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Review of Maternal Effects on Early Childhood Stunting

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INTRODUCTION

When under-nutrition is chronic and pervasive, it is an indicator of stunted growth. Pervasive undernutrition acts as a trigger for a child's body to change its metabolism and physiology, as a coping mechanism against under-nutrition, signalling some epigenetic modifications associated with stunting (1).

Stunting may first occur during foetal development stage with spill-over effects into early postnatal growth (2,3). A stunted child is more likely to have been born into a low-income household; hence, an intergenerational transmission of poverty and of childhood stunting emerges and may become a vicious cycle (3,4). Stunting is detrimental because it is linked to constrained cognitive development, which leads to poor educational performance and future low income (5).

There are three areas in which child stunting may emerge – the social environment, genetics, and epigenetics, which are linked to maternal effects. Mothers who experienced early childhood adversity are likely to have psychosocial stress in adulthood and psychosocial stress negatively affects offspring's linear growth (6,7). The interaction between genes and the environment during a mother's childhood exposure to a famine and subsequent stunted growth is associated with stunting in offspring, in the absence of famine (8). Finally, stunted mothers are more likely to have

stunted children, since the genes for stunted growth are passed on to the next generation (3).

The review aims to cover previous and current research of the past decade (2004-2014) by focusing on maternal factors affecting stunting, in the first five years of life and to link them to the social environment, genes or epigenetic influences. The review notes that other reviews have covered the impact of micronutrient interventions on preschoolers' nutritional status (9,10), including Cochrane reviews on supplementary feeding interventions for children aged 0-5 years and provision of micronutrient powders for children aged 0- 2 years (11,12). Another Cochrane review studied the effects of maternal supplementation during pregnancy to address childhood anaemia, but this is outside the scope of the present review (13).

MATERIALS AND METHODS

The articles used in the review were selected via PubMed. The search terms used were "maternal + stunted + growth + infant"; "maternal + stunted + growth + child"; "maternal + stunting + infant"; and "maternal + stunting + child". The scope for the search was January 1st, 2004-February 28th, 2014. The results of each search term were posted to Refworks 2.0, where duplicates were removed. Figure 1 shows the

process of selection and final inclusion (332 articles; only 60 are included).

Exclusion Criteria

The exclusion criteria for the review included the use of childhood stunting as a risk factor for other conditions/outcomes; a focus on concurrent obesity-stunting in children or concurrent maternal obesity-child stunting; study participants aged >= 5; and also studies that focused on intra-uterine stunting. Articles were excluded, if they did not clearly state that stunting was the component of nutritional status being analysed. Case reports, case series and solely descriptive and qualitative studies were also excluded. Articles published in other languages other than English were excluded.

Inclusion Criteria

Methodologies that fit the inclusion criteria included reviews/systematic reviews, meta-analyses, randomized controlled trials (RCTs)/other trials, cohort studies, longitudinal studies, case control studies, and cross-sectional studies, but only if they measured an association between some maternal exposure/characteristic and moderate/severe stunting in offspring, classified as 2 SD below median

length/height for age and 3 SD below median length/height for age, respectively. English language articles were included for the review.

Ethics

The present review mainly used summary statistics for the analysis, which emanated from studies designed and written up by other authors. Therefore, ethical approval was not required for the present review.

Statistics

The results will show that, *inter alia*, mother's weight, stature, body mass index (BMI), and the level of education influenced offspring's growth, in the first five years of life (Table 1). Effect sizes (log odds ratio) on child growth are also presented on child stunting using close, but different metrics, such as odds ratio (OR), relative risk (RR), and prevalence odds ratio (POR). The results mainly present statistically significant associations at the 5% level or lower, unless otherwise stated, using odds ratios (OR), relative risk (RR), hazard ratio (HR), prevalence odds ratio (POR) or presented with the prefix "a" when adjusting for confounders (e.g.,. aOR, aHR, aPR). Mean difference in length-for-age or height-for-age (LAZ/HAZ), and R^2 are also used. Any reference to stunting is assumed to be *moderate* stunting (LAZ/HAZ < -2], otherwise

LAZ/HAZ scores < -3 will be specified as severe. In addition, any reference to stunting should be regarded as stunting occurring in the offspring, not maternal stunting, unless stated otherwise. Confidence intervals (CI), p-values (P), standard deviations (SD), and study population/sample size (n), where n refers to number of children, are provided, if available. The statistics presented in the text are all significant, unless stated otherwise.

MAIN FINDINGS & DISCUSSION

Results Summary

The results showed that maternal-related factors, such as height, weight, and education were important in explaining stunted child growth. Maternal mental health status, exposure to violence, and autonomy/employment were less common, but, nevertheless, essential predictors of child stunting, which warrant further examination.

Maternal Height/ Stature

Maternal height is not only influenced by a woman's own nutritional status, particularly, during the growth phase, but is also affected by genetics (14,15). Thus, a shorter mother is more likely to have a shorter

child and vice versa. Maternal height shorter than 145 cm is considered as stunted.

Fifteen studies assessed the impact of maternal height, especially short stature, on early childhood stunting. Subramanian et al. (2010) found that being a tall mother reduced the relative risk of stunting among children aged 0-59 months (16). Subramanian et al. (2009) found that short maternal height (< 145 cm) was a risk factor for stunting, among pre-schoolers as did Ahmed at el. (2012), but in children aged 0- 12 months (17,18). Huntsman & White (2007) found that maternal height was associated with HAZ among preschoolers, using the CDC/WHO 1978 growth references, (19). Jesmin et al. (2011) found that shorter maternal height (≤ 148 cm) was associated with stunting in children (20). Addo et al. (2013) determined that, during the first two years of life, there was a strong association between a mother being short (<150.1 cm) and having a stunted child, as did Gewa & Yandell (2012) using a smaller sample size (21,22). More recently, Felisbino-Mendes et al. (2014) reported that a mother's height (<145 cm) reduced a child's height by 1.2 cm in preschoolers, adjusted for SES, while Frojo et al. (2014), in a smaller study, reported that among shorter mothers, the odds of stunting in their children were 2.55 times higher, (23,24). A larger study by Hambidge et al. (2012) found that maternal height (131-164 cm) was positively associated with LAZ in offspring, at age 6 months, as did McGrath et al.

(2012) who cited a weak, but protective effect against stunting, at age 2 years (25,26). Casapia et al. (2007) found that decreasing maternal height by 1cm slightly increased the odds of stunting (27).

Zottarelli et al. (2007) reported that taller mothers (160 cm+) were less likely to have stunted children, while shorter mothers (150-160 cm) were more likely to have stunted children, although the association was weaker in shorter mothers (28). Nguyen et al. (2014) showed that maternal height and child height were associated, in three different countries (29). Rehman et al. (2009) found that maternal height (< 150 cm) was associated with childhood stunting, among children aged 0-59 months (30) as did Gibson et al. (2009) and Bove et al. (2012), but starting from a slightly taller height (<160 cm) (30-32).

Senbanjo et al. (2013) reported a very strong association (OR=6.67) between stunted mothers and stunted children; however, the confidence interval spanned so wide (95% CI: 1.39-32.0) - varying considerably from the rest of the studies in the present review - that the accuracy of the estimated odds ratio is doubtful, although the result is statistically significant (33). Finally, Mamabolo et al. (2004) found that maternal height was positively associated with child stunting, although the association was not statistically significant (34) .

Maternal Underweight/ /BMI

Maternal underweight is also linked to childhood stunting. Maternal underweight is linked to poor nutrition due to low food, or nutrient intake, which increases the risk for small size-for-gestational age in offspring and eventually, in reduced child stature (3). The review identified 10 studies which examined the relationship between maternal underweight/BMI and childhood stunting. Gewa and Yandell (2012) found that the odds of stunting were 1.55 times higher in underweight mothers vs. mothers with normal weight, but only for children aged 0-24 months (22). In contrast, Uthman (2009) found that maternal underweight was associated with childhood stunting , among children aged < 5 years, (35). Mostafa (2011) also reported similar results, but with stronger, unadjusted results for both moderate and severe stunting (36). Goudet et al. (2011) determined that maternal underweight and stunting were strongly associated, but with a relatively wide confidence interval and a smaller sample (95% CI: 1.04-18.94; n=143) (37).

Given that BMI is a function of measured height and weight, it is not surprising that maternal BMI affects an offspring's length/height, in early childhood. Subramanian et al. (2010) found that a 1 unit increase of maternal BMI had a small protective effect against stunting, in children aged 0-59 months (16). Ahmed at el. (2012) found that a mother with a BMI < 18.5 kg/m2 was more likely to have a stunted child, aged < 2 years as did Bove et al. (2012), but with children aged < 5years (18,32).

Maternal Education/ Education on Health Services

The reviewed articles suggest that some socioeconomic factors are important determinants of early childhood stunting. Many studies established a link between maternal education and childhood stunting. The greater the number of years spent in education, accessing health education from healthcare service providers, and health-seeking behaviour, (ascertained by the number of completed routine/scheduled ante-natal and under-5 clinic visits) may have a protective effect against stunting. The converse was also true: lower maternal education led to stunted offspring. The review found 25 studies that reported associations between maternal education and childhood stunting, while 3 studies covered maternal health education and health-seeking behaviour.

Low, or no, education was an important risk factor for child stunting as indicated by a number of studies. Reurings et al. (2013) reported that low, or, no primary education was related to lower HAZ, in children aged 6-23 months) (38). Urke et al. (2011) found a positive association between incomplete primary education and childhood stunting, in both the national population and the Andean population levels (39). Wamani et al. (2004) found that non-educated mothers were more than twice as likely to have stunted children (aged 0-23 months) vs. mothers with more than primary schooling, as did Mohsena et al. (2010) (40,41). Sakisaka et al. (2006)

found that mothers' illiteracy, or lack of formal education, was associated with stunted growth, among children aged 0-23 months (42). Masibo and Makoka (2012) found that no maternal education or education at primary level was associated with stunting in children aged <5 years (43). Biswas & Bose (2010) found that maternal education and lower than secondary school level led to stunting in girls aged 1-5 years (44). Olusanya et al. (2010) found that mothers with no education were more likely to have stunted children aged 0-3 months[1] (45). Mukatay et al. (2010) found that low maternal education influenced LAZ/HAZ in children (age < 5 years), as did McDonald et al. (2012) (46,47). Baig-Ansari et al. (2006) found that no maternal education was strongly associated with stunting (48). Wamani et al. (2006) found that non-educated mothers were more than twice as likely to have stunted children, aged 0-23 months (49). Abubakar et al. (2012) found a strong association between low maternal education and childhood stunting (50). Gribble et al. (2009) found that low maternal education (0 years or 1-3 years) and stunting among children aged < 5 years were linked (51). Meshram et al. (2013) and Meshram et al. (2012a) reported an association between being an illiterate mother and having a stunted child (aged < 5 years), although Meshram et al. (2012b) found no significant association, an anomaly, which could be explained

[1] Adjusted for all significant factors ($P < 0.05$), in the univariate model.

by the small sample size and a non-nationally representative sample (52-54).

A full primary education – a step up from no, or low, education often reduces the odds of child stunting. Finlay et al.'s large study found that, after controlling for high SES, maternal attainment of full primary school was linked to childhood stunting vs. unadjusted results, in children aged < 5 years (55). Pramod Singh et al. (2009) found that maternal education (6+ years) was protective against stunting in offspring aged 6 to 36 months (56).

Higher education is often a strong protective factor against child stunting, as demonstrated by the following studies. McGrath et al, (2012), however, found that higher maternal education was negatively associated with stunting in offspring (26). Zottarelli et al. (2007) found that mothers with secondary/higher education were less likely to have stunted children, at age < 5 years (28). Webb et al. (2009) demonstrated that maternal schooling > 9 years increased a child's height at age 0-24 months by 0.9cm (57). Grjibovski et al. (2004) found that possessing a higher education was associated with incremental linear growth in children (58). Ozaltin et al. (2011) found that higher maternal education had a small protective effect against childhood stunting, among preschoolers (59). In a multi-country analysis, Nguyen et al. (2014) showed that maternal secondary school education and higher HAZ in

offspring were associated, as was maternal college education, or higher education (29). The authors found that maternal primary school education had a protective effect against stunting, but only in one country. Som et al. (2007) found that mothers who completed middle school, or higher education were less likely to have stunted children (60). Mamabolo et al. (2004) found a negative, but statistically non-significant association between maternal primary education and child stunting (34).

While investigating a different aspect of education, Abuya et al. (2012) found that a mother's education had a protective effect against stunting in children[2] (61). Maternal health-seeking behaviour index had a strong protective factor against stunting in offspring (35). Zhang et al. (2013) also found similar results, that is, maternal education through healthcare services, such as nutritional counselling on feeding practices, exhibited a protective effect against child stunting (62).

Maternal Depression/ Exposure to Violence

Maternal mental health and physical well-being may also affect a child's risk of stunting. Five studies discussed maternal depression, while three studies examined maternal exposure to maternal violence. Avan et al. (2010) found a positive association between maternal postnatal-

[2] Adjusted for child birth weight, gender, marital status, parity, pregnancy intentions, and health-seeking behaviour, and SES

depression and lower HAZ of children aged 2 years [3] (63). Nasreen et al. (2013) found that antepartum depressive symptoms were associated with stunting in children aged 6–8 months, after controlling for maternal and infant anthropometrics and SES (64). Surkan et al.'s (2011) meta-analysis found that mothers with depression, or depressive symptoms, were more likely to have stunted children (63). Black et al. (2009) also found that the odds of stunting were about 2 times higher in infants aged 12 months, whose mothers exhibited depressive symptoms vs. infants of mothers with few depressive symptoms (66). Notably, Harpham et al. (2005) found that common maternal mental disorders, identified as anxiety and depression, were only significantly associated with child stunting in India, while there was a no association found in Peru, Vietnam or Ethiopia (67).

Violence against mothers is an important factor when considering the maternal effects in early childhood stunting; however, only a few studies have explored the association between maternal exposure to any form of violence and an offspring's pattern of linear growth. Asling-Monemi et al. (2009) found that at age 24 months, child HAZ was negatively associated with maternal exposure to any form of violence (68). Ziaei et al. (2012) found that maternal lifetime exposure to physical "intimate partner violence" (IPV) and sexual IPV were associated with

[3] Adjusted for SES, maternal age, child gender, and preterm delivery.

stunting in offspring (69). Sobkoviak et al. (2012) found that mothers exposed to any form of sexual domestic violence in the previous year, were more than twice as likely to have stunted children vs. non-exposed mothers (70).

Maternal Autonomy/ Employment Status

Seven studies examined the effects of other maternal-related socioeconomic and demographic factors which were not commonly associated with childhood stunting. Shroff et al. (2009) found that mothers with higher autonomy - defined as access to money and freedom to travel to the marketplace - were less likely to have stunted children (aged < 3 years) (71). Medhin et al. (2010) found that at age 12 months, maternal autonomy was also associated with decreased stunting in infants (72). Paudel et al. (2012) found that "no maternal earnings" was strongly associated with stunting among children aged 6-59 months (73). Willey et al. (2009) found that employed mothers were less likely to have stunted children aged 30 months (74).

Kulwa et al. (2006) found that among children aged 6 to 24 months old, there was no significant association between a mother's employment status and childhood stunting (75). Urke et al. (2011) found a lower risk of having a stunted child among unemployed mothers, with a stronger association observed in the Andean population vs. the national sample

(40). Finally, Mamabolo et al (2004) found a negative, but statistically non-significant association between maternal unemployed status and child stunting (34).

Meta-analysis

The review pooled studies based on the measured maternal factor and summarised the median effect sizes in Table 2: Median Maternal Effect Sizes). The factor with the strongest protective effect for child growth was maternal higher education. A change from having no higher education to having a higher education lowered the odds of child stunting by 28% (median effect size: -0.284; n=3). Maternal secondary education lowered the odds of child stunting by 18% vs. no secondary education (median effect size: -0.187; n=4). Moving from no maternal education to primary education did not produce an effect on child stunting (median effect size: 0; n=4). The odds of child stunting were 27% higher for poorly, or non-educated mothers vs. educated mothers (median effect size: 0.276; n=16).

Concerning maternal height, being a taller mother (> 160 cm) lowered the odds of child stunting by 4% (median size effect: -0.041; n=4), while being a shorter mother (<148 cm) increased the odds of stunting by 46% (median size effect: 0.465; n=7). Regarding a mother's weight, being underweight (BMI < 18.5kg/m2) increased the

odds of stunting by 37% (median size effect: 0.375; n=6). Maternal exposure to domestic violence and mental health disorders produced relatively small effect sizes [(0.173; n=2) and (0.176; n=4), respectively], but still increased the odds of child stunting, in the exposed groups vs. the non-exposed groups by 17%. Pooled together, maternal autonomy and maternal employment lowered the odds of child stunting by 13% (median effect size= -0.136; n=4), while maternal unemployment had a stronger effect on child stunting vs. maternal employment and reduced the odds of stunting by 55% (median effect size= -0.552; n=2).

Discussion

The review revealed that maternal education is frequently studied as a factor of early childhood stunting, followed by maternal height and maternal weight. The other factors – maternal autonomy, employment and exposure to domestic violence – have been less frequently studied, in terms of effects on child stunting. Maternal height and weight are immediate factors in the causal pathway of stunting, which suggests the assumption of a biological gradient. Maternal mental health status and maternal autonomy/employment status are linked to a mother's ability to provide quality care for offspring and may be classified as intermediate factors. Low maternal education, being an underlying

cause of child stunting, is more amenable to influence adjustments in policy instruments, since education is linked to national institutions, but not directly tied to genetic and influences of child stunting.

Higher maternal education partly reflects the human capital investments made by a mother's parents during her childhood, but is not necessarily an indicator of past higher SES in many low-income countries, although some resources were evidently diverted from one area of household expenditure to support her education. Higher maternal education would certainly be an indicator of current higher SES, and reflects a mother's ability and knowledge to provide crucial resources during early childhood development. Both maternal height and weight have both genetic and epigenetic implications for the offspring's own linear growth, while maternal weight is often a function of a mother's socio-economic circumstances and, therefore, impacts her own child through the same social environment[4]. Maternal autonomy and employment suggest a mother has more power to determine the quality of care provided for a child, while maternal employment may also entail less time personally afforded to the care of

[4] Maternal overweight, though, may also induce epigenetic effects via gestational diabetes.

a child. Both maternal mental health issues and exposure to domestic violence convey the quality of and motivation for care of offspring.

At a regional level, Asia had the most studies featuring early childhood stunting, followed by South/Central America and Africa. All regions covered the effects of maternal education and maternal underweight.

Limitations

The results emerged from studies with different methodologies, sample sizes and target groups and, therefore, they are not necessarily comparable. The variability in the demarcations of short and tall maternal height was also a limitation, as was the cut-off point for underweight. The duration of full primary school education varied, for example, from 6-8 years, and variability was also observed for secondary school education and post-secondary school, but with minimal impact. Finally, given that pervasive malnutrition is highly prevalent in low income countries and some middle income countries, the findings are not necessarily transferrable to the developed countries' context.

Summary and Conclusion

Overall, the review confirms that maternal effects may help improve a child's height with the appropriate interventions. Therefore, appropriate investments extended to girls living in low-middle income countries may have long term benefits that spill-over to the next generation. Improved maternal nutritional status through nutritional interventions would reduce the negative effects on child stunting. Since there are few studies on the effects of maternal autonomy, the review cannot conclusively state that maternal autonomy mattered more in some regions and is, therefore, ill-equipped to provide policy recommendations. More regional data is, therefore, needed on the impact of psycho-social stress on early childhood stunting.

Figure 1: Search Results

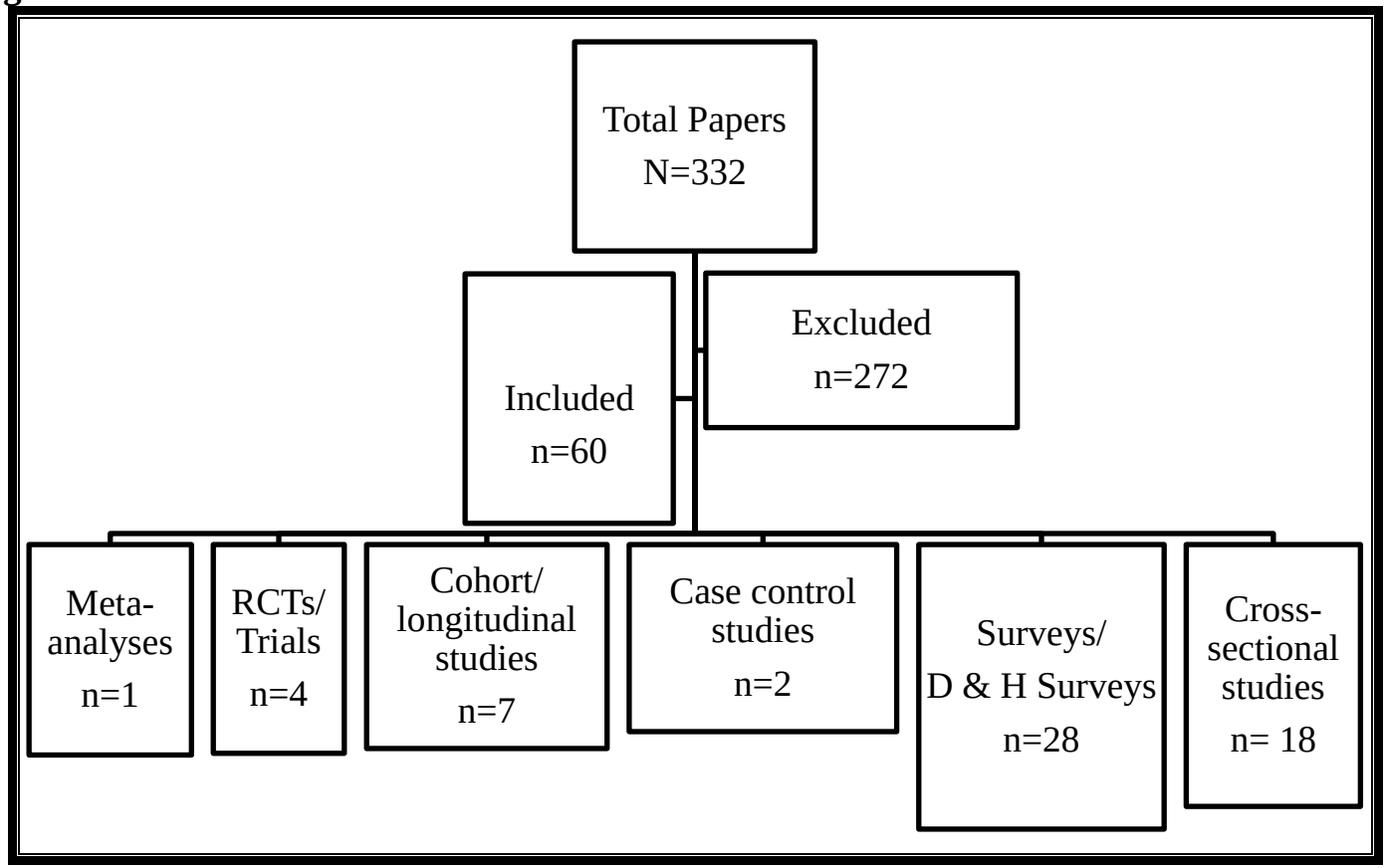

Table 1: Results and Findings

Authors	**Type of study**	**Measured association**	**Sample size**	**Place**/ Country
		Maternal Height/ Stature		
(16) Subramanian et al. (2010)	Nationally Representative cross-sectional sample, National Family Health Survey.	A 1-cm increase in height and child stunting at age 0-59 months. RR= 0.968 (95% CI: 0.967-0.968) A 1 unit increase of maternal BMI and child stunting at age 0-59 months. RR= 0.968 (95% CI: 0.968-0.969)	n=15,976	India
(17) Subramanian et al. (2009)	National Family Health Survey	Maternal height (< 145 cm) and child stunting at age 0-59 months RR= 1.947 (95% CI: 1.79-2.12; P<0.001)	n=50,750	India
(18) Ahmed at el. (2012)	National Nutrition Program, baseline survey	Maternal height (< 145 cm) at age < 2 years. OR=3.47 (95% CI: 2.91-4.12; P<0.01) Maternal BMI < 18.5 kg/m2 at age < 2 years.	n= 8,885	Rural Bangladesh

		OR=1.47 (95% CI: 1.24-1.74; P<0.01) Maternal primary education and child stunting at age < 2 years. OR=0.77 (95% CI: 0.64-0.93; P<0.01) Maternal secondary education at age < 2 years. 0.50 (95% CI: 0.31-0.79; P<0.01)		
(19) Huntsman & White (2007)	Survey	Found that maternal height was positively associated with HAZ, among preschoolers (using the CDC/WHO 1978 growth references)	n=691	Bali, Indonesia
(20) Jesmin et al. (2011)	Cross-sectional study	Short maternal height (≤ 148cm) was positively associated with stunting, among preschoolers. Low maternal education positively was associated with stunting (P=0.025), among preschoolers.	n=380	Dhaka city, Bangladesh
(21) Addo et al. 2013	Pooled analysis of 5 birth cohorts	Maternal height (<150.1 cm) and offspring's height at age 2 years. POR = 3.20 (95% CI: 2.80-3.60)	n=7630 mother-child pairs	Brazil, Guatemala, India, The Philippines, and

				South Africa
(22) Gewa & Yandell (2012)	Demographic and Health survey	Maternal height (<145 cm) reduced a child's height by 1.2 cm, adjusted for SES, at age 0–60 months.	n= 3793	Rural and urban Kenya
(23) Felisbino-Mendes et al. (2014)	Population based cross-sectional study	Maternal height (< 145cm) and child stunting at age 5-7 months. OR= 3.00 (95% CI: 1.57-5.74)	n= 4,258	Brazil
(24) Frojo et al. (2014)	Case-control study	Maternal height (131-164 cm) was positively associated with LAZ/HAZ at both age 6 and 12 months (P < 0.001).	n =169	Chimaltenango, Guatemala
(25) Hambidge et al. (2012)	Survey	Taller mothers and child stunting at age 2 years. aHR=0.96 (95% CI: 0.92- 0.99; P=0.02) Maternal higher education and child stunting at age 2 years. aHR=0.91 (95% CI: 0.85- 0.97; P=0.003)	n=412	Western Highlands of Guatemala
(26) McGrath et al. (2012)	Randomized feeding trial in HIV-1-infected women	Reducing maternal height by 1cm and child stunting at age < 5 years. OR=1.12 (95 % CI: 1.06-1.20)	n=338	Tanzania

(27) Casapia et al. (2007)	Household Survey	Maternal height and child stunting (150-160 cm) at age < 5 years. OR=0.60 (95% CI: 0.50-0.72; P<0.001) Maternal height (160 cm +) and child stunting at age < 5 years. OR=0.41 (95% CI: 0.33-0.51; P<0.001) Maternal Secondary/higher and child stunting at age < 5 years. OR=0.77 (95% CI: 0.61-0.98; P<0.05)	n=252	Peru
(28) Zottarelli et al. (2007)	Demographic and Health Survey	Maternal height and child stunting at age 0-5 years. Bangladesh: OR=0.91 (P<0.001) Vietnam: OR=0.88 (P<0.001) Ethiopia: OR=0.98 (P<0.001) Maternal primary education and child stunting at age 0-5 years.	n=15,573	Egypt

		Ethiopia: OR=0.78 (P<0.10) Maternal secondary education and child stunting at age 0-5 years. Bangladesh: OR=0.82 (P<0.10) Ethiopia: OR=0.65 (P<0.10) Maternal college education or higher and HAZ Vietnam: OR=0.52 (P<0.10)		
(29) Nguyen et al. (2014)	Cross-sectional survey	Found that maternal height was associated with stunting (< 150 cm), among children aged 0-59 months.	n=4219 n=3542 n=2578	Bangladesh Vietnam Ethiopia
(30) Rehman et al. (2009)	Longitudinal study	Maternal height (154.2 cm) and child stunting Mean difference=3.64 (95% CI: 1.42, 5.85) Maternal underweight (46.9 kg) and child stunting aged 6-23 months. Mean difference=2.74 (0.63, 4.85)	n=2168	

(31) Gibson et al. (2009)	Convenience sample	Maternal stature < 1.60 cm and child stunting at age < 5 years. OR=2.9 (95% CI: 2.0–4.3; P=0.00) Maternal BMI (<18.5 kg/m2) OR= 2.5 (95% CI: 1.4–4.4; P=0.00)	n=97	Sidama, Southern Ethiopia
(32) Bove et al. (2012)	Cross sectional study	Association between stunted mother and stunted child, among preschoolers OR=6.67 (95% CI: 1.39-32.0; P=0.007)	n=2046	Canelones, Uruguay
(33) Senbanjo et al. (2013)	Cross sectional survey	Positive association between maternal height and child stunting at age 1-12 months, with no statistical significance. Positive association between maternal primary education and child stunting at age 1-12 months, with no statistical significance. Negative association between maternal unemployed status and child stunting at age 1-12 months, with no statistical significance.	n=300 mother-child pairs	Lagos State, Nigeria

(34) Mamabolo et al. (2004)	Longitudinal, cohort study	Positive association between maternal height and child stunting at age 1-12 months, with no statistical significance. Positive association between maternal primary education and child stunting at age 1-12 months, with no statistical significance. Negative association between maternal unemployed status and child stunting at age 1-12 months, with no statistical significance.	n=134	Limpopo Province, South Africa
Maternal Underweight				
(35) Uthman (2009)	Survey	Maternal underweight and child stunting among preschoolers. Severe stunting: OR=2.53 (95% CI: 1.34-4.79) Moderate stunting: OR=2.37 (95% CI:1.47-3.83)	n=4007	Rural Nigeria
(36) Mostafa (2011)	Bangladesh Demographic and Health Survey	Maternal underweight and stunting OR=4.45 (95% CI: 1.04-18.94)	N=2096	Rural Bangladesh

(37) Goudet et al. (2011)	Household survey	Maternal underweight and stunting OR=4.45 (95% CI: 1.04-18.94)	n=143	Bangladesh
Maternal Education/ Education on Health or Nutrition Services				
(38) Reurings et al. (2013)	Survey	Maternal incomplete primary education and child stunting at age 6-60 months. National: OR= 1.872 (95% CI: 1.039-3.371; P<0.05) Andean: OR= 2.856 (95% CI: 1.245-6.551; P<0.05) Maternal unemployed status and child stunting at age 6-60 months. National: OR=0.583 (95% CI: 0.355-0.957; P<0.05) Andean: OR=0.135 (95% CI: 0.47-0.383; P<0.001)	n=299	Quetzaltenango, Guatemala
(39) Urke et al. (2011)	National DHS 2004-2006	Maternal no education and child stunting, aged 0-23 months OR=2.5 (95% CI: 1.4-4.4)	National: n=1426 Andes: n = 543	Peru

(40) Wamani et al. (2004)	Cross-sectional study	Maternal no education and child stunting, aged <5 years. Mean difference: 1.20 cm: P<0.001)	n=720 child/ mother pairs.	Hoima district, in western Uganda
(41) Mohsena et al. (2010)	The Bangladesh Demographic and Health Survey 2004	Mothers' illiteracy or lack of formal education and child stunting, aged 0-23 months. OR=3.476 (P<0.01)	n=4891	Bangladesh
(42) Sakisaka et al. (2006)	Cross-sectional study	Maternal no education or primary education and child stunting, aged <5 years ORs=1.6 (1993); 1.7 (1998); and 1.7 (2003)	n=755	Granada, Nicaragua
(43) Masibo & Makoka (2012)	Demographic and Health Surveys (1993, 1998, and 2003)	Maternal education status < secondary level and stunting in young girls, aged 1-5 years. OR=2.50 (95% CI: 1.54-4.03)	n=4757 n=4433 n=4892 n= 4958	Kenya
(44) Biswas & Bose (2010)	Cross-sectional study	Mothers with no education and child stunting at age 0-3 months. aOR=1.63 (95% CI: 1.14-2.33; P=0.025)	n=350 girls	West Bengal, India

(45) Olusanya et al. (2010)	Cross-sectional study	Maternal low education (< 7 years) and child stunting at age < 5 years. aOR=1.9 (95% CI: 1.5-2.5; P<0.001)	n=5888	Lagos, Nigeria
(46) Mukatay et al. (2010)	Cross-sectional survey	Positive association between low maternal education and child stunting at age < 5 years.	n=1963	Lubumbashi, DR Congo
(47) McDonald et al. (2012)	Survey	Maternal no education and child stunting at age < 5 years. aPOR= 2.9 (95% CI: 1.4-3.8)	n=2387	Tanzania
(48) Baig-Ansari et al. (2006)	Cross-sectional survey	Maternal no education and child stunting, aged 0-23 months. OR=2.1 (95% CI: 1.1-4.0)	n=399	Urban Pakistan
(49) Wamani et al. (2006)	Cross-sectional survey	Maternal low education and child stunting at age<36 months. OR= 2.31 (95% CI: 1.47-3.64; P=0.001)	n=720	Hoima district, in western Uganda

(50) Abubakar et al. (2012)	Cross sectional study design	Maternal low education and child stunting at age < 5 years. No education: OR=1.51 (P=0.001) 1-3 years: OR=1.32 (P=0.024)	n=423	Kilimanjaro region, Tanzania
(51) Gribble et al. (2009)	Sub-sample, family health survey	Maternal no education and child stunting, aged 6-11 months. OR=1.58 (95% CI: 1.36-1.83; P<0.01)	n=3853	El Salvador
(52) Meshram et al. (2013)	Community based cross-sectional study	Maternal no education and child stunting, aged < 5 years. OR=1.41 (95% CI: 1.27-1.56; P<0.01)	n=2729	Rural Madhya Pradesh, India
(53) Meshram et al. (2012)	A community based cross-sectional study	Positive association between no maternal education and child stunting, aged < 5 years. No significant association.	n=8355	9 States of India (Andhra Pradesh, Gujarat, Kerala, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Tamil Nadu and West Bengal)

(54) Meshram et al. (2012)	A community based cross-sectional study	Maternal full primary and child stunting, aged < 5 years, controlling for High SES. RR=1.27 (95% CI: 1.91-1.35)	n= 1172	Maharashtra, India
(55) Finlay et al. (2011)	Cross-sectional study, 118 Demographic and Health Surveys (1990 and 2008)	Maternal education (6+ years) and child stunting, aged 6- 36 months. OR=0.57 (95% CI: 0.37-0.89; P=0.013)	n=176,583	55 Low- and middle-income countries
(56) Pramod Singh et al. (2009)	Cross-sectional study	Maternal education (> 9 years) and child stunting ,aged 0-24 months Adjusted mean diff: 0.9 (95% CI: 0.3-1.4; p-trend=0.04)	n=443	Eastern Nepal
(57) Webb et al. (2009)	Randomized controlled trial	Positive association between linear growth and education (P=0.024)	n= 886	Dar es Salaam, Tanzania
(58) Grjibovski et al. (2004)	Community-based cohort study	Maternal higher education and stunting, in preschoolers OR=0.970 (95% CI: 0.969–0.971; P= 0.001).	n=1067	Severodvinsk, Northwest Russia

(59) Ozaltin et al. (2011)	109 Demographic and Health Surveys	Maternal education and stunting in preschoolers Middle school: OR=0.507 (P=0.000) Higher education: OR=0.185 (P=0.000)	n=735, 970	54 countries
(60) Som et al. (2007)	National Family Health Survey (NFHS-2)	Primary school education /less and child stunting, aged 0-42 months. OR=1.30 (95% CI: 1.11-1.52; P=0.001) Maternal education on complementary feeding and child stunting. aOR=1.26 (95% CI: 1.08-1.48; P=0.004)	n= 596, n=1033 n=2357	Bihar West Bengal Kerala, India
(61) Abuya et al. (2012)	Nairobi Urban Health and Demographic Surveillance System	Maternal education through healthcare services and child stunting at age 18 months. OR = 0.71 (95% CI: 0.53-0.94)	n=5156	Nairobi slums, Kenya
(62) Zhang et al. (2013)	Cluster-randomized, controlled trial	Maternal education through healthcare services and child stunting at age 18 months. OR = 0.71 (95% CI: 0.53-0.94)	n=599	Laishui, China

Maternal Depression/ Exposure to Violence				
(63) Avan et al. (2010)	Longitudinal birth cohort study	Positive association of maternal antepartum depressive symptom and stunting, at age 6–8 months (controlled for maternal and infant anthropometrics and SES).	n=891	Johannesburg, South Africa
(64) Nasreen et al. (2013)	Cohort study, population based study	Maternal depression or depressive symptoms associated with stunting, in children at age 6-30 months. OR= 1.4 (95% CI: 1.2-1.7)	n= 652	Bangladesh
(65) Surkan et al. (2011)	Meta-analysis	Mothers exhibiting depressive symptoms at age12 months. OR=2.17 (95% CI: 1.24, 3.81; P = 0.007)	n=13,923 mother and child pairs	11 developing countries
(66) Black et al. (2009)	Survey	Maternal common mental disorders and child stunting India: OR=1.4 (95% CI: 1.2-1.6) Peru: OR=1.1 (95% CI: 0.9-1.4) Vietnam: OR=1.3 (95% CI: 0.9-1.7) Ethiopia: OR=0.9 (95% CI: 0.7-1.2).	n=221	Rural Bangladesh
(67) Harpham et al. (2005)	Community based, cross sectional survey	Negative association between exposure to any form of violence during pregnancy and HAZ ($p<0.05$, adjusted for potential confounders) at age 24 months	n=2000	Urban and rural, India Peru Vietnam

				Ethiopia
(68) Asling-Monemi et al. (2009)	A substudy embedded into a community-based food and micronutrient supplementation trial	Maternal lifetime exposure to physical Intimate Partner Violence (IPV) and stunting in offspring, aged < 5 years. aOR=1.48 (95% CI: 1.23-1.79) Maternal exposure to sexual IPV and child stunting at age < 5 years. aOR=1.28 (95% CI: 1.02-1.61)	n=3164	Rural Bangladesh
(69) Ziaei et al. (2012)	Demographic Health Survey	Maternal exposure to any sexual domestic violence in the prior year and child stunting, aged < 5 years. aOR=2.23 (P< 0.01)	n = 2027	Bangladesh
(70) Sobkoviak et al. (2012)	Liberia 2007 Demographic Health Survey	Maternal exposure to any sexual domestic violence in the prior year and child stunting, aged < 5 years. aOR=2.23 (P< 0.01)	n=2467 mother-child dyads	Liberia
Maternal Autonomy/ Employment Status				
(71) Shroff et al. (2009)	Cross-sectional demographic, health and anthropometric data	Maternal autonomy and child stunting at age 6 months. aOR=1.11 (95% CI: 1.02-1.21)	n=821	Andhra Pradesh, India

(72) Medhin et al. (2010)	A population-based sample , Demographic surveillance site (DSS)	Mothers without earning and child stunting at age 6-59 months. OR=3.11 (95% CI: 1.26-7.65)	n=1065	Butajira, South-central Ethiopia,
(73) Paudel et al. (2012)	Community based case-control study	Employed mothers and child stunting at age 30 months aOR=0.60 (95% CI: 0.40-0.88)	n=354	Nepal
(74) Willey et al. (2009)	Birth to Twenty, cohort study	Employed mothers and child stunting at age 30 months aOR=0.60 (95% CI: 0.40-0.88)	n=1186	Johannesburg, South Africa
(75) Kulwa et al. (2006)	Cross-sectional study	Negative association between HAZ and the number of hours mothers worked outside the home, among children aged 6-24 months old.	n=100	Urban Dar es Salaam, Tanzania

Table 2: Median Maternal Effect Sizes

No.	Maternal exposure	Effect Size (Median Log Odds Ratio)[5]	Number of studies
1	MHE	-0.284	3
2	MSE	-0.187	4
3	MPE	0.000	4
4	MNE	0.276	16
5	MH (> 160 cm)	-0.041	4
6	MH (< 160 cm or <148 cm or < 145 cm)	0.465	7
7	MUW (< 18.5 kg/m2 or < 19 kg/m2)	0.375	7
8	MDS	0.176	4
9	MDV	0.173	2
10	MES	-0.136	4
11	MUE	-0.552	1
		TOTAL[6]	**56**

KEY

MH Maternal Height
MUW Maternal Underweight
MHE Maternal Higher Education
MSE Maternal Secondary Education
MPE Maternal Primary Education
MNE Maternal No Education/Low
MDS Maternal Depression/ Depressive Symptoms
MSV Maternal Sexual Violence
MES Maternal Employed Status/Maternal Autonomy
MUE Maternal Unemployed Status

[5] Since relative risk (RR) and prevalence odds ratio(POR) are similar to OR when certain conditions are met, the review has used log OR to represent RR and POR, in the pooled, median effect sizes.
[6] The total includes studies which have analyzed more than one maternal factor and, therefore, artificially inflating the total.

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