in the Appendix C is revealing. When accounting for only the primary outcomes in Figure A.8, there is no visual representation of publication bias. While when accounting for only the secondary outcomes in Figure A.9, a visual representation of publication bias persists. This suggests that the primary outcomes are largely unaffected by small-study bias, while the secondary outcomes are likely to have publication bias.

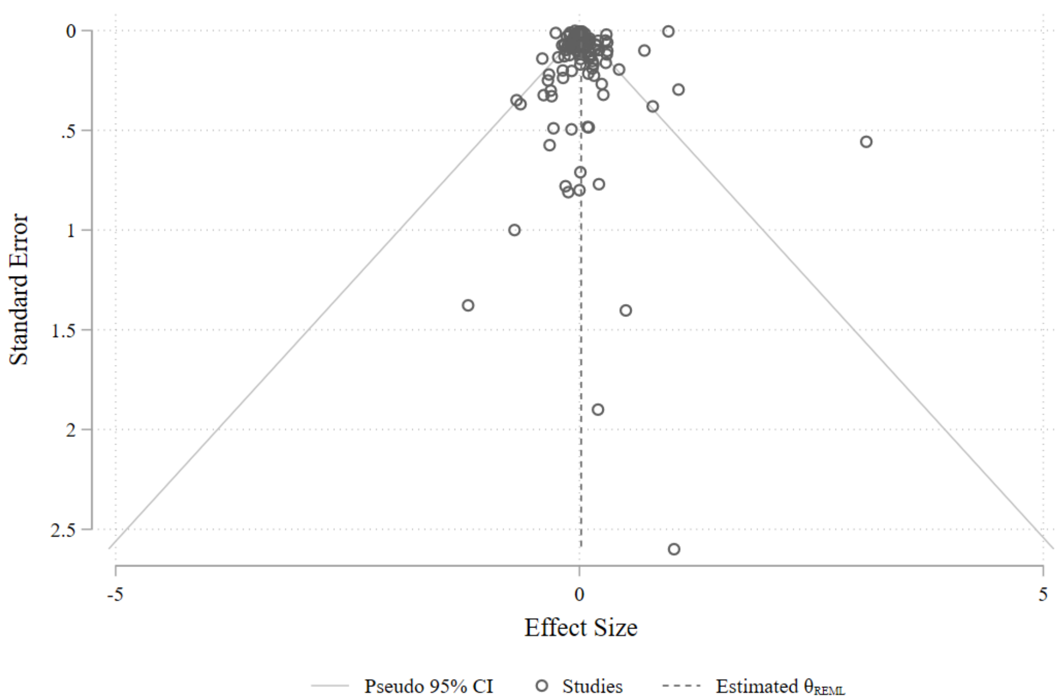
Examining the influence of publication bias more formally using the Egger test in Table A.1 echoes the visual evidence presented through the funnel plots. Overall, there is a positive publication bias present in the sample (p-value 0.0105). But this is almost entirely driven by bias in the secondary outcomes (p-value 0.0020). The primary outcomes as a whole do not show any presence of small-study bias (p-value 0.2167) with the exception of Anemia which has a positive small-study bias (p-value 0.0439). As a result, we can confidently assert that it is unlikely that the primary outcome findings are driven by publication bias. But the secondary outcomes are unlikely to be supportive evidence for the primary outcomes, as both measures of Height and Weight are strongly dictated by publication bias. Therefore the secondary outcomes likely are overestimating the effects of ECD interventions of those health outcomes.

Figure A.6: **Funnel Plot of Publication Bias**



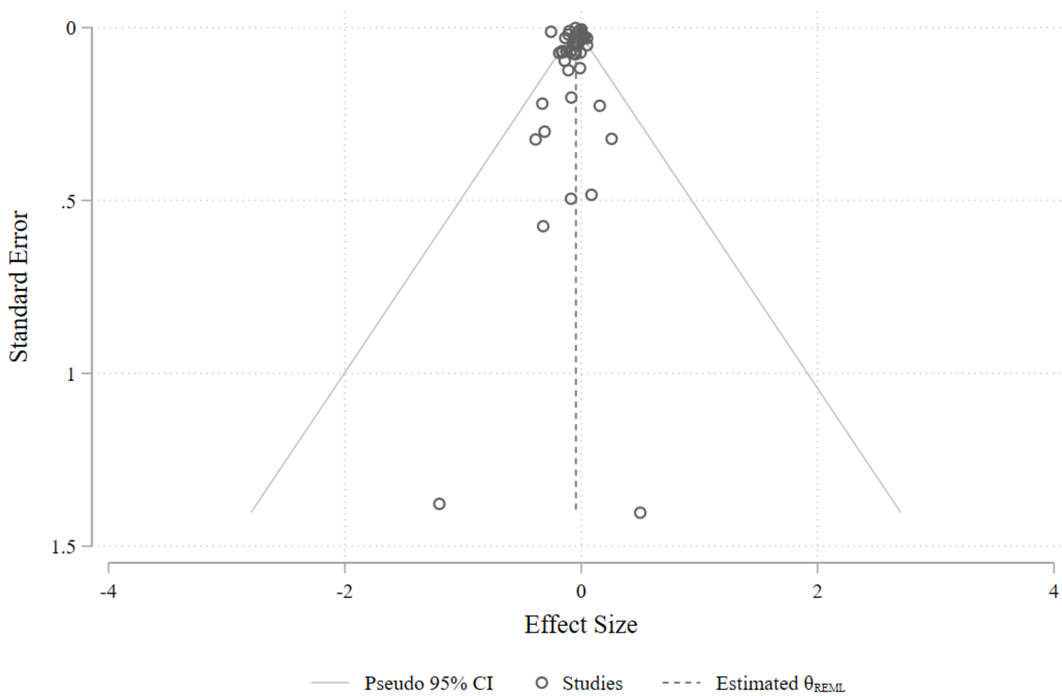
Notes: This funnel plot shows the point estimate and pseudo 95% confidence interval using a restricted maximum likelihood random effects model following a frequentest approach. Observations are plotted relative to the point estimate reported and their standard error.

Figure A.7: **Funnel Plot of Publication Bias Without Outliers**



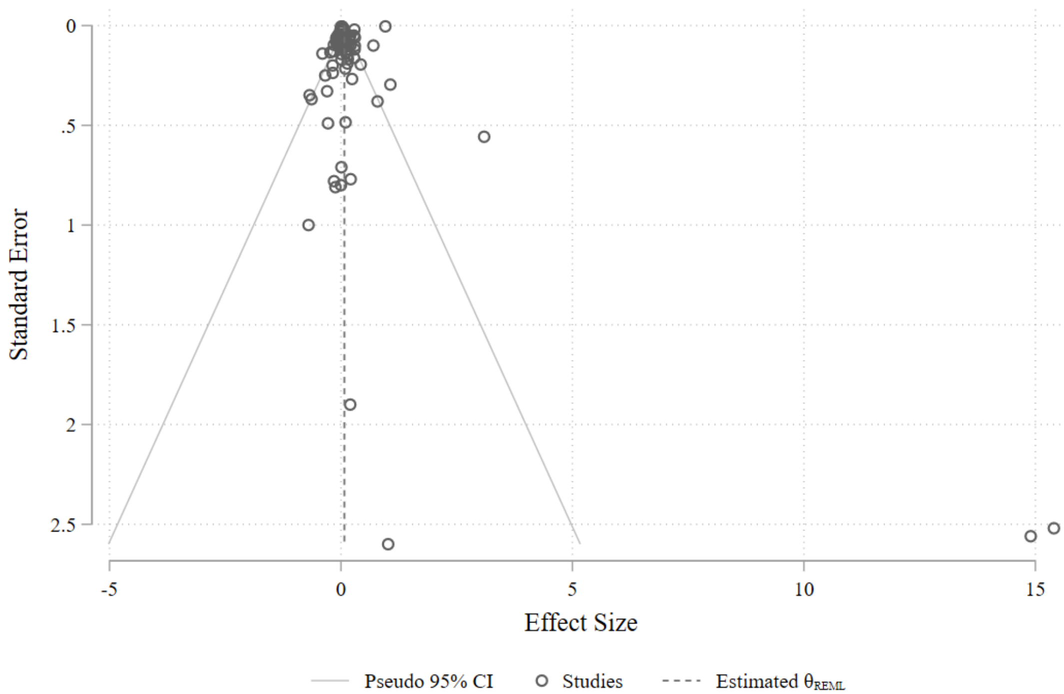
Notes: This funnel plot shows the point estimate and pseudo 95% confidence interval using a restricted maximum likelihood random effects model following a frequentest approach. Observations are plotted relative to the point estimate reported and their standard error. The two omitted outlier observations are from Vazir et al. (2013) for impacts on Height (in centimeters).

Figure A.8: **Funnel Plot of Publication Bias for Primary Outcomes**



Notes: This funnel plot shows the point estimate and pseudo 95% confidence interval using a restricted maximum likelihood random effects model following a frequentest approach. Observations are plotted relative to the point estimate reported and their standard error. This plot limits observations to the primary outcomes: anemia, stunting, underweight, wasting, mid-upper arm circumference, and worms infections.

Figure A.9: **Funnel Plot of Publication Bias for Secondary Outcomes**



Notes: This funnel plot shows the point estimate and pseudo 95% confidence interval using a restricted maximum likelihood random effects model following a frequentest approach. Observations are plotted relative to the point estimate reported and their standard error. This plot limits observations to the secondary outcomes: height, height for age, weight, weight for age, and head circumference.

Table A.1: **Small-study Effects by Outcome Measure**

Outcome	Egger's Bias	P-Value
Primary Outcomes		
Anemia	12.26	0.0439
Stunting	-0.47	0.2706
Underweight	-0.15	0.7398
Wasting	-0.29	0.7042
Mid-Upper Arm Circumference	-0.61	0.7145
Worms Infections	-1.04	0.1219
Overall	-0.33	0.2167
Secondary Outcomes		
Height	3.02	0.0000
Height for Age	0.08	0.8430
Weight	1.91	0.0108
Weight for Age	0.08	0.8684
Head Circumference		
Overall	0.76	0.0020
Primary and Secondary Outcomes		
Overall	0.48	0.0105

Notes: This table shows the Egger test for the overall review as well as test for each outcome measure separately. Head circumference only has one observation, and therefore an Egger test can not be performed for this outcome measure alone.

E Sample Composition

In this section, we explore the composition of the sample used in this review. Table A.2 shows from which search engines we gathered the articles to examine for the systematic review. Additionally, it shows the selection of articles from each search engine and their composition within the final dataset used in the meta-analysis. The majority of our selected articles came for Innovation for Poverty Action (42.50%), Web of Science (12.50%), ProQuest (12.50%), and Scopus (12.50%).

Table A.2: **Search Engine Results and Selection**

Search Engine	Search Results (N)	Percent of Search Results	Articles Selected (N)	Articles Snowballed (N)	Percent of Selected Articles
Web of Science	10,406	42.02	2	3	12.50
ProQuest	5,947	24.02	1	4	12.50
Scopus	4,032	16.28	1	4	12.50
PubMed	3,748	15.14	0	0	0.00
World Bank	266	1.07	0	0	0.00
Education Source	175	0.71	0	0	0.00
EconPapers	47	0.19	1	2	7.50
EconLit	38	0.15	1	1	5.00
Save the Children	34	0.14	0	0	0.00
Ideas/RePEc	19	0.08	0	0	0.00
OpenGrey	10	0.04	0	0	0.00
J-PAL	9	0.04	1	1	5.00
IPA	8	0.03	4	12	42.50
USAID	7	0.03	0	0	0.00
AgEcon Search	6	0.02	1	0	2.50
EconStor	4	0.02	0	0	0.00
BRAC	2	0.01	0	0	0.00
Oxfam	2	0.01	0	0	0.00
African Dev. Bank	1	0.00	0	0	0.00
Asian Dev. Bank	1	0.00	0	0	0.00

Table A.3 shows the frequency of countries that are represented by the selected articles in our review. This sample covers 34.3% of the global population, and LMIC countries present roughly 80% of the global population. So this sample is representative of close to half (42.88%) of the developing world's children. Compared to the World Bank's indicators of national population, Kenya, Zambia, Colombia, Bangaladesh, Jamaica, Pakistan, and Mexico are over represented amongst developing countries in our study compared to their portion of global population. Notable developing countries that are not represented include China, Brazil, and Indonesia. Each comprise a large portion of the globally poor (24.57%). Additionally, this sample omits the Pacific Islander and Middle Eastern contexts.

Table A.3: **Developing Country Representation**

Country	Region	Frequency of Studies	Frequency of Observations	Percent of Sample	Percent of World Population
India	South Asia	6	22	15.38	17.69
Kenya	Sub-Saharan Africa	4	17	10.26	0.70
Zambia	Sub-Saharan Africa	2	11	5.13	0.24
Nepal	Central Asia	1	10	2.56	0.38
Colombia	South America	3	9	7.69	0.65
Bangladesh	South Asia	3	8	7.69	2.11
Burkina Faso	Sub-Saharan Africa	1	8	2.56	0.27
Malawi	Sub-Saharan Africa	1	7	2.56	0.25
Bolivia	South America	1	6	3.66	0.15
Jamaica	Caribbean	2	6	5.13	0.04
Pakistan	South Asia	2	6	5.13	2.86
Mexico	Central America	3	5	7.69	1.65
Mali	Sub-Saharan Africa	1	4	2.56	0.26
Philippines	Southeast Asia	1	4	2.56	1.41
South Africa	Sub-Saharan Africa	1	4	2.56	0.76
Uganda	Sub-Saharan Africa	1	4	2.56	0.60
Peru	South America	1	3	2.56	0.42
The Gambia	Sub-Saharan Africa	1	2	2.56	0.03
Haiti	Caribbean	1	2	2.56	0.15
Cambodia	Southeast Asia	1	2	2.56	0.22
Tanzania	Sub-Saharan Africa	1	2	2.56	0.78
Nigeria	Sub-Saharan Africa	1	1	2.56	2.68

Table A.4 shows the frequency of the eleven outcome measures studied in this meta-analysis, subdivided into primary and secondary outcomes. Measurements on Height for Age, Weight for Age, and Stunting are the largest reported outcomes in this review. It is noteworthy that it is surprising that only 1 article from the final selection reported measurements of child Head Circumference.

Table A.4: **Frequency of Outcomes**

Outcome Measure	Frequency	Percent	Cumulative Percent
Primary Outcomes			
Stunting	18	12.59	12.59
Underweight	12	8.39	20.95
Wasting	8	5.59	26.54
Worms Infection	6	4.20	30.74
Upper Arm Circumference	6	4.20	34.94
Anemia	4	2.80	37.74
Secondary Outcomes			
Height for Age	30	20.98	58.72
Weight for Age	28	19.58	78.30
Height	17	11.89	90.19
Weight	13	9.11	99.30
Head Circumference	1	0.70	100

Table A.5 shows the frequency of the six ECD intervention categories (broadly defined) conducted in the studies selected for this systematic review. Because most of these interventions were shaped to fit their context, they have been simplified into these six related intervention categories. The details on the specific program and details on the interventions implemented for each study can be found in Table 1 as well as within the online search tracker mentioned in Section A.2. Nutritional Supplements and information related to childhood health was the primary intervention type (48.25%). There is less examination of the use of Psychosocial Stimulation programs or the use of Deworming Pills as ECD interventions.

Table A.5: **Frequency of Interventions**

Intervention	Frequency	Percent	Cumulative Percent
Nutritional Supplements	69	48.25	48.25
Childcare at Home, Preschool, and Play Group	27	18.88	67.13
Water, Sanitation, and Hygiene	21	14.69	81.82
Cash Transfers	17	11.89	93.71
Psychosocial Stimulation	6	4.20	97.90
Deworming Pills	3	2.10	100.00

Table A.6 provides further description on the intervention conducted and the treatment arms performed for each study. This table elaborates upon the ECD intervention conducted in each article included in this study. The description expands upon the program design, duration of the intervention, and treatment arms. The limitations presented in this table are those that are stated by the authors of these articles, separate from this review's evaluation of limitations through GRADE and ROB measures.

Table A.6: **Details on ECD Interventions Conducted**

(1) ID	(2) Article	(3) Program	(4) Timing	(5) Location	(6) Treatment Arms	(7) Stated Limitations
1	(Behrman and Hoddinott, 2001)	PROGRESA	Aug. 2000 - Dec. 2002	Guerrero, Hidalgo, Puebla Querétero, San Luis Potosi, Veracruz	Parents receive a conditional cash transfer for child attending school. nutritional supplements, and parents attend regular meetings on health and nutrition issues.	Limited sample for antropometric measures, Children also receive potential contamination from household sharing of nutritional supplements
2	(Attanasio et al., 2018)	FAMI	Sept. 2014 - Jul. 2016	Cundinamarca, Boyacá, and Santander	An early stimulation curriculum, pedagogical materials, training of facilitators, and nutritional supplements.	Limitations of offering the intervention at scale, singular curriculum may not be applicable across socioeconomic or cultural differences in regions, potential measurement errors.
3	(Levere et al., 2016)	Attencion a Crisis	Aug. 2013 - Dec. 2014	4 food insecure districts	1. Receives maternal health information, 2. Receives information along $7 USD	None stated
4	(Pickering et al., 2019)	Integrated WASH and Child Parasite Infections Study	Nov. 2012 - Jul. 2016	Kakamega, Bungoma, Vihiga	1. chlorine treatment (W), 2. toliets with plastic slabs (S), 3. hand soap (H), 4. combined WSH, 5. lipid-based nutrient supplements (N), 6. combined WSHN	No blinding of treatment status, potential attenutation of treatment effects from delayed followup survey
5	(Null et al., 2018)	Kenya WASH Benefits Study	Nov. 2012 - May 2014	Bungoma, Kakamega, Vihiga	1. Drink chlorinated water, 2. disposal of feces in latrines, 3. hand soap, 4. combined 1, 2, and 3, 5. counseling on nutrition and lipid-based nutrient supplement, 6. combined WASH and nutrients	Potential lack of protection from zoonotic pathogens, inability to mask interventions, behaviors self-reported, and low adherence to interventions
6	(Fink et al., 2017)	National Food and Nutrition Strategic Plan for Zambia	Oct. 2014 - Sept. 2015	Chipata	1. Home-based growth monitoring, 2. Community-based growth monitoring with targeted nutritional supplements	High heterogeneity in local nutrition and feeding customs, small sample size, short duration of interventions, seasonality related to harvest
7	(Ozier, 2018)	Primary School Deworming Project	2001 - 2010	Kenya's Western Province	Deworming protocol via local schools	No direct observations at baseline, child surveys were limited in scope
8	(Berry et al., 2017)	The Mid-day Meal Program & Weekly Iron Folic Acid Program	2013 - 2015	Keonjhar	1. Micronutrient mix in school mid-day meals, 2. Iron and Folic Acid supplements, 3. school mean monitoring	Contamination between treatment arms, and differential attrition related to school attendance
9	(Attanasio et al., 2014)	Independent RCT	2009 - 2011	Cundinamarca, Boyaca, Santander, Antioquia, Risaralda, Caldas, Huila, Tolima	1. Jamaican home visiting model, 2. mirconutrient supplement powder	Self-reports of compliance, no placebo used for micronutrients, do not measure iron status
10	(Martinez et al., 2018)	Community Child Nutrition Project	2008 - 2011	El Alto	Home visits on parental education for child health	Attrition issues, compliance issues
11	(Muhoozi et al., 2017)	Independent RCT	2013 - 2014	Kabale, Kisoro	6 months of group village meetings on hygiene	Small number of clusters, Lack measures of body composition due to logistical issues in rural setting
12	(Rockers et al., 2016)	Independent RCT	Aug. 2014 - Oct. 2015	Choma, Pemba	Fortnightly meetings for caregivers on child health services	Did not deliver intervention through existing health system, and relies on self-reports
13	(Yousafzai et al., 2014)	Lady Health Worker Programme	Jun. 2009 - Mar. 2012	Naushero Feroze	1. nutrition education and micronutrient powders, 2. responsive stimulation, 3. combination of interventions	None stated
14	(Fernald et al., 2009)	Oportunidades	2000 - 2007	7 Mexican states	Cash transfer conditional on children attending school	High attrition, imputation of some household data
15	(Attanasio et al., 2015)	Familias en Accion	2002 - 2006	622 Colombian municipalities	Conditional cash transfer on fulfilment of national preventive visit schedule	None stated
16	(Powell et al., 2004)	Independent RCT	2012 - 2013	Kingston, St. Andrew	Weekly home visits demonstrating play activities	Reduced government resources limited intervention fidelity
17	(Clasen et al., 2014)	Total Sanitation Campaign Offshoot	May 2010 - Dec. 2013	Odisha	Latrine promotion and construction	Low latrine useage, and outcome measured too early
18	(Lin et al., 2018)	WASH Benefits Bangladesh	May 2012 - Jul. 2013	Gazipur, Mymensingh, Tangail, Kishoreganj	1. chlorinated water, 2. hygienic sanitation, 3. handsoap, 4. lipid-based nutrient supplements, 5. combined WSH, 6. nutrition + combined WSH	Baseline rates of diarrhea already low
19	(Patil et al., 2014)	Total Sanitation Campaign	May 2009 - Apr. 2011	Madhya Pradesh	Subsidies for household latrines	Short duration of the study, and self-reported outcomes
20	(Pickering et al., 2015)	Community-led Total Sanitation	2011 - 2013	Koulikoro	Anti-open deification mobilization campagin	Self-reported measures, and seasonality of data collection
21	(Christian et al., 2015)	JiVitA Project	Sept. 2012 - May 2014	Gaibandha, Rangpur	1. Plumpy doz, 2. Rice lentil, 3. Chikpea, 4. Wheat-soy blend	No blinding, and delayed followup following end of program
22	(Iannotti et al., 2013)	Lipid-based Nutrient Supplements Program	May 2011 - Dec. 2012	Cap Haitien	Lipid-based nutrient supplement	Attrition due to out-migration
23	(Maleta et al., 2015)	Independent RCT	2013 - 2014	Mangochi, Namwera	Lipid-based nutrient supplements	High attrition, and Unable to deliver treatment for some households
24	(Hess et al., 2015)	iLiNS Project	Apr. 2010 - Jul. 2012	Dande	Weekly Lipid-based nutrient supplements	Partial blinding of subjects
25	(Hammer and Spears, 2013)	Total Sanitation Campaign	Feb. 2004 - Aug. 2005	Maharashtra	Community sanitation motivation campaign	Short followup period, and No directly observed latrine usage
26	(Kirwan et al., 2010)	Independent RCT	May 2006 - Aug. 2007	Akinlalu, Ipetumodu, Moro, Edunabon	Albendazole tablets	Baseline imbalance of Plasmodium prevalence
27	(Kandpal et al., 2016)	Pantawid Program	Oct. 2008 - Nov. 2011	North Province, Visayas, and Mindanao	Conditional cash transfer based on child health behaviors	None stated
28	(Gertler, 2004)	PROGRESA	Aug. 2000 - Dec. 2002	Guerrero, Hidalgo, Puebla	Parents receive a conditional cash transfer for child attending school	None stated
29	(Vermeersch and Kremer, 2004)	The Meals Program	Jan. 2000 - Dec. 2002	Teso, Busia	School meal program	None stated
30	(Bhandari et al., 2004)	The Integrated Child Development Services Scheme	2000 - 2002	Haryana	Monthly home visits to counsel on immunization and child health provisions	Potential survey demand effect
31	(Vazir et al., 2013)	The Integrated Child Development Services Programme	2001 - 2002	Andhra Pradesh	1. Complementary feeding program, 2. Complementary feeding with group play activities	None stated
32	(Penny et al., 2005)	Growth and Development Monitoring Programme	2000 - 2002	Trujillo	Health-service education	Not blinded, and differential baseline characteristics between treatment arms
33	(Olney et al., 2006)	International Nutritio	2004 - 2005	Pemba	1. Iron + folic acid, 2. Zinc, 3. Iron + folic acid and zinc	None stated
34	(Faber et al., 2005)	The Valley Trust	2004 - 2004	KwaZulu-Natal	Milled maize porridge meals for children	Poor sensitivity to zinc concentrations
35	(Gardner et al., 2005)	Independent RCT	2003 - 2004	Kingston, St. Andrew, and St. Catherine	1. Zinc supplements, 2. Weekly guided play visits	None stated
36	(Hamadani et al., 2002)	Independent RCT	2000 - 2001	Dhaka	Zinc supplements to pregnant mothers	Potential spurious correlation due to high rates of under-nutrition
37	(Blimpo et al., 2018)	Baby Friendly Community Initiative	2013 - 2014	Regions 2 and 6	Health and nutrition program targeted at school-age children	None stated
38	(Rahman et al., 2008)	Thinking Healthy Program	Apr. 2005 - Mar. 2006	Gujar Khan, Kallar Syedan	Psychological interventions for mothers with perinatal depression	None stated
39	(Bouguen et al., 2013)	Education Fast Track Initiative Catalytic Fund	2008 - 2011	10 Cambodian provinces	1. Construction of early childhood care and development classrooms, 2. Community preschools, 3. Home-based visit programs	Difficulties with implementation, limited time with children in the programs, and low take-up rates

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