Social Determinants of Child Health in Colombia: Can Community Education Moderate the Effect of Family Characteristics?

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Abstract

Contextual effects on child health have been investigated extensively in previous research. However, few studies have considered the interplay between community characteristics and individual-level variables. This study examines the influence of community education and family socioeconomic characteristics on child health (as measured by height and weight-for-age Z-scores), as well as their interactions. We adapted the Commission on Social Determinants of Health (CSDH) framework to the context of child health. Using data from the 2010 Colombian Demographic and Health Survey (DHS), weighted multilevel models are fitted since the data are not self-weighting. The results show a positive impact of the level of education of other women in the community on child health, even after controlling for individual and family socioeconomic characteristics. Different pathways through which community education can substitute for the effect of family characteristics on child nutrition are found. The interaction terms highlight the importance of community education as a moderator of the impact of the mother's own education and autonomy, on child health. In addition, the results reveal differences between height and weight-for-age indicators in their responsiveness to individual and contextual factors. Our findings suggest that community intervention programmes may have differential effects on child health. Therefore, their identification can contribute to a better targeting of child care policies.

Key words: Child health, community education, maternal education, cross-level interactions, Colombia.

Introduction

The effects of maternal education on child health outcomes have been examined extensively in the literature. However, the debate surrounding the causality of the relationship between these variables remains open. While many authors state that the mother's education can contribute positively to child health (Barrera, 1990; Caldwell, 1979; Hobcraft et al., 1984), others argue that the correlation between maternal education and child health may be spurious (Desai & Alva, 1998; John Hobcraft, 1993). Desai and Alva (1998), for example, find that after controlling for community of residence and household socioeconomic condition, the role of maternal education is attenuated. The authors suggest that education may act as a proxy for the community and family socioeconomic context.

It is possible that the characteristics of context explain some of the pathways through which education influences child health, above and beyond the mother's own education. In other words, that the individual-level perspective may fail to capture the full effect of education (Kravdal, 2004; Moestue & Huttly, 2008).

Although previous studies have examined the impact of the education of other women in the community on child health (Alderman et al., 2003; Andrzejewski et al., 2009; Gessner et al., 2010; Kravdal, 2004, 2010; Moestue & Huttly, 2008; Osorio, Bolancé, & Madise, 2012; Parashar, 2005), there is little evidence for differences in child health when individual characteristics interact with community education.

Better-educated mothers can take greater advantage of other women's education, since they may be more likely to adopt healthier diets, understand relevant information about disease and undertake training in health practices, as well as having a greater access to health services (Hatt & Waters, 2006). In such cases, community education will complement the effect of maternal education on child health. In contrast, less educated mothers may benefit relatively more from community education, indicating that individual and community education may act as substitutes (Barrera, 1990; Thomas et al., 1991).

Identifying the pathways through which community education can affect child health is very important in terms of policy making. "By knowing why and how maternal education affects child health, it may be possible to duplicate these channels in less costly and less roundabout programs other than a general education campaign" (Barrera, 1990, p.71).

This study contributes to the literature on contextual effects on child health by examining the role of community education on child health and possible interaction effects between community education and family characteristics, such as the mother's own education and autonomy. Moreover, we use a multilevel approach, taking into account important methodological issues such as sample weights and second level endogeneity in multilevel modelling, which have not been addressed in the empirical literature and could lead to biases in the estimates.

The main aim of this study is to identify whether the education of other women in the community influences child nutrition and the extent to which this influence may moderate the effects of family socioeconomic characteristics on child health, and if so, which groups of mothers and, consequently, which group of children, benefit more from communities with a higher level of education. This is an important policy tool since interventions seeking to improve child health by improving the socioeconomic conditions of the community could be particularly effective if targeted to specific population groups.

Conceptual framework

In order to obtain a better understanding of the differences in health status, their determinants and consequences on health inequities, the Commission on Social Determinants of Health (CSDH) was set up in 2005 by the World Health Organization (WHO). The CSDH conceptual framework highlights the importance for policy-making of the distinctions between the social factors that influence health and the social processes that determine their unequal distribution, giving special attention to the context and structural mechanisms that give rise to or strengthen social stratification (Solar & Irwin, 2010).

The conceptual framework is shown in Figure 1. The framework includes two key components of health inequities: structural determinants and intermediary determinants. The framework shows how the causes of health inequities are rooted in the socioeconomic and political context, which give rise a set of socioeconomic positions, whereby societies are stratified mainly according to income, education, occupation, gender, and ethnicity. These socioeconomic positions in turn have an indirect effect on health status, since they operate through a set of specific determinants (intermediary determinants) of health to shape health inequities (Ibid, 2010).

Figure 1 Conceptual framework of social determinants of child health

Source: Adapted from Solar and Irwin (2010)

Colombian context

Colombia is a unitary republic divided into 32 departments (primary administrative subdivisions) and one capital district (Bogotá), which is treated as a department. In turn, departments consist of municipalities (secondary administrative subdivisions). There are 1,103 municipalities, which are the fundamental territorial entity of the political-administrative subdivision. Municipalities have political, fiscal and administrative autonomy.

With a gross national income (GNI) per capita of $8,315 (constant 2005 PPP US dollars) and a Gini index of 58.5, Colombia is an upper-middle income country, but one of the most unequal countries in the world (UNDP, 2011). Approximately 34% of Colombians live in poverty and 11% in extreme poverty (DANE, 2012)

The country is currently on track to meet the Millennium Development Goals. In terms of child health Colombia has advanced in indicators such as global malnutrition (87%), chronic malnutrition (71%), infant mortality rate (83%) and under-five mortality rate (84%) (DNP, 2011) (figures in brackets represent % achievement of respective goal). However, despite this progress, national averages remain masking huge territorial disparities.

Colombia, as well as other Latin American countries, faces the double burden of over and undernutrition (Neufeld et al., 2010). While the levels of undernutrition among

children under five years old have been reduced in the country, the number of overweight children has increased. In fact, the prevalence of stunting has declined from 32% in 1965 to 9% in 2010 and the proportion of underweight children has dropped from 21% to 5% in the same period. Between 2005 and 2010, children who suffered from excess weight increased from 3.1% to 4.8% (Ojeda et al., 2011).

In the last few years, reducing inequity among departments and care in early childhood have been two of the priorities of the Colombian Government. Evidence of this is provided by the Childhood and Adolescence Code – Act 1098 in 2006, and Act 1295 in 2009. Likewise, the document CONPES 109 issued in 2007 and the current National Plan of Development 2010-2014, reflect the interest in child-oriented public policies. The most recent strategy designed by the Colombian Government, titled *"De cero a siempre"*, aims to coordinate both public and private institutions at the national and territorial level, in order to promote the development of all Colombian children aged 6 or under according to their age, context and living conditions.

Nevertheless, previous studies on social determinants of child health in Colombia are limited (Acosta, 2012; Flórez & Nupia, 2001; Gaviria & Palau, 2006; Osorio, Bolancé, & Madise, 2012; Tovar & García, 2007). Most of them have covered the issue from the perspective of the individual but little attention has been paid to the effect of context, with a few exceptions. Osorio et al. (2012), for instance, investigate the influence of community socioeconomic context, finding significant contextual effects on intermediary determinants of child health. Among these intermediary factors, the authors include variables related to the access and use of the health system and variables linked to parenting style. Against this background, understanding the structural and intermediary determinants of child health inequities, as well as the role played by community context, is essential for the design, monitoring and tracking of public child care policies in Colombia.

Data and methods

Data

The data used in this analysis were obtained from the 2010 Colombian Demographic and Health Survey (DHS). The survey has been carried out every 5 years since 1990 by Profamilia. This is a non-profit private institution and the main provider of sexual and reproductive health services in the country. The Colombian DHS is nationally representative and covers the urban and rural areas of 6 regions (Caribbean, Eastern, Bogotá, Central, Pacific, and Amazon and Orinoco), 16 subregions and 33 departments (administrative subdivisions).

The DHS sample was obtained through a stratified, multistage and cluster sampling design. The sample included 51,447 households in both urban and rural areas of 258 municipalities. Within municipalities, households with geographical proximity were

grouped to form clusters (primary sampling units, PSUs) with an average of 10 households. We used these sampling clusters as proxies for community.

The sample included a total of 17,443 children between the age of 0 and 59 months who were alive at the time of the interview. The data on antenatal care, delivery conditions and postpartum were collected only for the last child born alive (n=14,296). In order to investigate the effect of father's education on child health, the sample was restricted to children whose mothers had partner/husband at interview. Moreover, for this group of women, issues concerning autonomy are relevant. No significant changes in the results of the variables of interest were seen in models excluding mothers without a partner. Finally, for all variables included in the study, values of "don't know" or "missing" were excluded, since no significant differences between these cases and those included in the final sample were observed. Thus, our final sample comprised 10,165 children aged between 0 and 59 months and for whom we had complete information.

Variables

Dependent variables: height-for-age and weight-for-age

We used two anthropometric measures, height-for-age Z-scores (HAZ) and weight-for-age Z-scores (WAZ), as dependent variables. These indicators capture different dimensions of a child's health and are considered suitable measures of child health status (Bicego & Boerma, 1993). HAZ is an indicator of the linear growth of a child and reflects cumulated child health conditions. It is, therefore, a good measure of long-term social conditions. WAZ, by contrast, is a medium-term measure of health: a low WAZ score can reflect both acute and chronic malnutrition. While a deficit in height is difficult to correct, a deficit in weight can be overcome later in childhood if nutrition improves (UNICEF, 2009; Uthman, 2009).

According to the WHO, a child is stunted (chronically malnourished) when their height-for-age Z-scores are two standard deviations below the reference population median for the relevant sex and age group. In the same way, underweight (globally malnourished) and wasted (acutely malnourished) children are those defined as having weight-for-age and weight-for-height Z-scores lower than two standard deviations, respectively. The descriptive analysis is based on malnutrition rates. In the multilevel analysis we use the Z-scores as dependent variables.

Independent variables

We included, as explanatory variables, a set of background controls, intermediary determinants and structural determinants both at the family and community level, which are likely to influence a child's health.

-Background controls

Child-specific variables (age in months, age-squared, sex and birth order and preceding birth interval), mother's characteristics (age at first birth in years, body mass index, and

level of autonomy) and household characteristics (number of under-five children and place of residence) were considered into the models. The mothers' autonomy was represented by a composite index based on their decisions regarding their own health care, large and daily household purchases, visits to family or relatives, food to be cooked, husband's salary, studying and having sexual intercourse.

-*Intermediary determinants*

Following the approach proposed by Osorio et al. (2012), two composite indicators were included as intermediary determinants. The first groups variables linked to the use and access to the health system, such as: i) the number of antenatal visits during pregnancy (0, 1-3 visits or 4 or more), ii) whether or not the mother received a tetanus injection during pregnancy, iii) the person who attended the delivery (doctor or others), iv) the place of delivery (health institution or others), v) whether or not the child received the third dose of polio vaccine and vi) whether or not the child has a health card.

The second index represents behavioural and psychosocial factors. The index combines into a single measure variables related to: i) nutritional habits (breastfeeding: never, up to 2 years or more than 2 years), ii) physical activity (mother or household member spent time with child in physical activities in the last week: never, once, 2-4 times or 5 or more times), iii) playing activities (the frequency the mother played with child in the last week: never, once, 2-4 times or 5 or more times), iv) parenting style (whether or not the mother punishes the child physically), v) child's care (the person who cares for the child when the mother is out of home: the mother takes the child with her, the father, grandparents or others) and vi) presence of partner at home (whether or not the mother is cohabitating with her partner).

In order to generate the weight of the variables and take into account the discrete nature of the data, all composite indicators were constructed employing principal component analysis (PCA) using polychoric correlations (Kolenikov & Angeles, 2009; Olsson, 1979). The STATA (version 12) commands "*polychoric*" and "*polychoricpca*" were used to estimate the polychoric correlations and perform the PCA.

-*Structural determinants:*

Community-level variables. The key variable in this study is community education. The variable is measured as the mean years of the mother's education in the community by aggregating individual-level data. In order to avoid an overlap of the measures between the two levels of analysis, the values of the variable were derived from non-self means. We used information from the total of mothers included in the full sample (n=53,521).

Family-level variables. A set of *structural determinants* at the family-level was considered: i) mother's education (in years), ii) partner's education (in years) and iii) household socioeconomic status index, categorized into quintiles. The index is based on ownership of consumer durable goods (radio, TV, fridge, motorcycle and car/ truck) and

quality of housing (source of drinking water, type of toilet facility, floor and wall material and whether the household has electricity). The mother's occupation was also considered. However, preliminary results showed that this variable did not significantly contribute to the model, and, as such, was excluded from the analysis.

Statistical analysis: Multilevel models

The role of community education on child health was examined using multilevel models. This study took into account important methodological issues such as sample weights and second level endogeneity in multilevel modelling, which have not been addressed in the empirical literature and can lead to biases in the estimates.

Multilevel modelling allows us to take into consideration the hierarchical structure of the data and explore variations between and within clusters. In hierarchical data such as DHS data, individuals from the same cluster tend to be more similar among themselves than individuals from different groups. Consequently, the assumption of independence of observations on which standard statistical tests are based, is violated. Thus, if clustering is not considered, standard errors will be underestimated, confidence intervals will be too narrow and p-values will be too small, giving rise to spurious significances (Steele, 2008).

Multilevel models not only allow us to obtain statistically efficient estimations of the regression coefficients, they also enable us to analyse variables at different levels simultaneously (Hox, 2010). In other words, they enable us to investigate the extent to which differences in child health are accounted for by contextual characteristics. Furthermore, estimating the variance at each level allows us to differentiate between the variation in child health due to differences at community-level and those that are the result of differences in family characteristics.

One of the advantages of using multilevel modelling is the possibility for analysing interactions between variables at different levels. The aim is to determine whether variables at the group level may moderate lower-level relationships (Hox, 2010).

In this analysis, interaction terms between community education and family-level variables were included. We explored the characteristics of the mothers and households that may be influenced by the level of education in the community, such as the mother's education, her level of autonomy, the use of maternal and child facilities (represented by our health system index) and the household's socioeconomic status. The aim was to test whether living in a community with better-educated mothers can moderate the impact of family characteristics on child nutrition and, if so, how such an impact can be differentially influenced by the community education context.

In this study, given that the number of children per mother and mother per household is very small, children, mothers and households were placed in the same category of family. Thus, two-level regression models were fitted with 10,165 families (Level 1),

nested within 3,481 communities (Level 2). The models had the following general specification:

$$y_{ij} = \beta_0 + \sum_{k=1}^{p} \beta_k X_{kij} + \sum_{l=1}^{q} \beta_l Z_{lj} + \sum \beta_{kl} X_{kij} Z_{lj} + (u_j + e_{ij}), i = 1,\ldots,10165, j = 1,\ldots 3481, \qquad (1)$$

where y_{ij} is the Z-score of the height-for-age or weight-for-age for the ith child in the jth community; β_0 is the intercept parameter; X_{kij} refers to the family-level covariates; Z_{lj} refers to the community education; $X_{kij} Z_{lj}$ is the cross-level interaction; e_{ij} and u_j are the random errors at the family and community levels, respectively. These random errors are assumed to follow a normal distribution with mean zero and variances σ_e^2 and σ_u^2.

Like most of the samples from the DHS, the sample design of the Colombian DHS incorporated sampling weights in order to reduce the estimation bias that occurs as a result of unequal selection probabilities. However, many authors have argued that the use of sampling weights in the context of multilevel models is not straightforward and should be treated with caution (Asparouhov, 2004; Pfeffermann et al., 1998; Rabe-Hesketh & Skrondal, 2006). Multilevel models that incorporate sampling weights use pseudo maximum likelihood estimation, where weights enter into the function at different levels of the hierarchy, and hence, the inclusion of the level-1 weights is not sufficient. Moreover, in order to include design weights properly, it is also necessary to scale them (Carle, 2009).

Despite this, weights and scale can be incorporated into the model with Stata12 through the estimation command "xtmixed". Our DHS sample included only an overall weighting variable for individual level observations. Following Goldstein (1999), we calculated level-2 weights (w_j) from the individual-level weights (w_{ij}):

$$w_j = \frac{\sum_i w_{ij} / n_j}{\left(\sum_j \sum_i w_{ij} / n_j\right) / J} \qquad (2)$$

where J is the total number of clusters. Given that we have small cluster sizes (on average 13 households per community), we used the "effective" method for standardizing weights so that the level-1 weights sum to the effective cluster size (Carle, 2009).

Level 2 endogeneity in multilevel model estimations has been investigated in the recent literature (Grilli & Rampichini, 2006; Snijders & Berkhof, 2008), although few empirical studies have considered this an important issue in the analysis (Hanchane & Mostafa, 2010). Normally, endogeneity arises when unobserved covariates affecting the

outcome variable are correlated with the observed independent covariates included in the model. In this paper, we explore problems with second level endogeneity in multilevel estimation of child health outcomes. That is, in the case where omitted community variables (random effects) are correlated with family characteristics (first level covariates).

Level 2 endogeneity arises when level 2 errors (u_j) are correlated with a level one independent covariate (X_{ij}). Thus, $E(u_j \mid X_{ij}) \neq 0$ and, therefore, standard estimators are inconsistent for β (Grilli & Rampichini, 2006).

The existence of level 2 endogeneity can be detected using the Hausman specification test (Hausman, 1978). Here, we compare a fixed effects model containing only family characteristics, given that community effects are fixed, with our random effects model containing both family and the community level variable of interest. The null hypothesis is that the random effects u_j are not correlated with any of the family's variables (absence of endogeneity). If the null hypothesis holds, then the estimates of the coefficients for the random effects model are both consistent and efficient. By contrast, if the null hypothesis is rejected, the random effects model suffers from endogeneity, and then the fixed effects specification is preferred (the estimates of the coefficients are consistent but not efficient) (Grilli & Rampichini, 2006).

Results

Descriptive analysis

As in most countries, chronic malnutrition (stunting) in Colombia persists as a problem of greater magnitude than underweight or wasting. Figure 2 shows that while stunting affects 9.7% of children under the age of five, the percentage of underweight children is approximately half that and 3.3% of children suffer both.

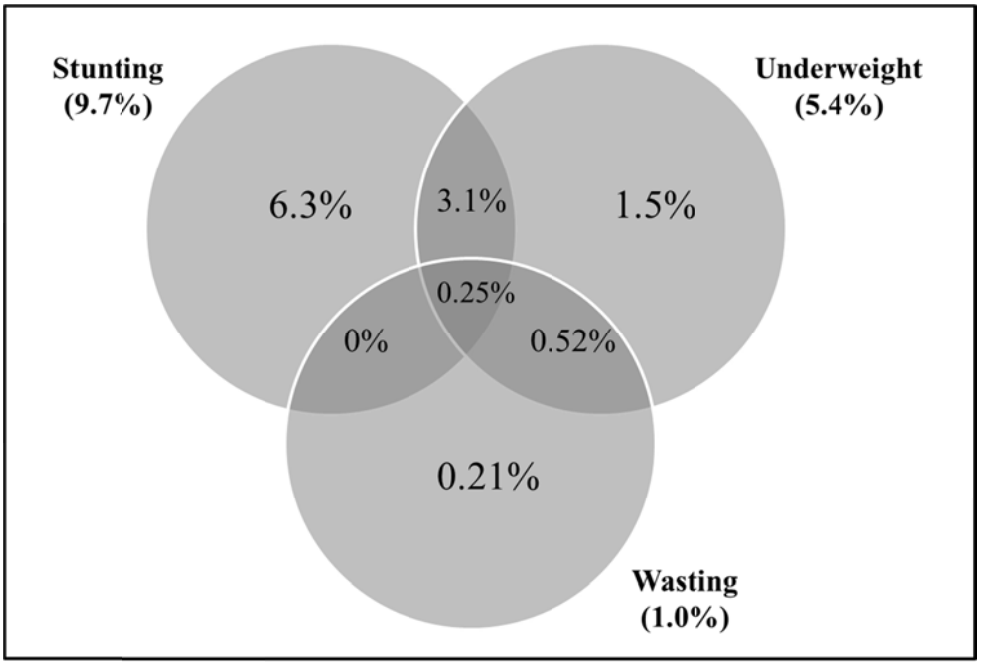
Figure 3 and Figure 4 illustrate the prevalence of stunted and underweight children by Colombian departments and municipalities. The maps show the great heterogeneity both between departments and within them. Some municipalities, for example, record no stunted children, whereas in others, the prevalence of chronic malnutrition is more than 50%, reaching rates of the highest-prevalence countries in the world. The departments with the highest levels of stunted and underweight children are located in the peripheral region. This region has per capita gross domestic product (GDP) levels well below the national average, little state presence, a hostile environment and a large proportion of the ethnic minorities in the country (Galvis & Meisel, 2010).

Table 1 shows the means, standard deviations and minimum and maximum of the variables used in the analysis. All descriptive statistics are weighted by sampling weights. The mean of height-for-age Z-score indicates that Colombian children are 0.63 standard deviations shorter on average than healthy children according to WHO

standards. Colombian children weigh 0.36 standard deviations less than the population reference.

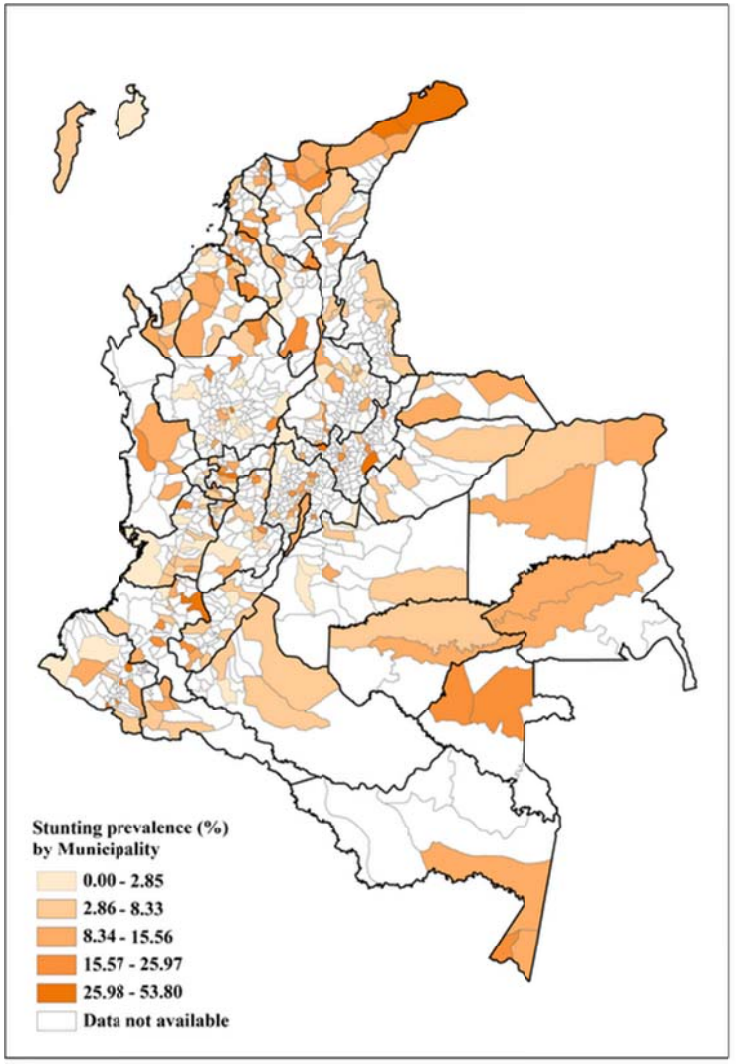
The average age of the children included in the sample is 27 months. They are almost evenly distributed between boys and girls. About 33% of the children do not have siblings and the majority (72%) reside in urban areas. In terms of family socioeconomic background, most children were born to mothers and fathers with 9 and 10 years of schooling on average, respectively. Furthermore, while about 27% of the children live in poor or very poor households, about 14% live in the wealthiest households. The average female education in the community is 8.5 years, ranging from 0.4 to 18.2 years.

Figure 2 Percentage of 0-59 month-old stunted, underweight and wasted Colombian children



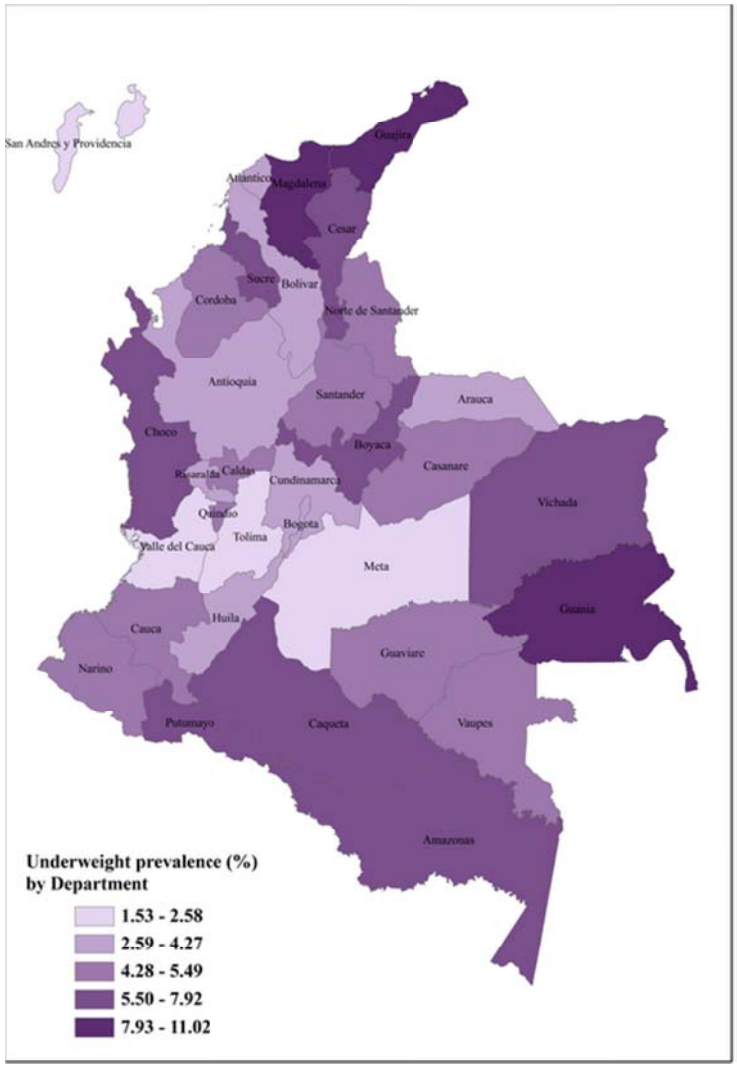
Source: Own compilation, DHS 2010

Figure 3 Percentage of 0-59 month-old stunted Colombian children by Departments and Municipalities (2010)



Source: Own compilation, DHS 2010

Figure 4 Percentage of 0-59 month-old underweight Colombian children by Departments and Municipalities (2010)



Source: Own compilation, DHS 2010

Table 1 Sample characteristics, 0-59 month-old Colombian children (n=10,165)

Variables	Mean	SD	Min	Max
Dependent				
Height-for-age	-0.63	1.02	-5.60	5.18
Weight-for-age	-0.36	1.06	-4.85	4.86
Background controls				
Child's age (months)	27.47	16.51	0.00	59.00
Child's sex				
boy	0.51	0.50	0.00	1.00
girl	0.49	0.50	0.00	1.00
Child's birth order and preceding birth interval				
first-birth	0.33	0.46	0.00	1.00
2nd-3rd and <2 years	0.04	0.20	0.00	1.00
2nd-3rd and >2 years	0.46	0.50	0.00	1.00
4th + and <2 years	0.03	0.17	0.00	1.00
4th + and >2 years	0.14	0.34	0.00	1.00
Mother's age at first birth (years)	20.40	4.60	10.00	43.00
Mother's body mass index (BMI)	25.21	4.58	13.38	56.49
Mother's autonomy index	0.28	1.39	-3.59	2.94
Number of under-five children	1.40	0.67	1.00	7.00
Place of residence				
rural	0.28	0.45	0.00	1.00
urban	0.72	0.45	0.00	1.00
Intermediary determinants				
Health system index	1.96	0.29	0.01	2.38
Behavioural and psychosocial factors index	0.62	0.69	-1.21	2.59
Structural determinants				
Community-level				
Mean years of mother's education	8.53	2.37	0.41	18.17
Family-level				
Mother's education years	8.83	3.97	0.00	23.00
Partner's education years	10.66	5.54	0.00	19.00
Socioeconomic status				
very poor	0.11	0.32	0.00	1.00
poor	0.16	0.37	0.00	1.00
medium	30.47	0.46	0.00	1.00
rich	26.82	0.44	0.00	1.00
very rich	14.23	0.35	0.00	1.00

Multilevel analysis

Tables 2 and 3 present the results of weighted multilevel models for height and weight-for-age Z-scores, respectively. All models were estimated using "xtmixed" command STATA version 12 and including sampling weights at both levels of analysis. Five sequential models were fitted for each outcome. Model 0 (null model) is a model with no explanatory variables, which shows whether there is a significant variation among communities. Model 1 adds the family background controls and intermediary determinants. Community education and mother's own education, respectively, are included in Model 2 and Model 3 in order to investigate the association between child

health outcomes and maternal education. Structural determinants at the family level (partner's education and household's SES) are included in Model 4. Finally, interaction terms were entered in Model5a and Model5b.

As the last rows of Tables 2 and 3 show, the models for HAZ and WAZ passed the Hausman test. The null hypothesis (absence of endogeneity) holds and therefore there is statistically no evidence of correlations left between family covariates and unobserved community characteristics.

-Influences of background controls and intermediary determinants

The performance of background controls was largely similar for the two anthropometric measures (Model 1a and 1b). Child's age index showed a significant and curvilinear association with both outcomes. Birth order and preceding interval and the number of under-five children in the household were negatively associated with child nutrition, whereas the age at first birth and body mass index of the mother, as well as residing in urban zones, had a positive effect on the child's height and weight-for-age Z-scores. Once community education was introduced in Model 2, the statistical significance of the effect of place of residence disappeared for both outcomes. The mother's autonomy had a positive impact on the child's height. In contrast, the variable was not significant for weight-for-age. The mother's autonomy index becomes significant for both outcomes models when the interaction term between this variable and community education was entered into the models.

As we expected, a greater access to and use of the health system increased the height and weight of children. However, the effect of the behavioural and psychosocial factors index was statistically insignificant for both anthropometric measures.

-Influence of maternal education

Model2a and Model2b show the effect of community education on child nutrition outcomes, after adjusting for background controls and intermediary determinants[1]. Community education was found to have a positive and statistically significant influence on both outcomes, even when the mother's own education was included in the models (Model3a and Model3b). In the case of HAZ, the association remained statistically significant, although the effect was attenuated when the partner's education and household's SES were controlled for in Model4a.

The results for the WAZ models indicated that the effect of community education disappeared after adjusting for family socioeconomic characteristics (Model 4b), reflecting the correlation between these factors. The association between the mother's own education and height and weight-for-age Z-scores remained positive and statistically significant in all models, although the effect on the child's height was attenuated when other structural determinants were entered into the model.

[1] With the aim of analysing the net effect of community education, we also tested models (not presented here) including only the community education variable. In both cases (height and weight-for-age), the effect was positive and very strong.

-Influences of structural determinants

The socioeconomic status of the household had a significant and positive impact on both anthropometric indices studied. However, the effect was stronger for HAZ. The height and weight-for-age Z-scores increased with increasing socioeconomic status index. The partner's education had a positive and significant influence only on the child's height.

-Community effects

The last rows of the Tables 2 and 3 show the variation in child height and weight-for-age Z-scores due to community characteristics. The community-level variance was significant in all models, indicating a significant unobserved heterogeneity in nutritional status between communities. In Model null (Model 0a), the variance partition coefficient (VPC)—the ratio between community-level variance and the total variance—indicated that 12.2% of the variability in HAZ is attributable to community factors, whereas in the case of WAZ, it is 8.2%. After adjusting for background controls and intermediary determinants (Model 2a and 2b), the variance due to community-level characteristics is reduced by about 19% for HAZ and 28% for WAZ. With the inclusion of community education, the VPC decreased to 9.2% for height-for-age and to 5.3% for weight-for-age Z-scores.

Table 2 Models Height-for-age Z-scores (HAZ) for 0-59 month-old Colombian children (N=10,165)

Variable	Model 0a Null model	Model 1a Background controls & Intermediary determinants	Model2a Community Education	Model3a Maternal Education	Model4a SES & Partner education
Background controls					
Child's age (months)		-0.020***	-0.019***	-0.019***	-0.018***
Child's age squared		0.000***	0.000***	0.000***	0.000***
Child's sex					
boy (reference)					
girl		0.048	0.047	0.045	0.039
Child's birth order and preceding birth interval					
first-birth (reference)					
2nd-3rd and <2 years		-0.182**	-0.174**	-0.164**	-0.147**
2nd-3rd and >2 years		-0.068**	-0.068**	-0.052*	-0.054*
4th + and <2 years		-0.376***	-0.362***	-0.312***	-0.280***
4th + and >2 years		-0.177***	-0.159***	-0.105**	-0.095**
Mother's age at first birth (years)		0.012***	0.008**	0.005*	0.005
Mother's body mass index (BMI)		0.015***	0.016***	0.016***	0.016***
Mother's autonomy index		0.027**	0.023**	0.019**	0.015
Number of under-five children		-0.110***	-0.107***	-0.107***	-0.104***
Place of residence					
rural (reference)					
urban		0.111***	0.000	-0.001	-0.056
Intermediary determinants					
Health system index		0.161**	0.128**	0.107**	0.063
Behavioural and psychosocial factors index		0.022	0.018	0.017	0.012
Structural determinants					
Community-level					
Mean years of mother's education			0.043***	0.028**	0.015*
Family-level					
Mother's education (years)				0.019***	0.014**
Partner's education (years)					0.005*
Socioeconomic status					
very poor (reference)					
poor					0.189***
medium					0.245***
rich					0.348***
very rich					0.312***
Random effect variances					
Community level	0.930***	0.100***	0.092***	0.093***	0.093***
Family level	0.130***	0.908***	0.909***	0.905***	0.899***
Variance Partition Coefficient (VPC)	0.122	0.099	0.092	0.093	0.093
Hausman test		17.84	18.8	18.95	22.47
Prob>chi2		>0.16	>0.13	>0.17	>0.13

* p<0.10; ** p<0.05; *** p<0.001

VPC: measures the proportion of total variance that is due to differences between-communities $\sigma_u^2 / \sigma_e^2 + \sigma_u^2$

Table 3 Models Weight-for-age Z-scores (WAZ) for 0-59 month-old Colombian children (N=10,165)

Variable	Model 0b Null model	Model 1b Background controls & Intermediary determinants	Model2b Community Education	Model3b Maternal Education	Model4b SES & Partner education
Background controls					
Child's age (months)		-0.049***	-0.049***	-0.048***	-0.048***
Child's age squared		0.001***	0.001***	0.001***	0.001***
Child's sex					
boy (reference)					
girl		0.038	0.036	0.034	0.029
Child's birth order and preceding birth interval					
first-birth (reference)					
2nd-3rd and <2 years		-0.203**	-0.195**	-0.182**	-0.171*
2nd-3rd and >2 years		-0.107***	-0.106***	-0.086**	-0.093**
4th + and <2 years		-0.338***	-0.323***	-0.261***	-0.243***
4th + and >2 years		-0.300***	-0.281***	-0.214***	-0.213***
Mother's age at first birth (years)		0.010**	0.006*	0.002	0.001
Mother's body mass index (BMI)		0.037***	0.038***	0.038***	0.037***
Mother's autonomy index		0.012	0.008	0.003	-0.000
Number of under-five children		-0.131***	-0.128***	-0.128***	-0.124***
Place of residence					
rural (reference)					
urban		0.067**	-0.033	-0.035	-0.075
Intermediary determinants					
Health system index		0.157***	0.124**	0.098**	0.069
Behavioural and psychosocial factors index		-0.005	-0.009	-0.011	-0.015
Structural determinants					
Community-level					
Mean years of mother's education			0.039***	0.019**	0.007
Family-level					
Mother's education (years)				0.024***	0.021***
Partner's education (years)					0.001
Socioeconomic status					
very poor (reference)					
poor					0.096*
medium					0.165**
rich					0.246***
very rich					0.273***
Random effect variances					
Community level	0.093***	0.061***	0.054***	0.054***	0.055***
Family level	1.045***	0.9723***	0.975***	0.971***	0.966***
Variance Partition Coefficient (VPC)	0.082	0.059	0.053	0.053	0.054
Hausman test		15.25	15.42	16.02	22.83
Prob>chi2		>0.29	>0.28	>0.31	>0.20

* p<0.10; ** p<0.05; *** p<0.001

VPC: measures the proportion of total variance due to differences between-communities $\sigma_u^2 / \sigma_e^2 + \sigma_u^2$

-Cross-level interactions: Community education and family socioeconomic characteristics

With the aim of exploring the possibility that community education modifies the association between family characteristics and child health, separate cross-level interaction terms were tested. Interactions between the mother's education and characteristics at the family level were included in the models after controlling for individual, family and community factors. Table 4 shows the models, including the interaction terms that were statistically significant in at least one model.

Cross-level interactions between community education and the mother's own education, as well as community education and the mother's level of autonomy, were found to be significant for HAZ (Model5a1 and Model5a2). For WAZ, the only interaction term that reached statistical significance was community education and the mother's autonomy (Model 5b2). All the interaction terms had a negative coefficient, indicating that the family characteristics tested and community education may be substitutes.

To facilitate the interpretation of the interaction terms, the fitted values of the outcome variables and the mean years of maternal education in the community were plotted, according to the characteristics at the family level.

In Figure 7, the positive slopes seen for all the mothers' education levels show that height-for-age Z-scores increase with increasing community education. However, the higher the level of education, the flatter the slope, indicating that community education has a greater influence on the health of children of less educated mothers. Similarly, Figures 8 and 9 show the association between the level of the mother's autonomy and community education. It seems that community education impacts relatively more the child's height and weight of mothers with low level of autonomy.

Table 4 Models height and weight-for-age Z-scores for 0-59 month-old Colombian children, including interaction terms (N=10,165)

	Height-for-age		Weight-for-age	
Variable	Model5a1	Model5a2	Model5b1	Model 5b2
Background controls				
Child's age (months)	-0.018***	-0.018***	-0.048***	-0.048***
Child's age squared	0.000***	0.000***	0.001***	0.001***
Child's sex				
boy (reference)				
girl	0.038	0.04	0.029	0.03
Child's birth order and preceding birth interval				
first-birth (reference)				
2nd-3rd and <2 years	-0.150**	-0.148**	-0.172**	-0.172**
2nd-3rd and >2 years	-0.053*	-0.052*	-0.092**	-0.091**
4th + and <2 years	-0.274***	-0.280***	-0.240***	-0.243***
4th + and >2 years	-0.085*	-0.091**	-0.209***	-0.210***
Mother's age at first birth (years)	0.006*	0.006*	0.002	0.002
Mother's body mass index (BMI)	0.016***	0.016***	0.037***	0.037***
Mother's autonomy index	0.015	0.108**	-0.000	0.066**
Number of under-five children	-0.104***	-0.103***	-0.125***	-0.124***
Place of residence				
rural (reference)				
urban	-0.065	-0.058	-0.079	-0.077
Intermediary determinants				
Health system index	0.051	0.055	0.064	0.063
Behavioural and psychosocial factors index	0.013	0.015	-0.015	-0.013
Structural determinants				
Community-level				
Mean years of mother's education	0.042**	0.018*	0.019	0.01
Family-level				
Mother's education (years)	0.038**	0.014**	0.032**	0.021***
Partner's education (years)	0.005*	0.005*	0.001	0.001
Socioeconomic status				
very poor (reference)				
poor	0.172**	0.173***	0.088*	0.081*
medium	0.222***	0.228***	0.155**	0.153**
rich	0.326***	0.331***	0.235***	0.233***
very rich	0.299***	0.301***	0.267***	0.265***
Cross-level interactions				
Community_educationX Mother_education	-0.003*		-0.001	
Community_educationX Mother_autonomy		-0.011**		-0.008*
Random effect variances				
Community level	0.092***	0.091***	0.054***	0.054***
Family level	0.899***	0.899***	0.965***	0.965***
Variance Partition Coefficient (VPC)	0.093	0.092	0.053	0.053
Hausman test	21.99	15.94	21.95	11.34
Prob>chi2	>0.24	>0.60	>0.23	>0.73

* p<0.10; ** p<0.05; *** p<0.001

VPC: measures the proportion of total variance that is due to differences between-communities $\sigma_u^2 / \sigma_e^2 + \sigma_u^2$

Figure 7 Interaction of mother's education and community maternal education: Height-for-age Z-scores of 0-59 month-old Colombian children

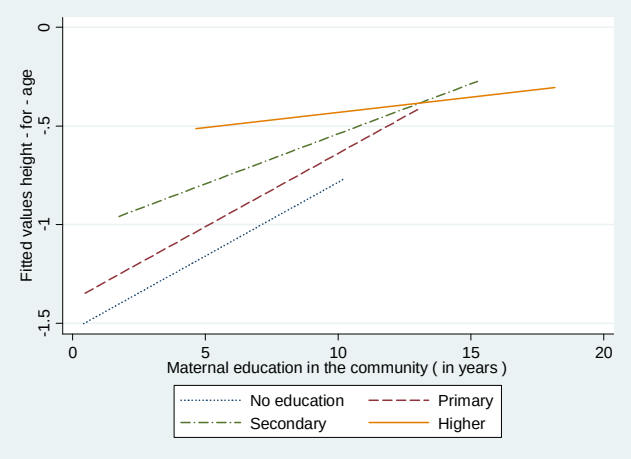


Figure 8 Interaction of mother's autonomy and community maternal education: Height-for-age Z-scores of 0-59 month-old Colombian children

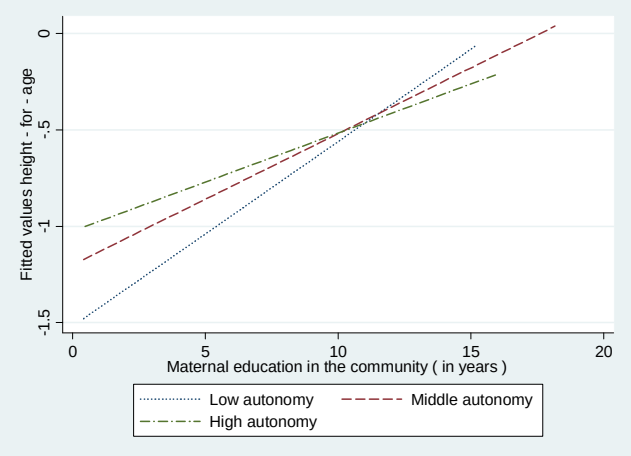
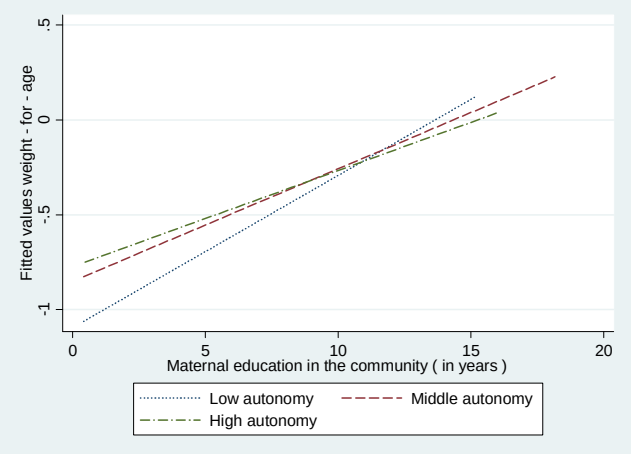


Figure 9 Interaction of mother's autonomy and community maternal education: Weight-for-age Z-scores of 0-59 month-old Colombian children



Discussion

This study has examined the influence of community maternal education and family socioeconomic characteristics on child nutritional status, as well as its interactions in the context of a Latin American country, Colombia. Despite the fact that previous studies have studied the impact of community socioeconomic context on child health, little is known about the mechanisms through which community education can influence child nutrition. Our results demonstrate that the education of other women in the community can positively influence child nutrition and can be particularly beneficial among certain groups of children. Furthermore, our study is innovative in methodological terms since it includes sample weights in the multilevel analysis and explores second level endogeneity problems in the estimation of child health outcomes, allowing us avoid biases in the coefficient estimates.

In particular, our findings contribute to the literature on community effects and child health and to the analysis of the social determinants of health in Colombia in the following ways:

1) The mother's own education and the externalities generated by other women's education

Our results indicate that community maternal education influences a child's height above and beyond the mother's own education. These findings suggest the importance in the long term that the education of other women in the community may have and the positive spillover effects on other parents within a community, regardless of their socioeconomic status and important background predictors, such as the mother's body mass index. These findings are consistent with previous studies that explore the association between child health and maternal literacy in the community (Alderman et al., 2003; Corsi et al., 2011; Kravdal, 2010; Moestue & Huttly, 2008; Parashar, 2005), which demonstrate that even children from uneducated mothers can benefit from the context created by other women's education.

Community education can affect child health through different mechanisms. Although a woman may not be interacting directly with all women in the community, the subgroup to which she relates may be part of the interaction network of the total female population in the community (Parashar, 2005). One possible mechanism is through social interactions (Kravdal, 2010). Connections with educated women in the community may lead to behavioural changes either through learning from the experiences of others—an *"imitative effect"*—or through normative influences (Moestue et al., 2007; Pamuk et al., 2011). Individuals living in more literate communities can also improve their health knowledge through the sharing of information (Andrzejewski et al., 2009).

On the other hand, the protective role of maternal own education on a child's health should not be downplayed. According to our results, both community education and the mother's own education are important determinants of child health. However, it seems that community education and the mother's own education operate together in the long-term in determining child health, whereas in the medium-term, child health is associated more with the mother's own education. Better-educated mothers are more likely to have access to well-paid jobs and are, therefore, more likely to receive higher incomes. Furthermore, they tend to live in wealthier communities with better access to health care. Maternal education allows women to acquire health knowledge, change attitudes and beliefs, adopt and understand new methods of child care and strengthen female autonomy. Thus, the context of family and community emerge as important mediators of the health conditions of children, both in the medium and long term.

2) The community education as moderator of family characteristics: effects on child nutrition

One of the main purposes of this paper was to examine the role of community education and its possible moderating effects on child health when interacting with characteristics at the family-level. In this vein, different ways through which community education can act as a substitute for family characteristics were found. First, living in relatively better-educated communities has a stronger influence on children's height of mothers with lower levels of education. Second, the impact of community education on a child's height and weight was greater for children whose mothers have less autonomy. Previous studies have also confirmed that female autonomy is one pathway through which maternal education influences child health (Aslam & Kingdon, 2012; Kravdal, 2004).

These results are particularly relevant from the point of view of public policy, since they allow for a better allocation of resources and an improvement in the efficiency of interventions and indicate that efforts to improve child health in Colombia will be more effective if targeted to the mothers with less education and autonomy in the community.

3) The responsiveness of child nutrition outcomes to individual and contextual characteristics

Our findings suggest that, although both the height and weight-for-age are indicators of child health status, they may be reflecting different dimensions and, therefore, that characteristics of family and the child's residential context may operate on these indicators through distinct channels. On the one hand, we found that a child's age, birth order and preceding birth interval, mother's age at first birth, mother's BMI, the number of under-five children in the household, the household's wealth and the health system index are associated with both nutrition outcomes, supporting the results of previous work in this field (Corsi et al., 2011; Rajaratnam et al., 2006). However, there are some

differences in terms of the impact of determinants at the family and community level on child nutrition outcomes.

The mother's own autonomy seems to be related more to longer term child health outcomes (height) than medium term indicators (weight), underlining the importance of female empowerment within the household, which allows mothers to have a greater say in decisions affecting both their own health and that of their children.

While the impact of maternal education on child nutrition has been studied in previous research, the effect of the partner's education has been explored less in the literature. Our results suggest that, in the long-term, better-educated partners of mothers can contribute to improving a child's health, even after controlling for the household's wealth and the mother's own education. This reflects the direct or indirect influence that the education of the mother's partner might have on maternal and child care. It is likely that the partner, although not being the primary child carer, makes decisions that directly or indirectly affect the child's health, highlighting the role that other adults can exert on a child's well-being (Moestue & Huttly, 2008).

We also found that socioeconomic status is an important predictor of both outcomes analysed. However, its effect is stronger on height-for-age Z-scores. It is possible that HAZ, an indicator of long-term health and well-being, is influenced more by structural conditions that are not easily modifiable in the short term, such as the socioeconomic status of the household.

On the other hand, our results indicate that about 12% and 8% of the variability in height and weight for age is attributable to between community differences. These findings possibly point to differences between the two indicators in their responsiveness to contextual influences (Boyle et al., 2006). While child height-for-age is an indicator of long-term health conditions, the weight-for-age varies with environmental influences such as acute infections and poor nutritional intake (Fotso et al., 2012). It seems that HAZ and WAZ can be determined by different factors, implying that distinct intervention strategies are, therefore, necessary to improve them.

Policy Implications

Despite the Colombian Government's efforts to develop strategies to promote early childhood development, the large disparities among communities highlight the need for a child protection policy that ensures territorial equity in both access and coverage of health services.

The reduction of the levels of both stunted and underweight children should be a priority for the national agenda, not only in terms of public health but also for the economic development of the country. A comprehensive strategy that guarantees healthy conditions during pregnancy and the children first years of life is necessary. The timely prevention and correction of nutritional deficiencies in this period is one of the

interventions with the highest returns, since this ensures that children develop to their full potential in readiness for adult life. In this vein, the community context and, especially, the context created by female education in the community, may be key elements in the implementation of programmes aimed at achieving behavioural changes that contribute to the promotion of healthy habits, physical activity, breastfeeding and supplementary foods, as well as the prevention, detection and appropriate treatment of chronic diseases.

The externalities generated by female literacy in the community highlight the importance of increasing women's overall education within communities. In particular, the promotion of the education of women participating in the programme *"Hogares Comunitarios de bienestar (HCB)"* should be a priority. This is one of the main Colombian Government child-oriented programmes. Each HCB benefits approximately 12 to 14 pre-school children, who receive care from one of the mothers in the community. We recommend expanding the coverage of programmes like "*Unidades pedagógicas de Apoyo (UPA)",* for example, through the public-private partnership. This is an educational support programme mainly targeted at urban children attending community nurseries (HCB), as well as their respective communitarian mothers. The programme seeks to add an educational component to the care and nutrition services.

The analysis of the interactions between characteristics at the family-level and the community-level observed may be very useful for the design of more effective policies in that these policies could be better targeted towards specific groups. According to our results, the intervention programmes aimed at enhancing women's education in a community can be particularly effective for the most disadvantaged mothers, i.e. less educated mothers and those with lower levels of autonomy.

Finally, one of the aims of the most recent childhood care strategy of the Colombian Government, titled *"De cero a siempre",* is the strengthening of the key role that family plays on early childhood development. Our findings suggest that in addition to the family socioeconomic background, there are significant contextual effects that may influence a child's health. We hope, therefore, that our study contributes to a better implementation of this strategy and that the context of the community where children live can be also prioritized.

Limitations

There are certain limitations in this study. Firstly, the significant between-communities variation, even after controlling for individual, family and community characteristics makes clear the need for further research into the pathways through which communities influence child health. The relationship between child health and community education may be much more complex than that examined in our models. It is possible that other variables linked to community exist that are likely to affect child health, such as the access, availability and price of food, as well as climate characteristics and distance to health facilities and markets, factors which were not available for analysis. Additionally,

the cross-sectional nature of this study does not allow us establish causal relationship. Nevertheless, this is a large population-based study with national representativeness.

Including and analysing other contexts where women interact and, therefore, could benefit from the externalities of education in order to disentangling contextual effects of education on child health, will be an important subject of future study. For instance, mothers could benefit from the networks and social interaction process generated in the work place, recreation areas or at public transport stops. These contexts, beyond the most proximate community context, may influence the health of children. Coordinate data from the Global Positioning System (GPS) could provide useful information about other proximate contexts since these coordinates would allow us calculate approximate distances between all PSUs. Although the data were collected in the Colombian DHS, they are not yet available. We hope to complete our study using this information in future investigations.

Conclusion

In summary, our results show that maternal education plays a protective role in child health. However, mothers and, therefore, their children, can benefit from education of other women in the community. Different pathways through which community education can substitute for the effect of family characteristics on child nutrition have been found, suggesting that childhood care programmes should not only focus on individuals but should also target the broader context of the communities, especially those communities with less educated mothers and with low female autonomy who could benefit more from intervention policies focused on promoting female education. Clearly, all strategies, programmes and policies in favour of early childhood in Colombia should take the community context into account.

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