Research in Economics 80 (2026) 101168

Contents lists available at ScienceDirect

Research in Economics

journal homepage: www.elsevier.com/locate/rie

Research Paper

Mother's education and child malnutrition in developing countries: the mediating role of feeding choices

Francesca Luppi, Matteo Migheli *

Università degli Studi di Torino Lungo Dora Siena, 100 10153, Torino, TO, Italy

ARTICLE INFO

Keywords:
Maternal education
Child malnutrition
Feeding practices
Developing countries
Mediation model

ABSTRACT

A positive relationship exists between mother's education and children's health. However, the effect of mother's education on children's health may also be mediated by feeding practices. Using a sample of mothers with 0–6 months children in 39 developing countries, we investigate the association between mother's education and child malnutrition as mediated by feeding practices. Results show that mother's education is mediated by the infant feeding practices; the strength and the sign of the effect and of the mediation varies depending on the level of economic development and gender equality of the country.

1. Introduction

Mother's education is one of the most important protective factors for child health, in particular in developing countries. Highly educated mothers have more probably access to modern health services compared to lower educated mothers and the former usually have a lower fertility (Nitsche and Hayford, 2020; Bergsvik et al., 2021), which allows allocating more resources to each child. Finally, in most non-traditional societies, educated mothers exert a greater control over children health because the mother has more bargaining and decisional power in family relationships. Feeding practices are one of the most important choices that mothers take in the first months of life of their children (Daniels, 2019).

Children undernutrition is still a major problem in several countries of sub-Saharan Africa (Akombi et al., 2017a). The World Health Organisation and the extant literature (Collins et al., 2016) show that exclusive breastfeeding in the first months of life is the best choice for children's health. Therefore, formula milk is recommended only when breastmilk is not available or sufficient, while any other food should be excluded during the pre-weaning phase. Nevertheless, the extremely variegated socio-economic conditions of mothers with new-borns in many developing countries, together with other contextual and cultural features, are often associated with a variety of nutritional practices (Abeshu et al., 2016). The question raised in this paper is whether education may mitigate the risk of inappropriate feeding choices, i.e., whether mother's education has is associated with a lower risk of child malnutrition[1] during the early phase of child life – 0–6 months – in developing countries. Following Colen and Ramey (2014) we hypothesise that the positive effect of maternal education on children's health goes also through feeding choices. Indeed, mothers choose how to feed their children, under the socio-economic constraints of their environment. Different levels of education may be associated with mothers' choice of different foods and/or practices within the set of those available. Indeed, education not only provides women with more information

* Corresponding author.
E-mail address: matteo.migheli@unito.it (M. Migheli).

[1] As further clarified in the text, malnutrition is here identified with feeding practices that engender overweight or underweight in children, though the possible outcomes of such a phenomenon are more varied.

https://doi.org/10.1016/j.rie.2026.101168
Received 29 May 2025; Accepted 30 July 2026
Available online 31 July 2026

about best practices and foods but allows also to better understand the information provided by informative campaigns and medical doctors. Feeding practices are therefore one of the ways, in which mothers' education translates into children's health. Should the data support the hypothesis that education of mothers is associated with choosing better feeding practices, this paper would offer an additional reason to combat female under-education in most of the developing economies.

As the next section shows, the literature finds mixed results on the effect of mother's education on child malnutrition. However, most of the extant works are either at the micro level, thus usually analysing country-specific, or, when they are comparative, at the macro level. This duality of approaches compromises the possibility of reaching general conclusions. Moreover, most of these studies focus on a single aspect of malnutrition (e.g., overweight or underweight). This paper, instead, proposes a study that tries to encompass the two aforementioned dimensions. Indeed, even though our study implies a micro-level analysis on a large sample of developing countries, we consider some contextual factors that seem to play a role in shaping the relationship between mother's education and child malnutrition. In particular, the level of economic development of countries may be associated with the degree of availability of formula milk or other baby foods,[2] while the level of women empowerment might be a proxy of the availability of ad hoc health services for women and policies for working mothers, which might sustain breastfeeding or healthy alternative feeding practices.

The data used are for a sample of women with a child aged 0–6 months, from 39 developing countries surveyed in the Demographic and Health Survey (DHS). Through mediation models, we estimate the association between mother's education and the risk of experiencing infant overweight and underweight, by mediating the relationship with four alternative feeding practices – i.e. exclusive breastmilk, exclusive formula milk, a mix of breastmilk and formula milk, and use of other alternative foods. Indeed, in some cases mothers may want to breastfeed their children, but do not have enough milk. Therefore, they resort to mixes of breastmilk and other foods, which may include formula milk or other, less appropriate, foods, such as different vegetable flours mixed with water. We try to understand the relationship that exists between socio-economic environment, education (as a mediator) and feeding practices by contrasting upper-middle income and low- and lower-middle income countries, while we take into account also for the level of gender inequality within each country.

Our results show that mother's education is generally associated with less child malnutrition, but such relationship is more evident in low- and lower-middle income countries.

2. Related literature

This review does not provide an exhaustive overview about child malnutrition and its causes, while it surveys the most relevant literature on the links between maternal education, child malnutrition and feeding practices. The definition of malnutrition[3] encompasses being under- and overweight conditions, while it includes other situations that are not covered by the present paper. Therefore, in this paper, malnutrition will be used in its limited meaning of under- or overweight.

Malnutrition is among the main causes of infant diseases, (Delisle and Batal, 2016), and underweight in particular is closely associated with higher mortality risk among children (Itay et al., 2018). The WHO operatively defines children's under- and overweight as the condition of those children falling, respectively, under the 2.3rd percentile or above the 97.7th percentile of the gender-specific infant weight-for-height distribution in the population.

Breastfeeding is one of the best practices to avoid child malnutrition: the World Health Organization has been highlighting this fact since years and provided empirical evidence supporting its campaigns in favour of breastfeeding (Mathur and Dhingra, 2014). Scherbaum and Srour (2016) review most of the extant literature and provide evidence that breastfeeding reduces not only children mortality, but also wasting, stunting, under- and over-nutrition, as long as it is not continued as the sole feeding practice after the 18th month of life of the child (Syeda et al., 2021). In particular, breastfed children are less likely to be underweight between 2 and 6 years of age and are less exposed to the risk of obesity at age 2 and more (Walters et al., 2019; Qiao et al., 2020; Dewey et al., 2021; Hummel et al., 2021; Li et al., 2022). Both the aforementioned outcomes emerge in particular when breastfeeding is compared to formula milk (Li et al., 2022). In other words, this practice reduces (although does not eliminate) malnutrition and health problems in early childhood. In addition, it is good both because the nutritional properties of breastmilk and because it protects against infections, transmitting maternal microbiotas to the child (Hummel et al., 2021; Layuk et al., 2021). Finally, breastfeeding is not only a feeding practice, but is also a way to establish a relationship between mothers and babies, so increasing its value also in terms of mental health of the child (Marshall et al., 2007).

The issue of breastfeeding is particularly relevant in developing countries, where *overweight* prevalence among children has been increasing during the last decades (the GBD 2015 Obesity Collaborators, 2017) and breastmilk may be unavailable or scarce because of mothers' undernutrition. In these countries, indeed, the literature finds the highest prevalence of child malnutrition due to lack of breastfeeding (Roy, 2019; Chakona, 2020; Menalu et al., 2021; Singh et al., 2021), which may depend on mothers' undernourishment (Ares Segura, 2016; Anik et al., 2019). In disadvantaged economic conditions, mothers substitute breastmilk with other foods, often according to cultural habits and local availability, so hindering their children's health as those foods are either under- or over-nourishing (Muhimbula and Issa-Zacharia, 2010). In addition, in developing countries, socio-economic factors are related to

[2] Of course, the level of economic development is likely to affect children health also through a number of other channels. However, discussing them would distract from the focus of the paper.

[3] The World Health Organization defines malnutrition as follows: "Malnutrition, in all its forms, includes undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity, and resulting diet-related non communicable diseases." (see https://www.who.int/news-room/fact-sheets/detail/malnutrition, lastly accessed on April 11th, 2020).

feeding practices differently than they are in advanced economies, thus suggesting the importance of studying these countries separately. In developing areas, mothers living in urban areas are less likely to breastfeed their children than women residing in the countryside (Amin et al., 2011). In addition, in poor environments, mothers tend to overtake fats and sugars, which then transfer to children via breastmilk; in such situations, breastfeeding may result in a higher risk of obesity than other foods (Magalhães de Melo et al., 2021).

In sum, the literature suggests that breastfeeding is generally protective for the children's health, although particular socio-economic factors may render it worse than formula milk (e.g. when mothers eat junk food), or may induce mothers to feed their children with inappropriate foods, such as vegetable flours. For these reasons, studying both the factors that induce women (not) to breastfeed and the socio-economic conditions that may either be associated with intake over-processed foods (for mothers) or to use inappropriate foods (for children) is important.

Several country-specific studies reveal a link between maternal education and child malnutrition, with the former that emerges one of the three main determinants of the latter (Vollmer et al., 2017; Katoch, 2022). There are several channels that may link these two variables. First, household socio-economic status is a determinant of child health (Katoch, 2022). Second, highly educated mothers access modern health services at a higher rate and have more decisional freedom about issues concerning children feeding and health because of their higher bargaining power in family relationships (Cui et al., 2019). Indeed, this factor is found to increase the positive role of household income on child health (Currie and Goodman, 2020). Several studies (see Katoch, 2022 for an extensive review) found that children obesity was more common in households with poorly educated mothers. Moreover, the literature shows that mothers with low levels of education fail to perceive their children as overweight, even when controlling for other socio-demographic characteristics such as household income, age, maternal BMI, race, smoking habits and child's gender (Freire et al., 2018). This may be one of the reasons why poorly educated women fail to choose adequate feeding practices for their children more often than highly educated women do. However, as the systematic review by Katoch (2022) suggests, the existing cross-sectional studies on the topic are inconclusive, as they provide mixed evidence.

However, results from cross-sectional and/or country-specific studies are not comparable for many reasons. First, they consider samples of children at very different ages. Second, for country-specific studies, the sample is not representative of the population of children and mothers. Third, the selection of the variables to control for differs quite a lot from one study to another. Finally, in cross-national studies the country selection can invalidate the generalisability of the results (Shrewsbury and Wardle, 2008).

Usually, mothers are those who choose how to feed their children; therefore, maternal education has a strong influence on such choices and on their consequences for the health of children (McPhie et al., 2014; Harrison et al., 2017). Some literature finds a positive relationship between maternal education and breastfeeding up to 6 months in developing countries (Zhao et al., 2017) which is recommended by the WHO as a way to prevent both child underweight and overweight (Horta et al., 2015). However, a number of mothers worldwide use formula milk, especially in combination with breastmilk, a mix that tends to increase the risk of an infant being overweight (Huang et al., 2018; Mueller and Blaser, 2018). However, if mother's milk is insufficient, formula milk is essential to address the risk of undernourishment. Yet, there is evidence that more educated and higher income mothers are able to provide both high quality breastmilk and better substitute to breastmilk without negative effects on child health, because of their better health knowledge and economic resources (Akombi et al., 2017b).

Regarding the relationship between mothers' education and feeding choices in developing countries, some works show that low-educated and poor mothers are more likely than the others to feed their children with inappropriate soft and hard foods, complementary to maternal milk. The evidence on this issue covers many developing countries (see Abeshu et al., 2016 for a review of the literature). Most of the studies surveyed by Abeshu et al. (2016) refer to single countries; however, using data on a number of countries, Shi et al. (2010) and Vollmer et al. (2017) find a negative relationship between mothers' education and children undernutrition, the last cited study using DHS data for 62 countries. In developing countries mother's education is a fundamental factor in determining the quality of the feeding: the higher the mother's education, the better the health conditions of her children, with lower risks of underweight and overweight with respect to the offspring of lesser educated women (Nguyen et al., 2018). The literature suggests that the effect of mother's – and father's to a lesser extent – education on children's health are possibly mediated by feeding choices (Jeong et al., 2018). This evidence is not restricted to low- and lower-middle income countries: for example, in Nicaragua, which is classified as medium-high income country, Contreras et al. (2015) show that mother's education and household's wealth are positively associated with both the non-exclusive use of breastfeeding and the administration of sugar-sweetened beverages and processed snacks in the first 12 months children's life.

The results previously summarised on the positive link between maternal education and healthy feeding choices suggest that the latter mediate the effect of the former on children's health. Indeed, education *per se* exists in power, but cannot affect children's statuses until it translates into practical choices that have some effect on children. Feeding choices stem from mothers' decisions, which are led also by their education: if different levels of schooling are associated with different feeding practices, then these last mediate the effect of maternal education (also) on children's health.

The extent to which mother's education translates into practical decisions, however, may depend on the decisional freedom of mothers themselves. This may be particularly relevant in developing countries, where high levels of gender discrimination and low women's empowerment co-exist (Mitchodigni et al., 2017; Na et al., 2018; Saaka, 2020). In particular, women use pre-maternal health services more in countries where women's empowerment indicators are higher (Ahmed et al., 2010), perhaps suggesting that empowered women are also better educated about feeding practices, and therefore feed their children better. Thus, we may expect that feeding practices are healthier in countries characterised by more empowered women. Nevertheless, Cunningham et al. (2015) show mixed evidence in the literature on South Asia. Cunningham et al. (2019) find a positive association between women's empowerment and children's health (assessed through child's length) within Nepal; however, Na et al. (2017) do not find any association between

women's empowerment and (appropriate or inappropriate) feeding practices in rural Pakistan, confirming the lack of clear evidence on this issue. In a similar vein, Bharati et al. (2008) found that in Indian regions with lower gender inequality, feeding practices and children's health are better, as mothers have higher levels of education and thus provide their children with better foods and practices. Ijarotimi (2013) suggests that women's empowerment is necessary to fight children's malnutrition, especially in development countries. For these reasons, the analysis presented in the next sections of the paper will address also the issue of women's empowerment.

A last caveat is in order before presenting data, methods, hypotheses and results: both the literature review and what follows refers to the "mother's choices" about feeding practices. However, it is noteworthy that the choice set may vary from a woman to another. Indeed, mothers who are not able to breastfeed, for instance, cannot choose breastmilk as food for their children. Nevertheless, the text of the paper will refer to the used option as to the "chosen option". In fact, it is anyway a choice between the other options available, even if the choice set is narrower than for other mothers.

3. Data and method

According to the WHO, the percentage of children who have low weight-for-height (underweight) represents "wasting" (i.e. low weight for height), indicating acute weight loss "stunting".[4]

The results of our study are based on the analysis of a sample of mothers and their children from 39 countries of the Demographic and Health Surveys (DHS), which is conducted by the United States Agency for International Development since 1984. The surveys cover 90 countries and collect data on several aspects of health, including socio-demographic characteristics of the households, family planning behaviours and attitudes, and the health conditions of their members. One if its modules specifically targets mothers and their children, providing detailed information on the child's and mother's health, pregnancy and delivery, and on the child's feeding practices.[5] Surveys are representative of the populations of their respective countries.[6] The surveys are conducted every five years and are designed to be comparable across and within countries. The execution of each survey generally requires about 20 months, from the design to data dissemination. A pilot survey precedes the collection of the data contained in the final datasets; this pilot allows to adjust the questions and the sample if needed. After these phases the final questionnaire is administered to the final sample and data collection for the final release takes between three and four months. Data cleaning and the writing of the report on the quinquennial survey follow the data collection. Datasets are therefore released about nine to ten months after the end of the collection.

We take the main data used in the paper from the aforementioned surveys, which are publicly available on the website of the programme (see footnote 5). Country selection in our study is driven by the availability of information on the main covariates included in the analysis (see Table 3A in the appendix for the full list of countries included in the analyses). The final dataset is cross-sectional and includes 39 developing countries, for which we took the last survey year available. The data used in the empirical analyses include only non-pregnant mothers and their children aged 0 to 6 months.

The original Indian survey includes a substantially larger number of respondents than the surveys conducted in the other countries in our sample. After restricting the data to non-pregnant mothers with children aged 0–6 months, the full eligible Indian sample contains 19,567 observations. Including all these observations in the pooled analysis would assign India a disproportionately large influence on the estimates for low- and lower-middle-income countries. To improve the balance across countries, we therefore used a random subsample of the eligible Indian observations.

Because this decision may reduce statistical precision and make the estimates sensitive to the particular random draw, we conducted a series of robustness checks. We re-estimated the relevant models using the full eligible Indian sample, the original random subsample, a new independent random subsample, and a specification excluding India entirely. The results obtained from the random subsamples are less precise, as expected given their substantially smaller number of valid observations. The magnitude of some point estimates also varies across random draws, and the sign of the maternal-education coefficient for underweight is not fully stable. However, the coefficients of maternal education remain statistically non-significant in all the alternative Indian-sample specifications. Moreover, excluding India does not produce substantively meaningful changes in the main results for the low- and lower-middle-income country group. Overall, the sensitivity analyses indicate that the paper's substantive conclusions are not driven by the inclusion of the Indian subsample, although subsampling entails a considerable loss of precision. The relative results are reported in the Appendix (Tables 4A and 5A).

Indeed, according to the World Health Organization, exclusive breastfeeding should be practice at least up to this age in order to prevent some health risks for the child, mainly related to immunization and malnutrition. Our final sample is made of 21,063 children for which we have complete information on their health status in terms of malnutrition, on their feeding practices, their mother's education, and on the main control variables included in the final model.[7]

Following the World Health Organization's (WHO) recommendations, child's malnutrition has been operationalized through two

[4] https://www.who.int/nutrition/nlis_interpretation_guide.pdf

[5] Detailed information about the surveys, including countries, variables, methods and the questionnaires used to collect data is freely accessible on the website of the DHS Programme: https://dhsprogram.com/Data/Guide-to-DHS-Statistics/index.cfm

[6] https://dhsprogram.com/Methodology/Survey-Types/DHS.cfm

[7] Anthropometric measurements are available only for living children. Because maternal education affects children's survival probability, the sample of living children over-represents children of educated mothers. Consequently, the effect of maternal education is likely to be slightly underestimated (Desai and Alva, 1998).

dependent variables: overweight and underweight. According to the WHO's Definitions (2006), the gender specific cut-off values of ±2 standard deviations of the infant weight-for-height[8] distribution in the population, which correspond to the 2.3rd and 97.7th percentiles, define respectively underweight and overweight. The DHS provides the information about the weight-for-height percentile of each child, calculated for her reference population. The weight-for-height parameter has been adopted because it is considered a reliable measure of the effect of chronic child malnutrition (Corsi et al., 2016) and socio-economic status (Rahman et al., 2016).

The other main variable of interest is mother's education, taken from the DHS dataset, which shows that, in our sample of countries, 30% of young women (20–35) have no education. This figure suggests that the average level of education in the sample is low and, therefore, tertiary education would be too restrictive for distinguishing women with high or low socio-economic status. Indeed, in our sample, only 6% of the mothers has tertiary education (consistent with Van Hook et al., 2013). However, secondary education is more widespread (32% of mothers in our sample has a secondary degree) and studies on the effect of education on malnutrition in developing countries consider it the typical threshold for high education (Still et al., 2017).[9] In addition, secondary education is more common in upper-middle than in lower-middle- and low-income countries. For this reason, selecting completed secondary education as threshold may be misleading, as the results would reflect also differences between richer and poorer countries in the sample. To solve this problem, we include mother's education as dummy variable, that captures whether the woman falls above or below the median educational level in her country. Noteworthily, the duration of compulsory education obviously affects the final level reached by citizens; therefore, the variable of interest may depend on national policies, which are accounted for by controlling for the number of years of compulsory education in each country.

Concerning feeding practices, the DHS provides detailed information on the type of food received by the child, but not about the frequency, preventing us to understand which is the prevalent feeding practice when more than one is used. For this reason, we categorise feeding practices as follows:

1. child is fed exclusively with breast-milk;
2. child is fed exclusively with formula-milk;
3. child is fed exclusively with a combination of breast-milk and formula-milk;
4. child is fed also with other food than breast-milk and formula-milk.

Other variables have been included in our model, to control for traditional confounders in malnutrition studies. The selection of these controls follows the extant literature on the determinants of breastfeeding and is based on survey papers (e.g., Still et al., 2017; Takahashi et al., 2017) and other articles on the topic. A first and often relevant issue is the physical condition of the mother, which may be proxied by her age and Body Mass Index (BMI) (Castillo et al., 2016). Indeed, undernourished or obese women may have problems in breastfeeding their children. A second factor, which is particularly relevant in developing countries is the accessibility of health services prior to the birth[10] (Sharma and Byrne, 2016; Brown, 2017). As Yaya et al. (2016) show, this may depend also on the household wealth, as financial resources are necessary to access private health structures, the fact of living in urban or rural area, as health services are generally located in the first. Analyses include also the number of other children aged <5 in the household, which is an indicator of birth-spacing, which may affect feeding decisions according to Damtie et al. (2021). Finally, we control for the household wealth, by including the quintile of the household wealth index as provided within the DHS dataset.[11] Information on mother's occupation or work status cannot be included as its availability is limited in some DHS surveys.

We have previously discussed the reasons why gender equality (as a proxy of women's empowerment and a more gender-egalitarian culture and institutional setting) is relevant, as it may be linked to mothers' education and give them many life-style options and decisional power while choosing feeding practices. Additionally, a more gender-egalitarian setting can provide women with more accessible information and services to support mother's and child's health. However, in developing countries women's emancipation and empowerment might be particularly costly, as these countries may provide scarce welfare support (e.g. maternal leaves, breastfeeding leaves, etc.) to women who are both working and caring their new-borns. In addition, breastfeeding in traditional societies may be unseemly (Stone and Smith, 2022). Therefore, the use of formula milk might become a common and even preferred feeding practices when compared to breastfeeding. The level of women empowerment comes from the 2016 UN's Gender Inequality Index (GII), which measures gender inequalities in three spheres:

1. *reproductive health*, measured by the maternity mortality ratio and adolescent birth rates;
2. *empowerment*, measured by the proportion of parliamentary seats occupied by females and the proportion of adult females and males aged 25 years and older with at least some secondary education;
3. *economic status*, expressed as labour market participation and measured by labour force participation rate of female and male populations aged 15 years and older.

[8] The weight-for-height indicator is provided within the DHS dataset; the indicator has been calculated based on the 2006 WHO Child Growth Standards. More information are available here: https://dhsprogram.com/data/Guide-to-DHS-Statistics/Nutritional_Status.htm

[9] Higher education is usually associated with high socio-economic status; therefore, educated mothers tend to concentrate in more developed areas. Given this disproportionate concentration, maternal education may be a proxy of higher access to a better health systems within the country (Desai and Alva, 1998).

[10] The prior health-service utilization is at least partly due to the availability and accessibility to them, but also to the mother's education.

[11] More details on its calculation are available here: https://dhsprogram.com/topics/wealth-index/Wealth-Index-Construction.cfm

The variable enters the analysis as a dummy, taking value 1 for the countries whose level of gender inequality falls above the second tertile of the distribution of the GII in our sample, thus representing the most gender-unequal countries. The introduction of this variable may cause endogeneity, as some characteristics of a country (e.g., welfare grants) may correlate with both gender inequality and children's health. However, mothers are observed at the individual level, while gender equality is assessed at the country level; while this mitigates endogeneity it does not solve it completely. However, the use of an instrumental variable approach is complicated by the multifaceted and complex nature of the GII. Li (2022) and Xu et al. (2023) propose the origin of the country legal system as instrument; however, when several African and Asian countries are included in the sample, the origin of legal systems becomes complex, as many countries employ combinations of European and traditional systems. Given the difficulties to find a suitable instrument, to alleviate the problem of potential endogeneity, the GII enters the empirical analyses as a dummy variable. Indeed, if entered as its magnitude at the country level, the GII would have simply represented a country fixed effect, thus representing the characteristics of each country, some of which affect the outcome variable. Instead, the dummy represents peculiarities that are common to group of countries included in the category. This reduces the relevance of the country-specific characteristics, capturing instead those common factors that reduce (or increase) the level of gender equality and may affect the outcome variable. Of course, the variable still includes several different aspects, but de-linking it from each country attenuates the bias engendered by the possible presence of endogeneity.

Similar concerns also apply to maternal education, which is the main explanatory variable in this paper. Maternal education may be correlated with unobserved characteristics such as family background, cognitive ability, preferences for investment in human capital, partner characteristics, and household resources. Since these factors may also influence child feeding practices and health outcomes, omitted-variable bias cannot be completely ruled out. If these omitted characteristics are positively correlated with both maternal education and child health, the estimated coefficient on maternal education is likely to overstate the association between education and children health, as it would partly capture the influence of correlated family and socioeconomic characteristics. Nevertheless, from a policy perspective, maternal education remains an informative predictor of child health because it summarises a set of characteristics – including knowledge, skills, and socioeconomic advantages – that are jointly associated with better child outcomes. Finally, the inclusion of the Gender Inequality Index partly accounts for cross-country differences in women's opportunities and institutional constraints, thereby reducing the risk that country-level gender disparities confound the estimated relationship. Therefore, although this does not eliminate potential endogeneity arising from unobserved individual and household characteristics, it may mitigate part of the omitted-variable bias associated with cross-country institutional and cultural differences.

The mediated effect of child's feeding practices on the relationship between mother's education and child's malnutrition might differ according to the economic and institutional context. Consequently, we categorise countries according to their level of development, running separated models for the different country clusters. For consistency with the data used (which avoid the consequences of the COVID-19 pandemic), we use the World Bank's classification based on the 2016 GNI per capita in US dollars. Four categories are defined: low-income countries (<1005 US$), lower-middle income countries (1006 – 3955 US$), upper-middle income countries (3956 – 12,235 US$) and high income countries (>12,236 US$). No country in our sample belongs to the fourth category. Although the preliminary analysis showed no statistically significant differences in the prevalence of overweight and underweight between low-income and lower-middle-income countries, similarity in outcome prevalence alone is not sufficient to establish that the underlying associations are homogeneous. We therefore assessed the sensitivity of the findings to the pooling of low-income and lower-middle-income countries. Specifically, we estimated models interacting maternal education with an indicator distinguishing the two

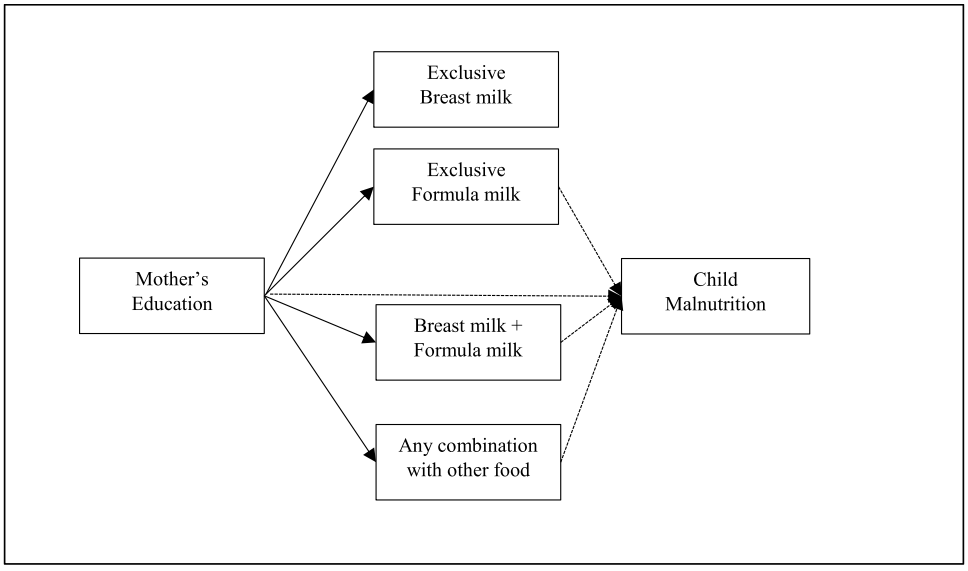

Fig. 1. Structure of the model.

income groups and calculated income-specific average marginal effects. These sensitivity models include the same individual- and country-level controls used in the main specifications. The interactions are not statistically significant for either overweight or underweight, indicating that the estimated association between maternal education and child malnutrition does not differ systematically between the two income groups. We therefore retain the pooled category in the main analyses to provide more precise and parsimonious estimates, while reporting the disaggregated results in Appendix Table 5A.

Finally, according to our hypothesis, the relationship between mother's education and child's malnutrition is mediated by the nutritional choices, and development may play a role in shaping the relationship itself. To test this hypothesis (see Fig. 1), we use the KHB decomposition method, implemented for the STATA software. The KHB is a general decomposition method for GLMs, which returns the degree to which a control variable mediates the relationship between the predictors and a latent outcome variable, underlying a nonlinear probability model. It compares the full-model (with all the covariates) with a reduced model that substitute some covariates with their residuals from a regression of the covariates on the mediators (see Karlson et al., 2011 for details).

4. Results

4.1. Descriptive analysis

Clustering our model according to the level of economic development of the country allows disentangling the context effect, which includes economic and institutional resources that might affect the relationship under study. As previously said, the World Bank indicator for the economic performance clusters our countries in three groups: low-income, lower-middle-income and upper-middle-income. However, the three clusters classification seems too sensitive for the aim of this study.

Different degrees of economic development are associated also with different scenarios of women's education. According to our data, in upper middle-income countries, mothers with at least secondary education are prevalent (68%). Finally, the level of country development is associated also with diverse infant feeding practices (see Table 1). In particular, in upper middle-income countries, exclusive or complementary use of formula milk is more widespread than exclusive breastfeeding.

4.2. The logit models

To test whether feeding practices mediate between mother's education and child malnutrition, we first run logistic models for overweight and underweight including only mother's education and the control variables. In this case, we aim to see whether mother's education has any significant relationship with child's health status. Feeding practices are added only in a second step: the mediation hypothesis is confirmed if feeding practices are significantly related to the child malnutrition outcome and, at the same time, mother's education loses – at least partially – its relationship with child malnutrition.

Firstly, the model was run separately on the two clusters of countries (i.e. upper middle income and low income), for both overweight and underweight. Results are shown in Table 2 and in Table 3.

In upper middle-income countries, mothers' education is not significantly related with the child's risk of being underweight. This outcome may depend on the measure of maternal education: indeed, in these countries, median education is higher than in low- and lower-middle income economies. If understanding that a child is underweight requires basic education, then being below or above the median is irrelevant in the set of richer countries. In addition, differently from poor countries, those in the group of upper middle-income have better healthcare services and lower poverty rates, which may contribute to reduce underweight and render it independent of maternal education. Finally, as education correlates with household income positively, in low- and lower-middle income countries, poor families may simply not afford to prevent their children from becoming underweight, while mothers in richer countries may afford sufficient food or access to healthcare facilities to avoid their children from becoming underweight. Hence, upper-middle income countries are excluded from additional analysis on underweight (presented further in this section). Instead, mother's education is positively related to the risk of being overweight. This result suggests that, in these countries, mothers with a high degree of education tend to overfeed their children or to provide them with inappropriate foods, which increases the risk of overweight. In low- and lower-middle income countries, high levels of mother's education are associated with a lower risk of overweight, but, as Table 2 suggests, the result is driven by gender equality (the inclusion of such a variable between the controls reverses the sign of the coefficient for mother's education). However, the risk of overweight depends on the inclusion or exclusion of the measure of gender equality in/from the regressions. As discussed further in the text, low- and lower-middle income countries seem to feature characteristics that explain why maternal education increases the risk of overweight in those countries.

Table 4 summarises these results, showing that high gender equality is always associated with a lower risk of malnutrition (resulting either in overweight or underweight). Instead, maternal education shows mixed associations: it is generally positive for overweight (especially after controlling for the gender equality index), suggesting that higher mother's education is linked to a higher risk of being overweight for children in all the groups of countries. Instead, the link is negative in the case of underweight in low and low-middle income countries, suggesting that, there children of highly-educated mothers show a lower risk of being underweight.

Fig. 2 provides graphical representation of the marginal associations of mother's education on each of the four feeding practices considered in the paper. The more significant effects are in the group of low- and lower-middle income countries, where levels of education above the median correspond to a higher probability of using exclusive breastfeeding and a lower probability of using combinations of different foods with respect to mothers, whose level of education is below the median. Maternal education does not display any statistically significant link with exclusive breastfeeding in upper-middle income countries; however, there is a slightly negative association between the propensity to use mixes of foods other than maternal and formula milk.

Table 1
Sample distribution across the dependent variables and the main covariates.

	Low Income	Upper-middle income
Proportion of:		
child overweight	26.71	38.27
child underweight	14.94	10.18
mother at least secondary education	38.54	67.8
exclusive breastfeeding	39.75	25.98
exclusive formula	1.65	6.62
breastfeeding + formula	6.01	22.1
other food	58.63	67.4
living in urban areas	30.38	51.4
Mean of:		
mother's age	26.6	27
number children < 5 years old	2.15	1.82
wealth index	2.81	2.72
mother's BMI	22.85	25.14
Sample size	7997	13,600

Table 2
Logit model for child's risk of being overweight, including control variables, among upper middle-income and low- and lower-income countries (Average Marginal Effects).

OVERWEIGHT	**Upper middle income**						**Low and lower-middle income**					
	Model 1			**Model 2**			**Model 3**			**Model 4**		
	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z
Individual level												
education above the median	0.043	0.024	0.076	0.041	0.024	0.089	−0.021	0.012	0.094	0.026	0.014	0.068
age	−0.002	0.002	0.163	−0.002	0.002	0.230	−0.002	0.001	0.009	−0.002	0.001	0.025
wealth	0.006	0.010	0.567	0.016	0.010	0.115	−0.002	0.005	0.657	−0.002	0.005	0.764
children age <5	−0.005	0.011	0.632	−0.017	0.011	0.112	−0.012	0.005	0.021	−0.017	0.006	0.003
urban	−0.005	0.026	0.847	−0.033	0.027	0.217	0.022	0.015	0.123	−0.026	0.017	0.126
bmi	0.011	0.002	0.000	0.011	0.002	0.000	0.011	0.002	0.000	0.012	0.002	0.000
Country level												
years compulsory education	0.006	0.003	0.037	0.009	0.003	0.001	−0.007	0.003	0.011	−0.006	0.003	0.023
high gender equality				−0.143	0.025	0.000				0.121	0.026	0.000

Table 3
Logit model for child's risk of being underweight, including control variables, among upper middle-income and low- and lower-income countries (Average Marginal Effects).

UNDERWEIGHT	**Upper middle income**						**Low and lower-middle income**					
	Model 1			**Model 2**			**Model 3**			**Model 4**		
	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z
Individual level												
education above the median	−0.003	0.014	0.826	−0.001	0.014	0.940	−0.039	0.008	0.000	−0.028	0.009	0.003
age	0.000	0.001	0.922	0.001	0.001	0.606	0.001	0.001	0.318	0.001	0.001	0.028
wealth	0.006	0.006	0.276	0.003	0.006	0.617	−0.003	0.003	0.405	−0.004	0.004	0.291
children age <5	0.006	0.006	0.296	0.008	0.006	0.139	0.007	0.004	0.040	0.007	0.004	0.060
urban	−0.013	0.016	0.398	−0.006	0.016	0.702	0.009	0.010	0.383	0.019	0.012	0.118
bmi	−0.001	0.001	0.501	−0.001	0.001	0.519	−0.005	0.001	0.000	−0.007	0.001	0.000
Country level												
years compulsory education	−0.011	0.001	0.000	−0.007	0.001	0.000	−0.003	0.002	0.111	−0.003	0.002	0.071
high gender equality				0.049	0.015	0.002				−0.065	0.024	0.007

Table 4
Summary of the previous results.

Outcome	Association with maternal education	Association with gender equality
Overweight (upper-middle income)	Positive *	Negative ***
Overweight (low and lower-middle income)	Positive (controlling for gender equality) * Negative (not controlling for gender equality) *	Negative *
Underweight (upper-middle income)	No statistically significant association	Negative ***
Underweight (low and lower-middle income)	Negative ***	Negative ***

Note: * indicates a p-value $\leq$ 0.01; * indicates a p-value between 0.1 and 0.05.**

The remaining three models have been run again adding the feeding practices among the predictors (Tables 1A and 2A in the Appendix[12]). For the risk of being overweight (Table 1A), in upper middle-income countries, the feeding practices seem not to mediate the relationship with mother's education. On the contrary, in low- and lower-middle income countries, the use of exclusive breastfeeding seems to mediate the relationship between mother's education and the child's risk of being overweight. In the model where the level of gender equality is not taken under control, mother's education is even more strongly associated with a reduction in the child's risk of being overweight when feeding practices are taken into account, while the relationship is no longer significant if the country level of gender equality is considered. In both cases, exclusive breastfeeding is positively related with the risk of overweight. On the risk of being underweight (Table 2A), in low- and lower-middle income countries, the use of exclusive breastfeeding seems to partially mediate the relationship with mother's education. Here exclusive breastfeeding shows a negative relationship with child malnutrition. In addition, the effect of gender equality appears to be relevant and positively linked to children's health in the most of cases, suggesting that the fight against gender discrimination is not only desirable for ethical reasons, but could also protect children's health.

Figs. 3 and 4 present the relationships between the different feeding practices and the risk of being overweight (Fig. 3) or underweight (Fig. 4) in low- and upper-middle-income countries. In these cases, statistically significant differences between feeding practices are present only in low- and lower-middle income countries, where exclusive breastfeeding is associated with an increase in the probability for children to be overweight, but the opposite is observed for being underweight when this practice is compared to the others. The evidence is thus mixed, as exclusive breastfeeding appears to be negatively associated with underweight, but the opposite holds for the risk of overweight.

In the light of these results, mediation models - in the next sub-section - have been tested only for low- and lower-middle income countries.

4.3. The mediation models

The output of the KHB model shows the estimated effect of the reduced model (total effect), the estimated effect of the full model (direct effect), and the estimated difference between these two effects (indirect effect). Results for overweight are reported in Table 5 and for underweight are in Table 6.

We see that mother's higher education is associated with a lower log odds for the child of being overweight of 0.12 when we do not control for the level of gender egalitarianism in the country. However, the relationship disappears in the model in which we control for gender egalitarianism. Controlling for feeding practices, the coefficient of mother education is augmented: here the log odds of being overweight declines by −0.15 (in the model without controlling for the level of gender egalitarianism), with an indirect effect of 0.03.

Results are much stronger in the models for underweight. In this case, controlling or not for the level of gender egalitarianism, mother's higher education has both a direct and an indirect link with the child's risk of being underweight. In particular, higher education is associated with a lower risk of underweight with a log-odds of 0.36 (in the model without controlling for gender egalitarianism): the magnitude of the direct link is 0.3, while the size of the indirect relationship (via feeding practice) is about 0.06.

Introducing the GII in regressions changes the results significantly. This calls for some additional comments on this variable. When the GII enters regressions, the most relevant change is in the association between mother's education and the risk of overweight in low- and lower-middle income countries. This change means that, only for low- and lower-middle income countries, the GII captures some characteristics common to this group of countries, which are negatively correlated with women education (such as traditional gender-discriminatory rules and uses). Once the regressions control for these factors, the size of the link between the level of education of mothers in low- and lower-middle income countries and the risk of overweight increases. This result may mirror a sort of insurance against starvation, still diffused in many poor countries: is may suggest that mothers who can afford feeding their children more than necessary (education is a proxy for income and wealth) may choose to do so to prevent them to starve in case of famine or other adverse events.

[12] To test the differences in the effect of mother's education on child malnutrition we run a model pooling all countries together and interacting the education variable with the dummy for the country level of economic development. Consistently with findings in Table 1A, we found that differences between low and upper-middle income countries are significant in the model of overweight among women with at least a primary education.

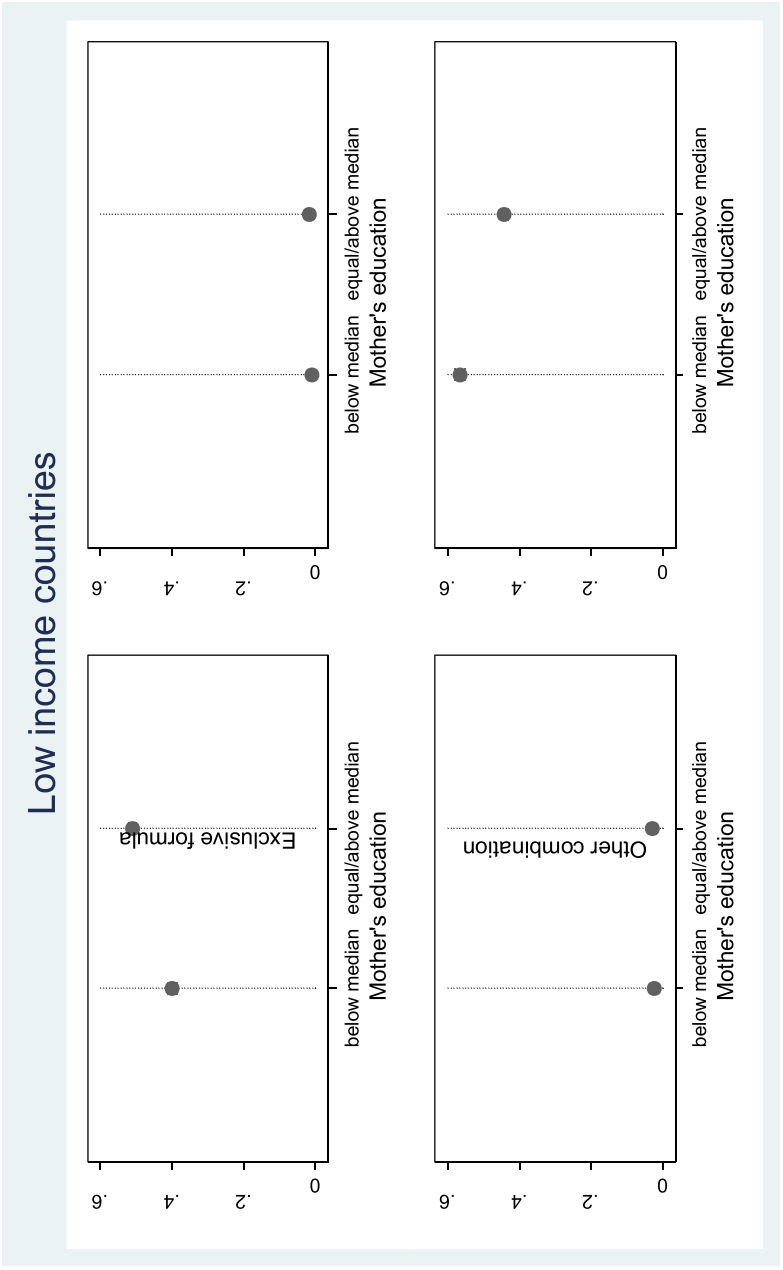

Fig. 2. Average marginal effects of mother's education on the four alternative feeding practices, for children aged <6 months in low- and lower-middle income countries (multinomial logit models, all control variables included).

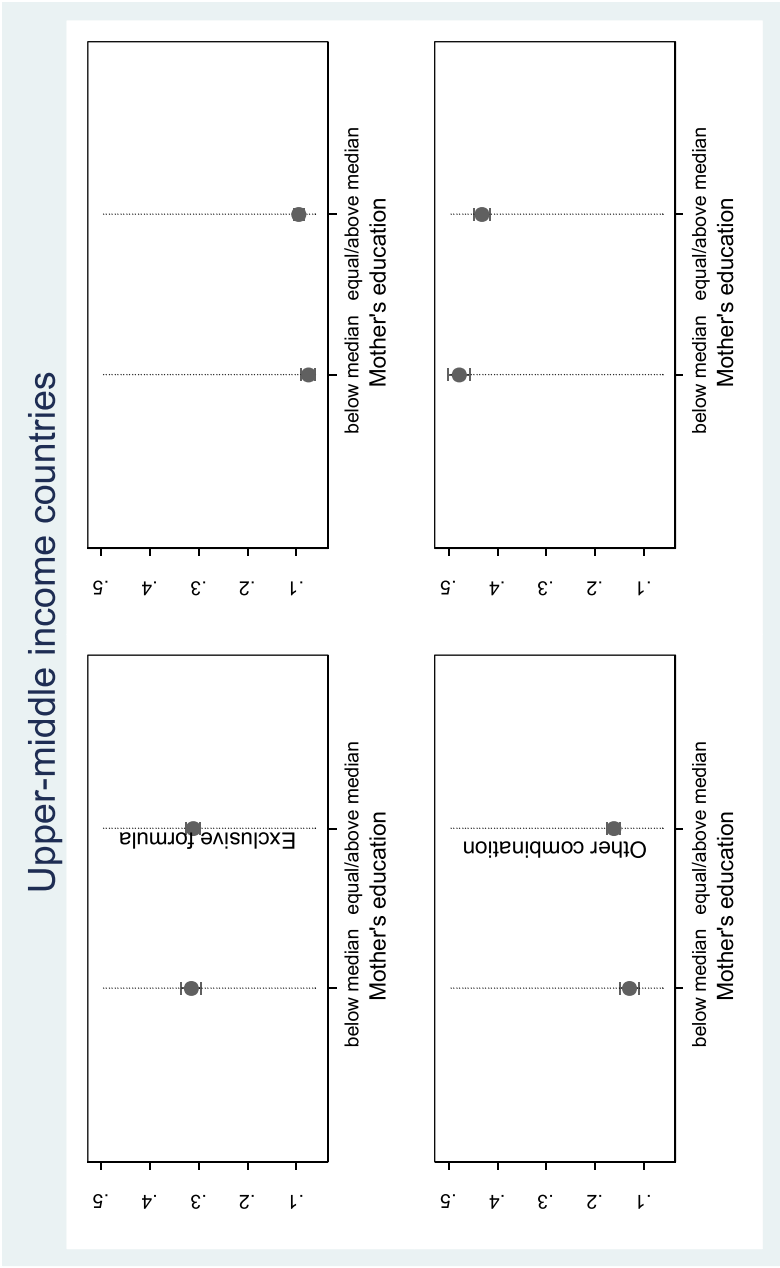

Fig. 3. Average marginal effects of the feeding practices on being overweight, for children aged <6 months in upper-middle- and low- and lower-income countries (all control variables included).

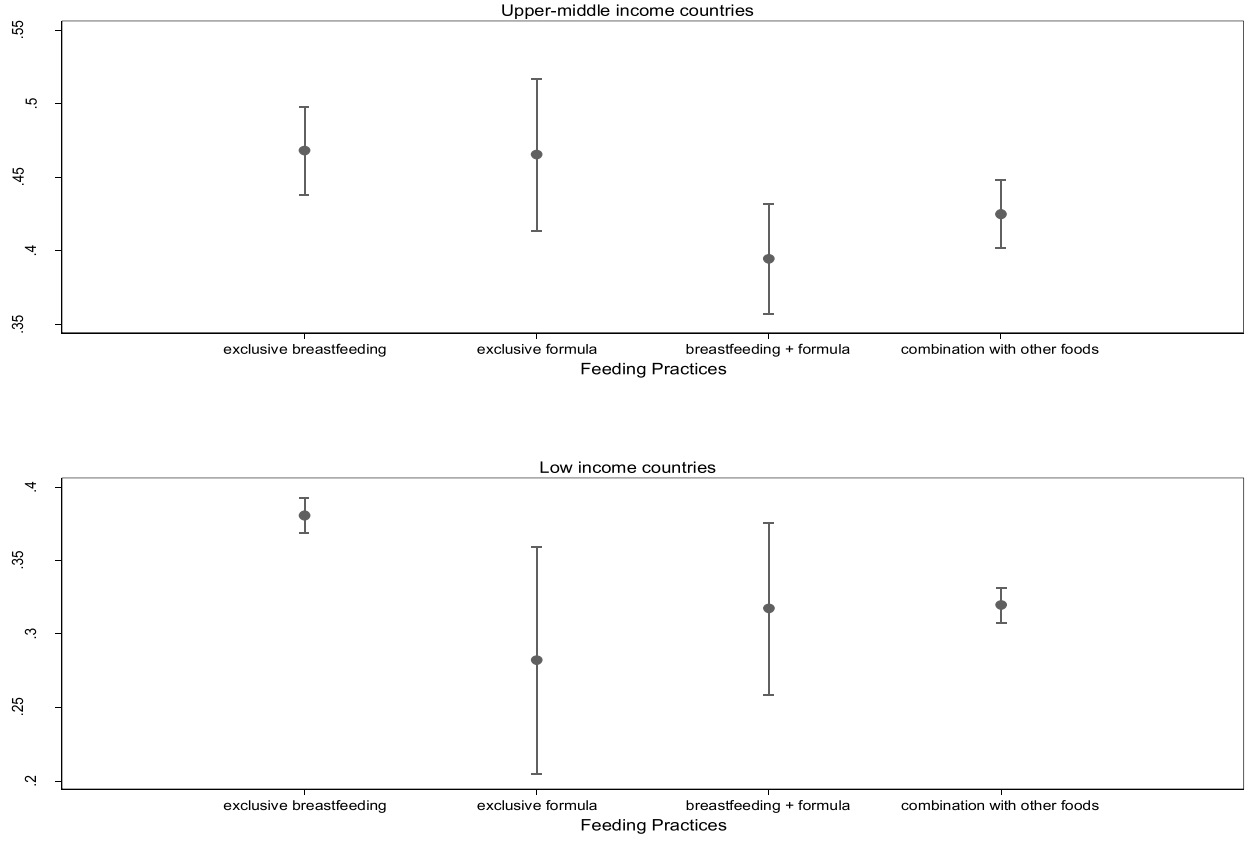

Fig. 4. Average marginal effects of the feeding practices on being underweight, for children aged <6 months in low income countries (all control variables included).

Table 5
Direct and indirect effect of mother's education on the child's risk of being overweight in low- and lower-income countries, mediated by feeding practices.

	Without gender equality			With gender equality		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Reduced	−0.123	0.050	0.015	0.074	0.060	0.218
Full	−0.155	0.051	0.002	0.043	0.060	0.476
Diff	0.032	0.008	0.000	0.031	0.008	0.000

Table 6
Direct and indirect effect of mother's education on the child's risk of being underweight, mediated by feeding practices.

	Without gender equality			With gender equality		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
Reduced	−0.362	0.070	0.000	−0.295	0.081	0.000
Full	−0.306	0.070	0.000	−0.261	0.081	0.001
Diff	−0.056	0.012	0.000	−0.033	0.011	0.002

5. Discussion and conclusions

The empirical analysis presented in this paper contributes to the debate about mothers' education and children's health in developing countries, by showing some new results in a relatively large sample of developing countries. The lack of studies on a large sample of countries may have hidden the complexity of the relationships between mother's education, feeding practices and outcomes in terms of children's health. The analyses presented in the paper reveal some mixed evidence on the relationship between mothers' education and the risk of children being over- or underweight. Models without mediators show that it is negatively associated with underweight and overweight in low- and lower-middle income countries, although for the second outcome gender equality plays a crucial role (but the coefficient of maternal education is not robustly different from 0 – see the fourth columns of Tables 1 and 3). The negative relationship between mother's education and overweight in low- and lower-middle income countries is instead robust to the inclusion of additional controls. In upper-middle-income countries, instead, mothers with high levels of education are more likely to have overweight children. Breastfeeding features a negative relationship with underweight in low- and lower-middle income countries, but it appears to be associated with higher risks of overweight in upper-middle-income countries. Other feeding practices do not appear to be associated with child malnutrition.

The contributions of this paper to the extant literature are mainly two. The first is providing wide empirical evidence on the role of feeding practices as meditators of mothers' education on children's health. From a policy point of view, such evidence suggests that investing in girls' and women's education would may improve also the choice of foods chosen for children, should the association between these two variables be causal. The second contribution is to provide some evidence about the relevance of gender equality and feeding practices. In this case, the policy implication of the results is to pay attention to the level of gender equality, when designing policies aimed at affecting feeding practices and choices, as mothers' responses may differ according to this variable. Moreover, as the promotion of gender equality is essential, its effects on side variables and policies should be accounted for.

In this paper mother's education is interpreted as mediated by feeding practices, while readers might take a different perspective, viewing the first as a moderator variable. However, the point of view taken in the analyses is as follows: when mothers choose how to feed their children, they evaluate the available (affordable) practices and then choose one (or a mix of some). In this process, maternal education can play a role through different channels, which are not directly tested in the paper, but constitute some ground for discussion in the light of the extant literature. One is the ability to process and understand the information relative to each practice; another is the mother's understanding of the importance of asking for and eventually following medical recommendations, which education helps to understand. In fact, more educated mothers are more likely to utilise medical services and advices than less educated women (Verma et al., 2016). In this sense, education affects children's health through the chosen feeding practices. This is true also under a diachronic perspective: both in the reasoning presented just before and in the data used in the analyses proposed in the paper, maternal education comes temporally before the choice of the feeding practice, which, therefore, mediates the effect of the first on the health of the babies. Assuming a production function perspective, the mother's education is the production function, while the feeding practice is the product, which is then used by the "customer" (the child). In this sense, the second mediates the first. Nevertheless, we recognise that maternal education may also have some moderation effect, as it may render the same feeding practice more effective in protecting children's health: more educated mothers might indeed use the same practice better, for instance by dosing its quantity better than less educated women. Moreover, as mentioned before, the possible presence of endogeneity in the estimations does not allow to conclude that the evidence shown in the previous section is (completely) causal.

However, the focus of the paper is not on how a given practice is used, rather it is the choice of a given practice. For this reason, the results presented in the previous section suggest that feeding practices are more a mediator of education, rather than the latter be a moderator of the relationship between the former and the children's health.

The complex picture that emerges from the paper suggests that, even though advising mothers to breastfeed their children is crucial

for sustaining children's health worldwide, both mother's education and economic and social features of the context are also relevant for children's health and some of these are absent from the current analyses, therefore constituting a limitation of them. This means that mother's education and her cognition about child's need are important resources to prevent child's malnutrition, even more than the simple adoption of a specific feeding practice during the first months of life of the child. Moreover, as our results suggest a strong relevance of the contextual resources, best policies are to be designed within single countries, where and when different socio-economic situations characterise different regions.

Additionally, the results suggest that women empowerment may improve the health of children. Nowadays, national and international institutions promote gender equality and women empowerment as central points of their development strategies. The results presented in this paper show that such programmes seem to be positively correlated to children health, in particular when they promote and support the education of women. Therefore, policies aiming at bettering off the health of suckling babies should share a common part supportive of economic growth (and perhaps income redistribution) and female education in general, while they need adjusting to local needs and peculiarities. Feeding practices clearly emerge as a major mediator factor between maternal education and health outcomes in low- and lower-middle income countries.

This paper presents also some limitations. Of course, many other factors than mother's education exist that may affect feeding practices. Employment status, religious rules, extra-household care provision, etc. may all be relevant. However, including deep analyses of these variables would have broadened the focus of this paper too much. A second limit is the use of cross-sectional data, which do not allow for studying the evolution of the phenomenon over time. Finally, as already highlighted, the analysis evaluates exclusive breastfeeding against all the other alternatives, including those involving also breastmilk as part of the food given to children. Disentangling all the options would have enriched the analysis and allowed for better understanding of the mechanisms linking mother's education and feeding choices; however, for the reasons discussed earlier in the paper, such a strategy was not feasible.

Future research should focus on the role that educative campaigns addressed to future mothers. Indeed, the sensitivity of feeding practices and their results to maternal education call for deepening our understanding about which education is more effective to improve children's health.

Data are publicly available

Footnotes 5 and 6 provide the links to the datasets.

CRediT authorship contribution statement

Francesca Luppi: Writing – original draft, Methodology, Data curation. **Matteo Migheli:** Writing – original draft, Methodology, Conceptualization.

Conflict of interest

The authors declare that they have no conflict of interest relative to the present paper.

Appendix

Table 1A
Logit model for child's risk of being overweight, including breastfeeding practices, among upper middle-income and low- and lower-middle income countries (Average Marginal Effects).

OVERWEIGHT	upper middle income						Low- and lower-middle income					
	without gender equality			with gender equality			without gender equality			with gender equality		
	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z	AME	Std. Err.	P>z
Individual level												
education above the median	0.043	0.024	0.081	0.042	0.024	0.082	−0.027	0.012	0.031	0.022	0.014	0.119
excl. Formula	0.086	0.042	0.038	−0.003	0.044	0.951	0.007	0.046	0.885	−0.099	0.056	0.079
excl. Breastfeeding	−0.025	0.034	0.470	−0.074	0.035	0.036	−0.046	0.034	0.171	−0.064	0.043	0.139
breastfeeding + formula	−0.002	0.028	0.939	−0.043	0.029	0.142	−0.051	0.011	0.000	−0.061	0.012	0.000
age	−0.002	0.002	0.189	−0.002	0.002	0.216	−0.002	0.001	0.008	−0.002	0.001	0.029
wealth	0.006	0.010	0.543	0.019	0.011	0.071	−0.002	0.005	0.652	−0.001	0.005	0.855
children age <5	−0.009	0.011	0.427	−0.019	0.011	0.083	−0.012	0.005	0.019	−0.018	0.006	0.002
urban	−0.011	0.027	0.668	−0.037	0.027	0.160	0.024	0.015	0.106	−0.025	0.017	0.139
bmi	0.012	0.002	0.000	0.011	0.002	0.000	0.011	0.002	0.000	0.012	0.002	0.000
Country level												
years compulsory education	0.005	0.003	0.070	0.007	0.003	0.017	−0.009	0.003	0.001	−0.009	0.003	0.001
high gender equality				−0.152	0.027	0.000				0.097	0.026	0.000

Table 2A
Logit model for child's risk of being underweight, including breastfeeding practices, among low- and lower-middle income countries (Average Marginal Effects).

UNDERWEIGHT	low income					
	without gender equality			with gender equality		
	AME	Std. Err.	P>z	AME	Std. Err.	P>z
Individual level						
education above the median	−0.035	0.009	0.000	−0.027	0.009	0.005
excl. Formula	0.038	0.036	0.284	0.127	0.056	0.023
breastfeeding + formula	0.066	0.028	0.018	0.066	0.037	0.074
Combination of others	0.039	0.008	0.000	0.027	0.009	0.002
age	0.001	0.001	0.306	0.001	0.001	0.036
wealth	−0.003	0.003	0.363	−0.005	0.004	0.210
children age <5	0.007	0.004	0.035	0.008	0.004	0.043
urban	0.007	0.010	0.527	0.017	0.012	0.161
bmi	−0.005	0.001	0.000	−0.007	0.001	0.000
Country level						
years compulsory education	−0.001	0.002	0.490	−0.002	0.002	0.282
high gender equality				−0.053	0.025	0.031

Table 3A
List of selected countries and last survey year available.

Country	Country code	Last survey year	Sample size (mothers with children < 6 months)
Albania	AL	2018	135
Armenia	AM	2016	172
Azerbaijan	AZ	2006	223
Bangladesh	BD	2014	531
Bolivia	BO	2008	769
Cambodia	KH	2014	442
Cameroon	CM	2011	503
Chad	TD	2015	1158
Congo	CG	2012	468
Congo Democratic Republic	CD	2018	971
Dominican Republic	DR	2013	83
Ethiopia	ET	2016	1068
Gabon	GA	2012	377
Guinea	GN	2016	365
Guyana	GY	2009	214
Haiti	HT	2017	427
Honduras	HN	2012	993
India	IA	2016	1689
Jordan	JO	2018	490
Kyrgyz Republica	KY	2012	426
Lesotho	LS	2014	156
Malawi	MW	2017	515
Maldives	MV	2017	218
Myanmar	MM	2016	442
Namibia	NM	2013	226
Nepal	NP	2016	200
Niger	NI	2017	633
Pakistan	PK	2018	336
Peru	PE	2014	773
Rwanda	RW	2017	337
Sao Tome and Principe	ST	2014	188
Senegal	SN	2017	926
Swaziland	SZ	2007	196
Tajikistan	TJ	2017	405
Togo	TG	2017	288
Uganda	UG	2016	471
Yemen	YE	2013	1586
Zambia	ZM	2014	1125
Zimbabwe	ZW	2015	538

Table 4A
Sensitivity of the estimated association between maternal education and child malnutrition to alternative treatments of the Indian sample.

	Full eligible sample	Original random subsample	New random subsample
Panel A. Overweight			

(*continued on next page*)

Table 4A (*continued*)

	Full eligible sample	Original random subsample	New random subsample
Maternal education above the median	−0.020	−0.101	−0.168
Standard error	(0.041)	(0.148)	(0.143)
p-value	0.620	0.494	0.241
95% confidence interval	[−0.100; 0.060]	[−0.390; 0.188]	[−0.448; 0.113]
Panel B. Underweight			
Maternal education above the median	−0.034	0.090	−0.116
Standard error	(0.039)	(0.141)	(0.136)
p-value	0.381	0.521	0.395
95% confidence interval	[−0.111; 0.042]	[−0.186; 0.366]	[−0.382; 0.151]
Observations	19,567	[1602]	1614

Table 5A
Sensitivity of the association between maternal education and child malnutrition to the pooling of low-income and lower-middle-income countries.

	Overweight			Underweight		
	AME	Std. Err.	p-value	AME	Std. Err.	p-value
Low-income countries	0.021	0.008	0.012	−0.068	0.008	<0.001
Lower-middle-income countries	0.004	0.012	0.760	−0.055	0.012	<0.001
Interaction test						
Education × lower-middle-income	−0.091	0.075	0.227	0.069	0.077	0.370
Wald χ^2	1.46		0.227	0.80		0.370

Notes: The group-specific estimates are average marginal effects. Interaction coefficients are estimated on the log-odds scale and should not be directly compared in magnitude with the average marginal effects. All models include the same individual- and country-level controls as the main specifications.

References

Abeshu, M.A., Lelisa, A., Geleta, B., 2016. Complementary feeding: review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries – Lessons from Ethiopia. Front. Nutr. 3, 41 article.

Ahmed, S., Creanga, A.A., Gillespie, D.G., Tsui, A.O., 2010. Economic status, education and empowerment: implications for maternal health service utilization in developing countries. PLoS One 5 (6), e11190.

Akombi, B.J., Agho, K.E., Merom, D., Renzaho, A.M., Hall, J.J., 2017a. Child malnutrition in Sub-Saharan Africa: a meta-analysis of demographic and health surveys (2006-2016). PlosOne 12 (5), e0177338.

Akombi, B.J., Agho, K.E., Hall, J.J., Wali, N., Renzaho, A.M., Merom, D., 2017b. Stunting, wasting and underweight in Sub-Saharan Africa: a systematic review. Int. J. Environ. Resour. Public Health 14 (8), 863 article.

Amin, T., Hablas, H., Al Qader, A.A., 2011. Determinants of initiation and exclusivity of breastfeeding in Al Hassa, Saudi Arabia. Breastfeed. Med. 6 (2), 59–68.

Anik, A.I., Rahman, M., Rahman, M., Tareque, I., Kahn, N., Alam, M.M., 2019. Double burden of malnutrition at household level: a comparative study among Bangladesh, Nepal, Pakistan and Myanmar. PLoS One 14 (8), e0221274.

Ares Segura, S., Arena Ansótegui, J., Díaz-Gómez, N.M., 2016. The importance of maternal nutrition during breastfeeding: do breastfeeding mothers need nutritional supplements? Anal. Pediatr. 84 (6), 347.e1-347.e7.

Bergsvik, J., Fauske, A., Hart, R.K., 2021. Can policies stall the fertility fall? A systematic review of the (quasi) experimental literature. Popul. Dev. Rev. 47 (4), 913–964.

Bharati, S., Pal, M., Bharati, P., 2008. Determinants of nutritional status of pre-school children in India. J. Biosoc. Sci. 40 (6), 801–814.

Brown, A., 2017. Breastfeeding as a public health responsibility: a review of the evidence. J. Hum. Nutr. Diet. 30 (6), 759–770.

Castillo, H., Santos, I.S., Matijasevich, A., 2016. Maternal pre-pregnancy BMI, gestational weight gain and breastfeeding. Eur. J. Clin. Nutr. 70, 431–436.

Chakona, G., 2020. Social circumstances and cultural beliefs influence maternal nutrition, breastfeeding and child feeding practices in South Africa. Nutr. J. 19, 47.

Colen, C.G., Ramey, D.M., 2014. Is breast truly best? Estimating the effects of breastfeeding on long-term child health and wellbeing in the United States using siblings. Soc. Sci. Med. 109, 55–65.

Collins, N.C., Bahndari, N., Hajeebohy, N., Horton, S., Lutter, C.K., Martines, J.C., Piwoz, E.G., Richter, L.M., Victoria, C.G., 2016. Why invest and what it will take to improve breastfeeding practices? Lancet 387 (10017), 491–504.

Contreras, M., Zelaya Blandón, E., Persson, L.-Å., Hjern, A., Ekström, E.-C., 2015. Socio-economic resources, child feeding practices, consumption of highly processed snacks and sugar-sweetened beverages: a population based survey on rural Northwest Nicaragua. BMC Public Health 15, 25.

Cui, Y., Liu, H., Zhao, L., 2019. Mother's education and child development: evidence from the compulsory school reform in China. J. Comp. Econ. 47 (3), 669–692.

Cunningham, K., Ruel, M., Ferguson, E., Uauy, R., 2015. Women's empowerment and child nutritional status in South Asia: a synthesis of the literature. Matern. Child. Nutr. 11 (1), 1–19.

Cunningham, K., Ferguson, E., Ruel, M., Uauy, R., Kadyiala, S., Menon, P., Ploubidis, G., 2019. Water, sanitation, and hygiene practices mediate the association between women's empowerment and child-length-for-age-z-scores in Nepal. Matern. Child. Nutr. 15 (1), e12638.

Currie, J., Goodman, J., 2020. Parental socioeconomic status, child health, and Human capital. In: Bradley, S., Green, C. (Eds.), The Economics of Education. Academic Press, Cambridge (MA).

Damtie, Y., Kefale, B., Yalew, M., Arefaynie, M., Adane, B., 2021. Short birth spacing and its association with maternal educational status, contraceptive use, and duration of breastfeeding in Ethiopia. A systematic review and meta-analysis. PlosOne 16 (2), e0246348.

Daniels, L.A., 2019. Feeding practices and parenting: a pathway to child health and family happiness. Annal. Nutr. Metab. 74 (S2), 29–42.

Delisle, H., Batal, M., 2016. The double burden of malnutrition associated with poverty. Lancet 387 (10037), 2504–2505.

Desai, S., Alva, S., 1998. Maternal education and child health: is there a strong causal relationship? Demography 35 (1), 71–81.

Dewey, K.G., Güngör, D., Donovan, S.M., Madan, E.M., Venkatramanan, S., Davis, T.A., Kleinman, R.E., Taveras, E.M., Bailey, R.L., Novotny, R., Terry, N., Butera, G., Obbagy, J., de Jesus, J., Stoody, E., 2021. Breastfeeding and risk of overweight in childhood and beyond: a systematic review with emphasis on sibling-pair and intervention studies. Am. J. Clin. Nutr. 114 (5), 1774–1790.

Freire, W.B., Waters, W.F., Rivas-Mariño, G., Belmont, P., 2018. The double burden of chronic malnutrition and overweight and obesity in Ecuadorian mothers and children, 1986–2012. Nutr. Health 24 (3), 163–170.

GBD 2015 Obesity Collaborators, 2017. Health effects of overweight and obesity in 195 countries over 25 years. N. Engl. J. Med. 377, 13–27.
Harrison, M., Brodribb, W., Hepworth, J., 2017. A qualitative systematic review of maternal infant feeding practices in transitioning from milk feeds to family foods. Matern. Child. Nutr. 13 (2), e12360.
Horta, B.L., de Mola, C.L., Victora, C.G., 2015. Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure, and type-2 diabetes: a systematic review and meta-analysis. Acta Paediatr. 104 (467), 30–37.
Huang, J., Zhang, Z., Wu, Y., Wang, Y., Wang, J., Zhou, L., Ni, Z., Hao, L., Yang, N., Yang, X., 2018. Early feeding of larger volumes of formula milk is associated with greater body weight or overweight in later infancy. Nutr. J. 17, 12 article n.
Hummel, S., Weiss, A., Bonifacio, E., Agardh, D., Akolkar, B., Aronsson, C.A., Hagopian, W.A., Koletzko, S., Krischer, J.P., Lernmark, Å., Lynch, K., Norris, J.M, Rewers, M.J., She, J.-X., Toppari, J., Uusitalo, U., Vehik, K., Virtanen, S.M., Beyerlein, A., Ziegler, A.G., the TEDDY Study Group, 2021. Association of breastfeeding with childhood autoimmunity, allergies, and overweight: the environmental determinants of diabetes in the young (TEDDY) study. Am. J. Clin. Nutr. 114 (1), 134–142.
Ijarotimi, O.S., 2013. Determinants of childhood malnutrition and consequences in developing countries. Curr. Nutr. Rep. 2 (3), 129–133.
Itay, A., Woo, J., Basu, R., Kaddourah, A., Goldstein, S., Kaplan, J., 2018. Increased mortality risk in underweight, not obese, critically ill children. Crit. Care Med. 46 (1), 247.
Jeong, J., Kim, R., Subramanian, S.V., 2018. How consistent are associations between maternal and paternal education and child growth and development outcomes across 39 lower-income and middle-income countries? J. Epidemiol. Community Health 72 (5), 434–441.
Katoch, O.R., 2022. Determinants of malnutrition among children: a systematic review. Nutrition 96, 111565.
Layuk, N., Sinrang, A.W., Asad, S., 2021. Early initiation of breastfeeding and gut microbiota of neonates: a literature review. Med. Clín. Pediátr. 4 (S1), 100222.
Li, Y., 2022. The impact of female empowerment on income inequality – evidence from 96 countries. Adv. Comput. Sci. Res. 101, 726–732.
Li, W., Yuan, J., Wang, L., Qiao, Y., Liu, E., Wang, S., Leng, J., 2022. The association between breastfeeding and childhood obesity/underweight: a population-based birth cohort study with repeated measured data. Int. Breastfeed. J. 17, 82.
Magalhães de Melo, J.M., Lemos Fontes Silva Dourado, B.L., Egito de Menezes, R.G., Longo-Silva, G., Cardoso da Silveira, J.A., 2021. Early onset of overweight among children from lower-income families: the role of exclusive breastfeeding and maternal intake of ultra-processed foods. Pediatr. Obes. 16 (12), e12825.
Marshall, J.L., Godfrey, M., Renfrew, M.J., 2007. Being a 'good mother': managing breastfeeding and merging identities. Soc. Sci. Med. 65 (10), 2147–2159.
Mathur, N.B., Dhingra, D., 2014. Breastfeeding. Indian J. Pediatr. 81, 143–149.
McPhie, S., Skouteris, H., Daniels, L., Jansen, E., 2014. Maternal correlates of maternal child feeding practices: a systematic review. Matern. Child. Nutr. 10 (1), 18–43.
Menalu, M.M., Bayleyegn, A.D., Tizazu, M.A., Amare, N.S., 2021. Assessment of prevalence and factors associated with malnutrition among under-five children in Debre Berhan town, Ethiopia. Int. J. Gen. Med. Volume 14, 1683–1697.
Mitchodigni, I.M., Hounkpatin, W.A., Ntandou-Bouzitou, G., Avohou, H., Termote, C., Lennedy, G., Hounhouigan, D.J., 2017. Complementary feeding practices: determinants of dietary diversity and meal frequency among children aged 6-23 months in Southern Benin. Food Secur. 9, 1117–1130.
Mueller, E., Blaser, M., 2018. Breast milk, formula, the microbiome and overweight. Nat. Rev. Endocrinol. 14 (9), 510–511.
Muhimbula, H.S., Issa-Zacharia, A., 2010. Persistent child malnutrition in Tanzania: risks associated with traditional complementary foods (a review). Afr. J. Food Sci. 4 (11), 679–692.
Na, M., Aguayo, M., Arimond, M., Narayan, A., Stewart, C.P., 2018. Stagnating trends in complementary feeding practices in Bangladesh: an analysis of national surveys from 2004 to 2014. Matern. Child. Nutr. 14 (S4), e12624.
Na, M., Aguayo, V.M., Arimond, M., Stewart, C.P., 2017. Risk factors of poor complementary feeding practices in Pakistani children aged 6-23 months: a multilevel analysis of the Demographic Health Survey 2012-2013. Matern. Child. Nutr. 13 (S2), e12463.
Nitsche, N., Hayford, S.R., 2020. Preferences, partners, and parenthood: linking early fertility desires, marriage timing, and achieved fertility. Demography 57 (6), 1975–2001.
Nguyen, P.H., Avula, R., Headey, D., Tran, L.M., Ruel, M.T., Menon, P., 2018. Progress and inequalities in infant and young child feeding practices in India between 2006 and 2016. Matern. Child. Nutr. 14 (S4), e12663.
Qiao, J., Dai, L.-J., Zhang, Q., Ouyang, Y.-Q., 2020. A meta-analysis of the association between breastfeeding and early childhood obesity. J. Pediatr. Nurs. 53, 57–66.
Rahman, M.S., Howlader, T., Masud, M.S., Rahman, M.L., 2016. Association of low-birth weight with malnutrition in children under five years in Bangladesh: do mother's education, socio-economic status, and birth interval matter? PlosOne 11 (6), e0157814.
Roy, P.M., 2019. Malnutrition in children and its determinants: a study from East India. Trop. Doct. 49 (2), 113–117.
Saaka, M., 2020. Women decision making autonomy and its relationship with child feeding practices and postnatal growth. J. Nutr. Sci. 9, e38.
Scherbaum, V., Srour, M.L., 2016. The role of breastfeeding in the prevention of childhood malnutrition. In: Biesalski, H.K., Black, R.E. (Eds.), Hidden Hunger. Karger, Basel.
Sharma, I.K., Byrne, A., 2016. Early initiation of breastfeeding: a systematic literature review of factors and barriers in South Asia. Int. Breastfeed. J. 11, 17.
Shi, L., Zhang, J., Wang, Yan, Caulfield, L.E., Guyer, B., 2010. Effectiveness of an educational intervention on complementary feeding practices and growth in rural China: a cluster randomised control trial. Public Health Nutr. 13 (4), 556–565.
Shrewsbury, V., Wardle, J., 2008. Socioeconomic status and adiposity in childhood: a systematic review of cross-sectional studies 1990–2005. Obesity 16 (2), 275–284.
Singh, M., Alam, S., Majumdar, P., Tiwary, B., Narzari, H., Mahendradhata, Y., 2021. Understanding the spatial predictor of malnutrition among 0-2 years children in India using path analysis. Front. Public Health 9, 667502.
Still, R., Marais, D., Hollis, J.L., 2017. Mothers' understanding of the term ìexclusive breastfeeding': a systematic review. Matern. Child. Nutr. 13 (3), e12336.
Stone, C., Smith, J.P., 2022. The visibility of breastfeeding as a sexual and reproductive health right: a review of the relevant literature. Int. Breastfeed. J. 17, 18.
Syeda, B., Agho, K., Wilson, L., Maheshvari, G.K., Raza, M.Q., 2021. Relationship between breastfeeding duration and undernutrition conditions among children aged 0-3 years in Pakistan. Int. J. Pediatr. Adolesc. Med. 8 (1), 10–17.
Takahashi, K., Ganchimeg, T., Ota, E., Vogel, J.P., Souza, J.P., Laopaiboon, M., Castro, C.P., Jayaratne, K., Ortiz-Panozo, E., Lumbiganon, P., Mori, R., 2017. Prevalence of early initiation of breastfeeding and determinants of delayed initiation of breastfeeding: secondary analysis of the WHO global survey. Sci. Rep. 7, 44868.
Van Hook, J., Altman, C.E., Balistreri, K.S., 2013. Global patterns in overweight among children and mothers in less developed countries. Public Health Nutr. 16 (4), 573–581.
Verma, S., Kumar, V., Singh, P., 2016. Managing childhood diarrhoea at homes in India: an opportunity to reduce child morbidity and mortality. Infect. Dis. Health 21 (4), 176–183.
Vollmer, S., Bommer, C., Krishna, A., Harttgen, K., Subramanian, S.V., 2017. The association of parental education with childhood undernutrition in lower- and middle-income countries: comparing the role of paternal and maternal education. Int. J. Epidemiol. 46 (1), 312–323.
Walters, C.N., Rakotomanana, H., Komakech, J.J., Stoeker, B.J., 2019. Maternal determinants of optimal breastfeeding and complementary feeding and their association with child undernutrition in Malawi (2015-2016). BMC Public Health 19, 1503.
World Health Organization, 2006. WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development. World Health Organization, Geneva, Switzerland.
Xu, S., Asiedu, M., Effah, N.A.A., 2023. Inclusive finance, gender inequality, and sustainable economic growth in Africa. J. Knowl. Econ.y 14, 4866–4902 in press.
Yaya, S., Bishwajit, G., Shah, V., 2016. Wealth, education and urban-rural inequality and maternal healthcare service usage in Malawi. BMJ Glob. Health 1, e000085.
Zhao, J., Zhao, Y., Du, M., Binns, C.W., Lee, A.H., 2017. Maternal education and breastfeeding practices in China: a systematic review and meta-analysis. Midwifery 50, 62–71.