Socioeconomic determinants of early childhood health in Colombia: exploring the role of context

Ana María Osorio Mejía

SOCIOECONOMIC DETERMINANTS OF EARLY CHILDHOOD HEALTH IN COLOMBIA: EXPLORING THE ROLE OF CONTEXT

Ana María Osorio Mejía

Supervisor
Catalina Bolancé Losilla

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Abstract

The overall aim of this thesis is to contribute to an understanding of the pathways through which structural and intermediary determinants influence child health in Colombia and how they operate through the context where children live in a more comprehensive way than has been determined to date.

Colombia has made significant progress in child health in the last few decades and it is currently on track to meet the Millennium Development Goals (MDG). Nearly 90% of the goals on global malnutrition, infant mortality rate and under-five mortality rate have been achieved. However, despite the progress, national averages remain masking huge territorial disparities. While some regions present figures similar to those of a developed country, others report indicators similar to those of a very poor African country. Some municipalities, for example, record no stunted children, whereas in others, the prevalence of chronic malnutrition is greater than 50%. In this context, empirical research that enhances our understanding of socioeconomic determinants of child health and guide policy-making is crucial in order to reduce place-based health inequities in Colombia.

This thesis is based on three research articles. The data used in these studies are drawn from the 2010 Colombian Demographic and Health Survey (DHS). The DHS is a large survey programme designed to collect high-quality nationally representative data on population, health and nutrition for developing countries. The DHS are widely recognised as the most important source of information for the analysis of health inequities in the developing world.

Firstly, intermediary determinants of early childhood health have been analysed through the construction of a composite index (Chapter 3). The intermediary determinants are the most immediate mechanisms through which socioeconomic position influence child health inequities. Therefore, their identification should contribute to the drafting of intervention policies at this level, given the importance of these factors in programmes aimed at improving maternal and child care. The index allowed us to identify key immediate determinants of child health and their relative importance among Colombian departments (administrative subdivisions). The index was constructed using a more sophisticated methodological approach than that commonly used in the literature, termed polychoric principal component analysis (PCA). A hierarchical cluster analysis was also carried out in order to identify how departments cluster based on the health of their children rather than their geographic proximity. The results showed that the largest differences in intermediary determinants of child health are associated with health care before and during delivery. Furthermore, the departments that perform relatively better in the most immediate determinants of child health are located in the centre of the country. In contrast, those departments that perform worse are located in the peripheral region. This region has a per capita gross domestic product (GDP) well below the national average, little state presence, a hostile environment and a large proportion of the

ethnic minorities. Our index provides very useful information in terms of public policy since it facilitates measuring, visualizing and monitoring of child health indicators, and may, therefore, help identify potential intervention strategies for improving the well-being of Colombian children.

Secondly, this thesis examines the effect of individual, family and community socioeconomic conditions on different indices representing intermediary determinants of child health, using a coherent conceptual framework (Chapter 4). Using a weighted multilevel approach, the results indicate that whilst community socioeconomic context can exert a greater influence on factors linked directly to health, in the case of psychosocial factors and parent's behaviours, the family context can be more important. In addition, the results indicate that a significant percentage of the variability in the overall index of intermediary determinants of child health is explained by the community context, even after controlling for individual, family and community characteristics. This study provides evidence that community socioeconomic context is a key component for improving child health in Colombia. However, the role played by context may vary according to the category of the intermediary determinants of child health analysed, highlighting the importance of distinguishing between community and family intervention programmes.

Thirdly, the influence of education of other women in the community and family socioeconomic characteristics on child nutrition outcomes, as well as their interactions, was investigated (Chapter 5). The contextual effects of education on child health were studied using weighted multilevel models. This study takes 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. Different ways through which community education can substitute for the effect of family characteristics on child nutrition were found, suggesting that child care programmes should focus not only on individuals but should also target the broader context of communities. In particular, those communities with less educated mothers and with low female autonomy are those that could benefit more from intervention policies that focus on encouraging female education.

To conclude, previous studies on the social determinants of child health in Colombia are limited. Most of them have covered the issue from the perspective of the individual and little attention has been paid to the effect of context. In this vein, understanding the structural and intermediary determinants of child health inequities, as well as the role played by community socioeconomic context, is essential for the design, monitoring and tracking of public child care policies in Colombia.

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Introduction

1. Introduction

The analysis of childhood living conditions and their main determinants in developing countries allows the identification of shortfalls in the access to and provision of key social services. The existence of such shortfalls reflects the lack of priority given to children in the social and economic agenda and overcoming them present challenges for public social policies in these countries.

Commitments by Colombia to childhood issues, as set out in the Millennium Development Goals (MDG) and the article Colombia 2019, reflect the priority given to issues surrounding infancy in this country. For example, infant mortality rates for 2011 was 15 per 1000 live births, which, when compared to the goal of 14 per 1000 live births, indicates that Colombia is close to attaining an acceptable indicator of better development conditions for the population.

Reaching these goals would represent a significant achievement for both the country and children. Nevertheless, in certain areas, such as infant mortality, Colombia falls short of the indicators of other Latin American countries (for example, in Cuba, the infant mortality rate is 5 per 1000 live births and 8 per 1000 in Chile). Moreover, if the indicators within the country are analysed, the large disparities among regions are those that pose the real challenge.

As stated by UNICEF (2009), it has become increasingly evident that the deprivation of children's rights to survival and development is particularly concentrated in certain continents, regions and countries. Within nations there are also remarkable disparities in the implementation of children's rights, which are caused by circumstances such as geographic location.

The analysis of the socioeconomic determinants and the effects of context on child health not only allows us to understand better the mechanisms through which the social determinants and location operate on inequities in health, but is of vital importance to policy objectives, fulfilment of the MDG, as well as all those programmes that aim to improve child well-being. A methodological approach at various levels—such as the departmental or community context—permits the analysis of territorial disparities in areas fundamental to child development, as well as the identification of key areas where intervention would bring about improvements in health and, consequently, well-being.

In this thesis the conceptual framework proposed by the World Health Organization (WHO) through the Commission on Social Determinants of Health (CSDH) has been adapted to the context of children. The CSDH was set up in 2005 to "collect, collate, and synthesize global evidence on the social determinants of health and their impact on health inequity, and to make recommendations for action to address that inequity" (Marmot et al., 2008, p. 7). The CSDH framework distinguishes between two kinds of health inequity determinants. On the one hand, the framework includes those determinants that generate social stratification and determine individual socioeconomic position, and which are rooted in the socioeconomic and political context (structural determinants), and on the other hand, those specific determinants of health status (intermediary determinants).

In this context, the main aim of this thesis is to investigate the structural and intermediary determinants of child health in Colombia and their effect according to the context where the children live. This thesis is based on the following publications:

i) Osorio, A., Bolance, C. and Alcañiz, M. (2012) Measuring Intermediary Determinants of Early Childhood Health: A Composite Index Comparing Colombian Departments. *Child Indicators Research,* DOI: 10.1007/s12187-012-9172-4. A previous version of this paper was published in the working papers series of the *Research Institute of Applied Economic*s (IREA working paper 2011/22).

ii) Osorio, A., Bolance, C. and Madise, N. Community context and its influence on intermediary determinants of child health: evidence from Colombia (Submitted). A previous version of this paper was published in the working papers series of the *Xarxa de Referència en Economia Aplicada* (XREAP working paper 2012-13).

iii) Osorio, A., Bolance, C., Madise, N. and Rathmann K. Social determinants of child health in Colombia: Can community education moderate the effect of family characteristics? A previous version of this paper was presented at the 2013 Population Association of America (PAA) annual meeting and was published in the working papers series of the *Xarxa de Referència en Economia Aplicada* (XREAP working paper 2013-02).

The data used in this thesis were obtained from the 2010 Colombian Demographic and Health Survey (DHS). DHS surveys provide unique information on sexual and reproductive health, as well as the socioeconomic characteristics of the population, allowing for monitoring and access to important benchmarks for the design and review of policies on maternal and child health.

Different methods have been used to analyse the data. First, all composite indicators were calculated through principal component analysis (PCA) using polychoric correlations. This methodological approach, which is more sophisticated than those normally used in the literature for the construction of indicators, is appropriate in instances with categorical variables, which the majority of those included in DHS are. A hierarchical cluster analysis was also carried out, allowing the identification of groups of departments based on the health characteristics of their children beyond the classification commonly used in Colombia, which is based on geographic proximity.

Furthermore, multilevel models were used to analyse the effects of context and to quantify the influence of individual and family characteristics on intermediary determinants of child health and, subsequently, the effect on the outcomes of child health. Two important methodological approaches are performed in what is referred to as the application of multilevel models. On the one hand, we include the sample weights for each of the two levels studied (family and community), and, on the other, problems of second level endogeneity in the estimation of child health outcomes are examined. These problems have been recently studied in the literature. Until now, however, no empirical study on the contextual effects on child health has taken into account these issues in multilevel modelling. Therefore, the methodological approaches used in this thesis represent an important contribution in that they allow the nature of the data and features of sample design to be taken into account, thereby reducing the level of biases in the estimations.

In the first part of this thesis (Chapter 3) a composite indicator is built which attempts to summarise in a single measure the intermediary determinants of child health. The intermediary determinants of early childhood health index (IDECHI) proposed here show which regions are performing better in child health and permits observation of how more immediate determinants of child health vary across Colombian departments, as well as between urban and rural

areas in the country. The index covers five dimensions related to child health: material circumstances, behavioural factors, psychosocial factors, biological factors and the health system.

In the second part (Chapter 4), the effects that structural determinants—such as the level of education of the parents and the socioeconomic status of the household—have on intermediary determinants are analysed, as well as the effect that the socioeconomic context of the communities where the children grow up has on their health. Following the approach used to build the indicator outlined in chapter 3, an indicator combining the behavioural and psychosocial factors with the related characteristics of health system is built. The aim is to examine the underlying causes of inequities in child health, as well as examining the distinctive effect that the socioeconomic context of the community may have on the more immediate determinants of child health.

We assume that ideas, behaviours and socioeconomic environment of people living in close proximity can affect children's health independently of their individual and family characteristics. Specifically, using the multilevel models under consideration, specific characteristics of the child, and their associated family and community, are explored with the general indicator and with the two constructed sub-indices. The first sub-index aggregates variables associated with the use of and access to the health system, while the second groups factors associated with the upbringing and care of the child.

Finally, in the third and last part of the thesis (Chapter 5) we focus on child nutrition. Malnutrition—the cause and symptom of situations of poverty and inequality—is one of the biggest problems for public health in developing countries. The main aim of this study is to explore the role of education of other mothers in the community in child health, as measured by two antropometric indicators—height-for-age and weight-for-age Z-scores—as well as examining how education in the community interacts with household characteristics. By including cross-level interactions in multilevel models, it is possible to determine whether the level of maternal education in the community can moderate the effect of socioeconomic characteristics of the family on the child's health and if so, which group of mothers and, consequently, which group of children, might benefit more from better educated communities.

To summarize, the analysis of the socioeconomic characteristics of the community plays an important role in determining the differences in child health, since it may help to explain the large gaps seen between regions in Colombia. Furthermore, community characteristics may exacerbate or mitigate differences in child health associated with the socioeconomic attributes of the household by complementing or substituting certain household characteristics, thus providing vital information regarding public policy.

The rest of this introduction outlines the importance of the effects of location (either community or neighbourhood) on health, followed by a review of previous research on the contextual effects on child health. Then the conceptual framework of the social determinants of health is presented, and finally the characteristics of the Colombian context, including a description of the socioeconomic situation of the country, the institutional framework for children, as well as the main child-orientated policies and programmes. Finally, a general overview of the evolution of child health indicators in Colombia in recent years is presented.

1.1 Health and place: the role of context

The causal pathways by which the place where people live—communities, neighbourhoods or local residential environments—influences health outcomes and shapes health inequities, have been extensively discussed in recent literature (Bernard et al., 2007; Cummins et al., 2007; Diez Roux, 2001; Kawachi & Berkman, 2003; Macintyre et al., 2002; Sampson, 2008; Shankardass & Dunn, 2012). The growing research on the effect of local areas on health outcomes has been possible in part by the advances in last years in multilevel modelling techniques, the developments in related software and the widespread availability of geo-coded databases (Shankardass & Dunn, 2012).

Neighbourhoods or communities—understood as spaces where communities are located and where social networks are established—have emerged as important contexts since they share physical and social characteristics which probably affect the health of individuals and help explain social inequalities in health (Diez Roux, 2007; Kawachi & Berkman, 2003). The neighbourhood environment may affect health through access to and availability of health

services, as well as to resources, and exposure to stressors (Pickett & Pearl, 2001).

The debate surrounding the geographical patterning of health has mainly focused on the distinction between the contextual and compositional. That is, to what extent spatial variations in health are the product of variations on the personal characteristics of people (individual or compositional effects) or are the result of the characteristics of the place where those people live (area or context effects) (Macintyre et al., 1993).

For example, from compositional approach, the associations between health and place can be explained by the fact that people with similar socioeconomic backgrounds tend to live within geographical proximity either because they share cultural beliefs or because they have monetary constraints which forces them to move to a certain area (Bernard et al., 2007). The contextual explanation attributes the geographical variations in health to characteristics of the environment. However, it has been argued that beyond the context and composition dichotomy, it is essential to recognize the processes and interactions occurring between people and places, as well as those that occur over time (Cummins et al., 2007). This implies understanding the pathways through which society and neighbourhoods jointly determine health and well-being of people (Shankardass & Dunn, 2012).

The literature identifies distinct pathways through which the residential area or neighbourhood context influences individual outcomes. Some of the most relevant are briefly described below.

Macintyre & Ellaway (2000) propose five characteristics of local areas that may influence health: physical attributes of the environment (e.g. quality of air and water); availability of healthy environments at home, work and play (e.g. parks); quality of services (e.g. education, transportation and health services); sociocultural features of the neighbourhood (e.g. religion, ethnic, norms and values) and the reputation of the area, that is how the areas are perceived by their residents and other relevant parties. In a later work, Macintyre et al. (2002) suggested complementing this approach by using a framework of universal human needs as a basis for measuring and conceptualising area influences on health.

Bernard et al. (2007) argue that in part health inequalities are determined by the access to resources provided by neighbourhoods. The authors establish five domains through which individuals acquire resources necessary for the production of health within neighbourhoods. These resources are accessible according to a set of rules. The physical domain includes natural and built environments and it is determined by proximity. The economic domain is determined by prices. The institutional domain, which mainly includes access to public services, is governed by rights. And finally, the local sociability domain and the community organisations domain are governed by informal reciprocity.

Recently, Galster (2012) provided a new approach to understanding neighbourhood effect mechanisms. The author uses a pharmacological metaphor—"dosage-response"—to pose several questions regarding the composition, administration and response to the neighbourhood dosage that should be considered in any empirical research of neighbourhood context effects. The author identifies four categories into which the causal pathways by which neighbourhoods affect individual outcomes can be grouped: social-interactive mechanisms (referring to social processes endogenous to neighbourhoods), environmental mechanisms (referring to natural and built attributes of the space that may affect health, but not behaviours), geographical mechanisms (referring to neighbourhood location and accessibility to, for example, job opportunities or public services) and institutional mechanisms (referring to actions of external actors who control resources).

Clearly, as the literature reveals, neighbourhood effects on health are the result of "multiple, overlapping and bi-directional mechanisms that link people to their neighbourhoods, which are, in turn, embedded within large social, political and economic structures" (Shankardass & Dunn, 2012, p. 139).

To sum up, despite the widespread and growing interest in investigating the effects of household on individual outcomes, there are many questions still to be answered in order to determine causal mechanisms through which the area where people live affect individual outcomes, such as, for example, health.

Recently, Van Ham (2012) proposed ten challenges to guide future research on the effects of neighbourhood: 1) identify the specific causal mechanisms

through which the context influences individual outcomes; 2) explicitly investigate the relative contribution of these mechanisms to the outcome of interest; 3) amplify the range of variable outcomes, for example, by including subjective welfare; 4) include the temporal dimension of neighbourhood effects; 5) include an inter-generational perspective; 6) understand neighbourhood selection effects and incorporate this explicitly into the models; 7) improve the operationalization of neighbourhoods; 8) include other spatial contexts in which individuals interact; 9) collect better data and 10) combine quantitative and qualitative research methods.

1.2 Previous research on community context and child health outcomes

There exists substantial evidence of the association between the place where children live and their health (Marmot et al., 2008). The place where children are born may have considerable influence on their growth, development and survival. While a child born in Sweden has 3% probability of dying before their fifth birthday, one born in Sierra Leone is about 60 times more likely to die within the same age-range. However, even within countries, these differences in life chances persist between social groups.

The effects of community socioeconomic context on child health outcomes have been increasingly investigated in developing countries. The vast majority of studies focus on African and Asian countries, use Demographic and Health Surveys and apply a multilevel modelling approach. Previous research has also examined different pathways through which community effects operate to influence child health.

For example, Fotso & Kuate-Defo (2005) explore how the socioeconomic status (SES) of families and communities interact to influence child health in five African countries. The authors find that community SES plays an important role on child malnutrition and morbidity; in some cases its effect is independent of the household's wealth level. Moreover, their results reveal that community SES can modify the effect of the household SES on child health. Fotso (2006, 2007) used a set of 15 countries in Sub-Saharan Africa (SSA) to investigate inequities in child malnutrition across urban and rural areas. The author finds that urban-rural gaps disappear in almost all countries

when community SES, household wealth and maternal education are controlled for.

Results from other studies have also demonstrated that community environmental factors, such as access to water, sanitation and electricity, influence child health. Pongou et al. (2006) used a composite index representing access to community environmental status in Cameroon to show that better community access to clean environmental conditions positively influences children's nutritional status. Similar results have been found in rural Nigeria, where Uthman (2009) represents various characteristics of the community where children live through the construction of composite indices. The author shows that an increase in the community environmental factors index and maternal health-seeking behaviour index reduces the odds of being stunted.

Other recent studies have examined the effect of community context on child nutrition using different measures of socioeconomic context. Corsi et al. (2011), for example, using the weight and height-for-age Z-scores of children aged between 0 and 59 months in Bangladesh, find a positive association between the characteristics of the community context (such as water and sanitation infrastructure, health and education services, employment, as well as level of education in the community) and child nutritional status. In this study the community education was found to be the strongest predictor of both child nutrition outcomes (weight and height).

Similar results have been reported in other developing countries. In the context of a Latin American country, Alderman and colleagues (2003) also find that community female education has a positive effect on a child's nutrition outcome in Peru, even after controlling for the mother's own education and household consumption. In addition, the findings of this study demonstrate that there is a positive nutrition externality in private infrastructure access (sanitation and water). Similarly, for Vietnam, Moestue & Huttly (2008) find a positive association between the proportion of literate mothers in the community and child nutrition, even after controlling for parental education and other individual-level characteristics.

Using three indices of health knowledge as outcome variables, Andrzejewski et al. (2009) investigate the effects of community context in Ghana. The authors

conclude that even if a mother herself is not literate, living in a community with high literacy rates can improve her knowledge of the aetiology and prevention of childhood illnesses. Community education has also been found to be a significant determinant of a child's immunization, above and beyond their own mother's education in rural India (Parashar, 2005). Recently, Adekanmbi et al. (2011) found that Nigerian children from communities with higher illiteracy rate have greater odds of being stunted than children living in better educated communities.

Using data from a group of tea producing states in south India, Luke & Xu (2011) found significant community effects for weight-for-age at age one. In contrast to other studies using large-scale surveys, in this study it is possible to isolate direct neighbourhood effects, given certain specific features of the tea states sample. Self-selection in the neighbourhoods, socioeconomic characteristics and access to health services are controlled for. The authors find that community-level female education and empowerment are associated with child health.

Other research provides evidence that contextual effects at the community-level on child health vary according to family socioeconomic characteristics. Comparing a set of six Sub-Saharan African countries and four Indian states, Griffiths et al. (2004) observe significant differences in community-level variance in weight-for-age Z-scores. The authors conclude that community context is able to mediate the effect of individual and family characteristics on child nutrition and that wealthier households are more able to overcome adverse community environments. In previous research, Madise et al. (2001), using the same set of countries, found a significant but smaller clustering effect at the community level for Malawi, Nigeria, Tanzania and Zambia.

Programme-level variables within the community have been also included in the analysis of contextual effects on childhood health. Rajaratnam et al. (2006) examined the effect of access to healthcare facilities and programmes and the availability of health professionals on the nutrition of children living in rural India. The authors, however, did not find a clear association between these variables and nutritional indicators. Sahu et al. (2010) examined the impact of community context on child immunization in rural India. The community-level covariates included the availability of health facilities, roads and information, and education and communication activities organized in the

community in the previous year. All community-level variables were found to increase the likelihood of a child being fully immunized.

Community effects on child immunization have been also investigated in Nigeria by Antai (2009) and Babalola (2009). For example, Antai (2009) found that, at the community-level, the proportion of mothers that had hospital delivery is associated with the likelihood of a child receiving full immunization. Both studies support the idea that a clustering pattern in child immunization remains even after individual, household and community factors have been considered. Likewise, Antai (2011) examined individual and community-level determinants of child mortality across Nigerian regions. Among community variables, the proportion of mothers seen by a doctor whilst attending prenatal care was found to be the main determinant of regional under-five mortality rates.

Chin et al. (2011) studied the spatial pattern of infant and child mortality in Nepal and its association with mother, household and community characteristics. The covariates at the community level included the distance to the nearest primary health centre, the distance to the nearest highway and altitude. This latter variable was the only one found to be associated with infant mortality. Children hazard rate of dying decreases 2 per cent for each 100-meter increase in altitude. A significant spatial trend is found, especially for infant mortality, even after accounting for individual and community variables.

The relationship between the fertility in the community and child health outcomes has been also studied. Nevertheless, using a large sample of DHS which included 23 Sub-Saharan African countries, Kravdal & Kodzi (2011) found a weak adverse effect of the fertility of other members in the community on child stunting.

In addition to the contextual effects, some studies have also investigated how community and individual or household characteristics interact. For example, Sastry (1996) studied the role of community characteristics in shaping child mortality differentials and how these interact with households attributes in Brazil. The author found that whereas maternal education and network sanitation are substitutes in the northeast, they are complements in the south/southeast region of the country. The findings suggest that the level of

development of the infrastructure in these two regions is very distinct, and that, therefore, public interventions aimed at improving child survival can have different effects.

The effects of the interaction between maternal education levels and community factors in Laos were investigated by Kamiya (2009) using anthropometric indicators. The author found that for the wasting indicator the mother's secondary education and average time spent getting water in the community have a supplementary relationship, but complementary with respect to latrine coverage. For stunting, wasting and being underweight, the results suggest that the mother's primary education and radio coverage are substitutes.

On the other hand, Lynnemayr et al. (2008) investigated how programmes, measured as the presence of a non-governmental organizations (NGO) offering services such as sanitation, nutrition and those aimed at combating illiteracy, and the availability of health facilities in the community, compensate or substitute the impact of the mother's human capital on child malnutrition in Senegal. The authors conclude that young mothers could benefit more from the presence of a health facility or an NGO and, in particular, those mothers with older heads of households would benefit from the NGO services.

Despite the differences in the conceptualization and operationalization of the contextual effects found in empirical studies, and the possibility that area-level effects act as proxies for the individual traits not measured, most authors concluded that the place where children live influences their health.

In this way, studies which attempt to quantify the effects of place (neighbourhoods, communities, etc.), such as that presented here, are important not only for the design of policies that directly affect health, but for their potential impact on other policies such as for example, those concerning housing or urban planning, which affect the context where individuals live, work, play and interact (Diez Roux, 2007). Thus, the measurement and conceptualization of community effects allows not only the identification of associations between characteristics of place and health related outcomes, but also potential means for intervention (Cummins et al., 2007).

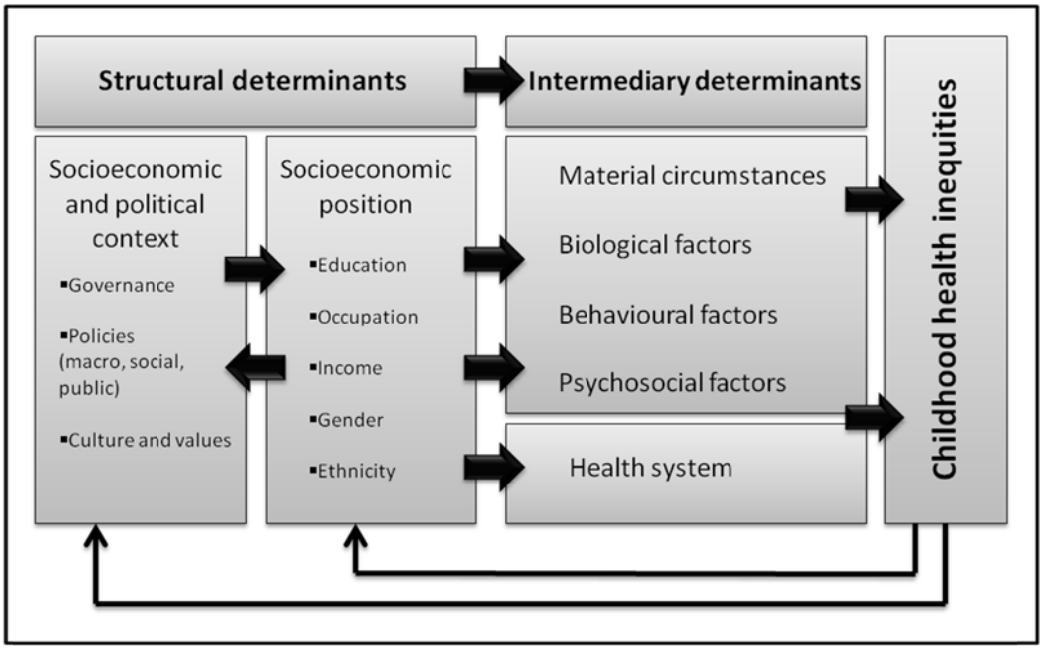
Although some studies have included Colombia in comparative analyses of child health outcomes (Hatt & Waters, 2006; Larrea & Freire, 2002; Mcquestion, 2001), previous studies on social determinants of child health in this country are limited (Acosta, 2012; Attanasio et al., 2004, 2012; Flórez & Nupia, 2001; Gaviria & Palau, 2006; Rosenzweig & Schultz, 1982; Tovar & García, 2007). Moreover, we are not aware of any research that has explored the role of community context in child health in Colombia in the last thirty years.

In fact, most of the previous work has covered the issue from the perspective of the individual, and little attention has been paid to the effect of context, thereby ignoring the multilevel nature of influences on health and, in some cases, the hierarchical structure of the data. Against this background, understanding the structural and intermediary determinants of child health inequities, as well as the role played by community socioeconomic context, which we take into consideration in this investigation, is essential and necessary for the design, monitoring and tracking of public child care policies in Colombia.

1.3 Conceptual framework: Social determinants of child health inequities

With the aim of obtaining a better understanding of the differences, determinants and consequences of 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 (see Figure 1) 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 (Solar & Irwin, 2010).

Figure 1. Conceptual framework of social determinants of childhood health inequities



Source: Adapted from Solar and Irwin (2010)

The framework includes two key components—structural determinants and intermediary determinants—of health inequities and welfare. The framework shows how the causes of health inequities are rooted in the socioeconomic and political context, which gives rise to a set of socioeconomic positions, whereby societies are stratified according to income, education, occupation, gender, race/ethnicity and other factors. These socioeconomic positions in turn have an indirect effect on health status; they operate through a set of specific determinants (intermediary determinants) of health to shape health inequities (Solar & Irwin, 2010).

The main intermediary determinants are: material circumstances, behavioural factors, biological factors, psychosocial factors and the health system. Material circumstances relate to living and working conditions, food availability, etc. Behavioural factors are associated with differences in lifestyle, such as tobacco and alcohol consumption, nutritional habits and physical activity. Biological factors include genetic factors, as well as age and gender distribution. Psychosocial circumstances are linked to stressful events experienced in life. Finally, the model includes the health system itself as a social determinant of health.

1.4 The Colombian context

Colombia is located in the extreme north of South America. It is a unitary republic divided into 32 departments (first administrative subdivisions) and one capital district (Bogotá), which is treated as a department. In turn, departments consist of municipalities (second 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.

The country is heterogeneous both in its geography and in the level of socioeconomic development among departments and municipalities. 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 in the world. Only three other countries have greater income inequality (UNDP, 2011a).

Colombia has made significant progress in social and contextual indicators over the last decade. The Human Development Index (HDI) increased by 6 points between 2000 and 2010, rising from 0.78 to 0.84 (UNDP, 2011b). Poverty levels fell between 2002 and 2011, from 53.7% to 45.5% (approximately 34% of Colombians live in poverty and 11% in extreme poverty). Nevertheless, in absolute terms, the number of poor people is still very high (nearly 20 million people) and the inequities between people, regions, as well as between urban and rural areas, continue to grow. Forced displacement as a result of violence is the main cause of internal migration. The country has also experienced a demographic transition, fertility and death rates have fallen, and life expectancy has risen to 73.4 years (PAHO, 2012).

Political framework in favour of childhood

In the last few years reducing inequity among departments and the care in early childhood have been two of the priorities of the Colombian Government. The priority given to childhood issues in Colombia is reflected in the level of official recognition of children's rights and a consequent improvement in living conditions. The regulatory interest is clearly wide-ranging: examples include the ratification of the *Convention on the Rights of the Child (CRC)* in 1991 and the *Childhood and Adolescence Code* – Act 1098 in 2006

and Act 1295 in 2009 – whose target is children under six years old and pregnant women from lower socioeconomic levels.

Previous regulations are found in the main documents outlining the planning of child-orientated policies. In effect, the need to formulate goals, strategies and indicators that allow the quantification of the advances and setbacks in distinct dimensions of welfare and/or in the fulfilment of the rights of minors is made evident.

In the case of Colombia, the targets derived from Millennium Development Goals are contained in the documents *CONPES 091* of 2005 (DNP, 2005), *CONPES 140* of 2011 (DNP, 2011a) and in the monitoring reports of the MDG. The guidelines of Colombian child-oriented public policies public policy in favour of children are also reflected in the document *CONPES 109*, issued in 2007 (DNP, 2007), the *National Plan on Children and Adolescence 2009-2019* (MPS, 2009) and the current *National Plan of Development 2010-2014* (DNP, 2011b). The guidelines for the use and distribution of resources for early childhood are gathered in *CONPES Social 152* of 2012 (DNP, 2012).

Furthermore, the country's 32 governors have met since 2004 in the *"Governor's Summit for Infancy and Adolescence"*. The purpose of this summit is to propose actions that strengthen public policies towards the fulfilment of the rights of minors.

Main programmes in favour of early childhood

In Colombia, all activities associated with the protection of minors and the family are governed under the National Constitution and the provisions set out in Law 7 of 1979. This law resulted in the creation of the National System for Family Welfare, which is integrated by public institutions at the national and territorial level, in addition to the organized communities and legally authorized individuals that provide services to minors.

The public institutions at the national level are the Ministry of Social Protection, which is the governing entity, and the National Institute of Family Welfare (ICBF), which is the main direct provider of public services for family welfare in the country. At the territorial level, services for minors are offered by the departments and municipalities. From decrees 1137 and 1138 of 1999,

the Municipal and Departmental Councils for Social Policy were created as entities responsible for the integration of social policies benefitting children and families at the local and regional level.

The ICBF has an comprehensive portfolio of programmes for the prevention and protection of the family and minors which includes gardens and children's homes, psychological help, care of pregnant women, child protection in cases of abandonment, displacement, physical abuse, and violation of the law (for a detailed description of the ICBF programmes, see Bernal & Camacho, 2010).

In terms of the programmes, one of the main ICBF initiatives in favour of early childhood care—titled "*Hogares Comunitarios de Bienestar"* (HCB)—is a community nursery programme implemented in 1986 with the aim of providing childcare and food to pre-school children. Each HCB helps approximately 12 to 14 children, who receive care from one of the mothers in the community, named "communitarian mothers". Currently, there are nearly 80,000 HCBs in the country and about 800,000 children under the age of six (32% coverage) from the poorest households participating in the programme. The effectiveness of this strategy in promoting children's cognitive and socio-emotional skills (Bernal & Fernández, 2012), as well as improving their height (Attanasio et al., 2012), has been proven.

Another well-recognised programme of the Colombian Government for the promotion of the accumulation of human capital and child health is "*Familias en Acción"*. The programme is aimed at the poorest families, as well as displaced and indigenous families, in municipalities of less than 100,000 inhabitants. The programme consists of monetary transfers to beneficiary mothers, subject to compliance with certain commitments: in education, class attendance by the children, and in health, attendance at growth and development checks.

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 (0-6 years old), according to their age, context and living conditions.

An overview of child health indicators

Despite the advances in the last decade in child health in Latin America and the Caribbean, the region still presents indicators below those of other regions in the world, with large differences between countries and within. While in Chile in 2011 child mortality rates stood at 9 deaths per 1,000 live births, in Bolivia, it was 51. Colombia has seen improvements in the key indicators that measure the basic well-being of children: in terms of infant and child mortality, indicators in Colombia show decreasing trends and are below the average of Latin America and the Caribbean. Nevertheless, Colombia falls short of the indicators of Chile and Costa Rica, although, in relative terms, it is better than Bolivia and at a similar level to that of Peru (see Table 1).

Table 1. Child health indicators in selected Latin American and Caribbean countries

	Under-five mortality rate[a] (2011)*	Infant mortality rate[b] (2011)*	Stunting prevalence[c] (%) (2003-2008)**	Underweight prevalence[d] (%) (2003-2008)**
Argentina	14	13	8	4
Bolivia	51	39	22	6
Brazil	16	14	7	2
Chile	9	8	1	1
Colombia	18	15	15	7
Costa Rica	10	9	6	5
Ecuador	23	20	23	9
Mexico	16	13	16	5
Peru	18	14	30	5
Venezuela	15	13	12	5
Latin America & Caribbean	19	16	14	6

[a]Probability of dying (per 1000) under age five years. [b]Probability of dying (per 1000) under one year old. [c]Percentage of children under 5 years old who are moderately or severely stunted. [d]Percentage of children under 5 years old who are moderately or severely underweight. *UNICEF, 2012 ** UNICEF, 2009b

Colombia has made significant progress in child health. For example, between 2005 and 2010 the under-five mortality rate fell from 24 to 19 deaths per 1000 live births; births attended by a doctor increased by 5 percentage points to

93% and immunization coverage rates reached 84% (Ojeda et al., 2011). 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, 2011c) (figures in brackets represent % achievement of respective goal). However, despite the progress, national averages remain masking huge territorial disparities. For instance, by department, under-five mortality rates in 2010 ranged from 6 (Casanare) to 50 (La Guajira) (see Figure 2). A social gradient in indicators of nutrition is also seen for illnesses such as acute diarrhoea, and Severe Acute Respiratory Infections (ARI) (see Table 2).

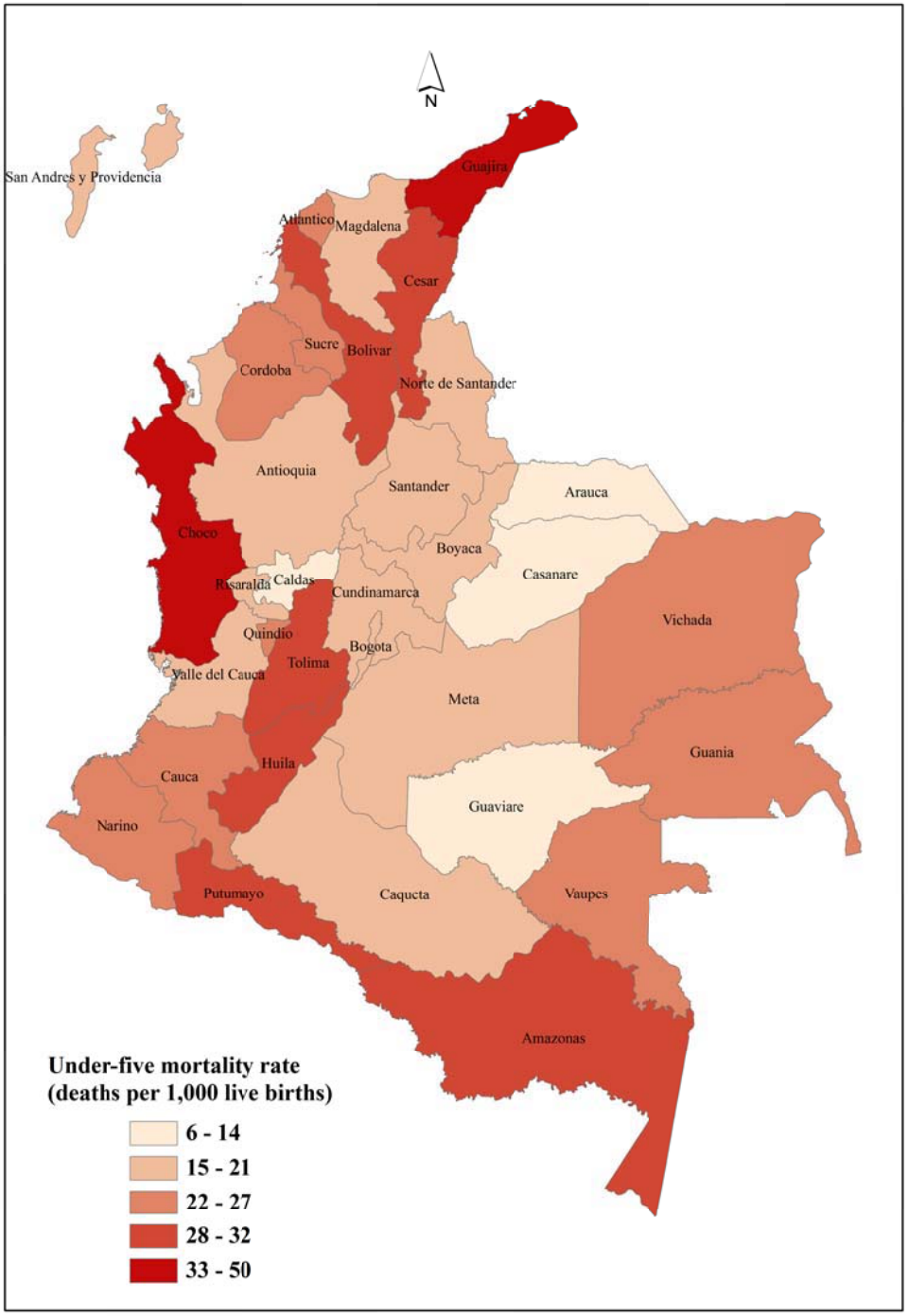
Table 2. Child health indicators by Socioeconomic Status

Socioeconomic Status (SES)	Stunting (%)	Acute Respiratory Infection (ARI) (%)	Acute diarrhoea (%)
Poorest	14.5	9.7	16.5
Poorer	9.2	9.6	14.4
Middle	7.8	10.1	11.3
Richer	6.0	8.2	10.3
Richest	4.4	6.8	7.7

Source: own compilation, Colombian DHS 2010

With regard to child nutrition, Colombia, as well as other Latin American countries, faces the double burden of over and undernutrition (Neufeld, Rubio, Pinzón & Tolentino, 2010). While the levels of undernutrition among children under five years old have been reduced in the country, problems of excess weight have 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. However, between 2005 and 2010, the percentage of overweight children increased from 3.1% to 4.8% (Ojeda et al., 2011).

Figure 2. Under-five mortality rate (U5MR) by Colombian departments (2010)



Source: Colombian DHS 2010

1.5 Aims and research questions

The main aim of this thesis is to improve our understanding of the ways through which structural and intermediary determinants influence child health in Colombia and how they operate through the context where children live. The research questions that have arisen from the review of literature on child health and contextual effects, both for developing countries and for Colombia, are laid out and addressed in the following chapters:

Chapter 3:

i) Which intermediary determinants are most related to child health?
ii) How do intermediary determinants of child health vary across Colombian departments and urban/rural areas?
iii) How do departments cluster based on the health of their children according to the index scores?

Chapter 4:

i) What role does community socioeconomic context play in shaping intermediary determinants of child health?
ii) Does this role vary when taking different categories of intermediary determinants into account?
iii) Is there a significant variation in intermediary determinants of child health across communities?
iv) What is the relative contribution of individual and family characteristics to intermediary determinants of child health?

Chapter 5:

i) What is the role of community maternal education and the mother's own education on child health outcomes?
ii) Can community education moderate the effect of family characteristics on child health? If so, which group of mothers and, consequently, which group of children benefit more from better educated communities?
iii) What is the relative contribution of structural and intermediary determinants to child health?

Chapter 2:

Data

2. Data

The data used in this thesis are drawn from the Colombian Demographic and Health Survey (DHS) conducted in 2010. The DHS is a large survey programme designed to collect high-quality nationally representative data on population, maternal and child health, fertility, family planning, gender, HIV/AIDS, malaria and nutrition. Since 1984 the DHS programme has provided technical assistance for the implementation of more than 300 surveys in 90 countries throughout the developing world. DHS surveys are implemented with the support of Macro International Inc., De Calverton, Maryland, U.S.A., and the U.S Agency for International Development (USAID). The DHS is widely recognised as the most important source of information for the analysis of health inequities in the developing world.

In Colombia, the survey has been carried out every 5 years since 1990 by *Profamilia*, a non-profit private institution and the main provider of sexual and reproductive health services in the country. The 2010 Colombian DHS is nationally representative and covers the urban and rural areas of 6 regions (Bogotá, Atlantic, Central, Eastern, Pacific and Amazon and Orinoco), 16 sub-regions, and each one of the 32 Colombian departments

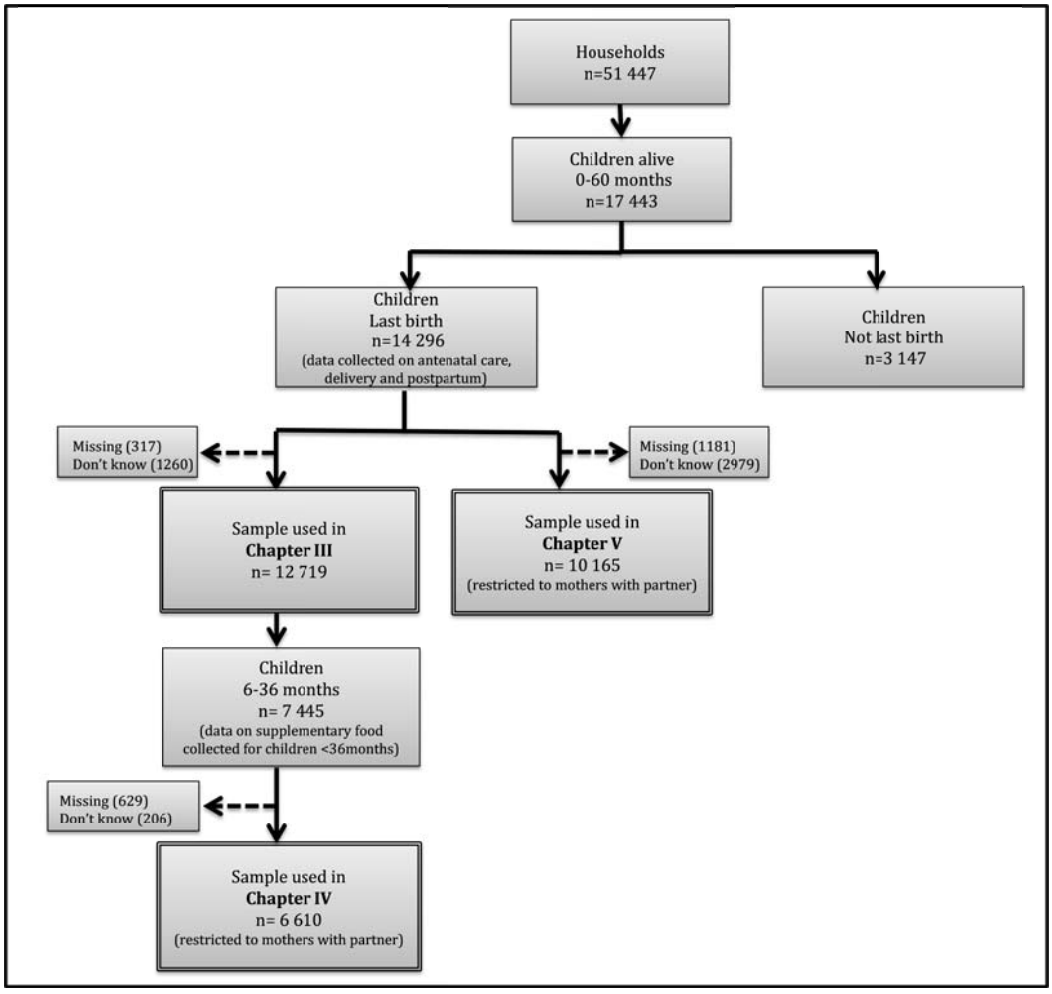
The survey collected information on the socioeconomic and demographic characteristics of women aged between 13 and 49 years old, the woman's partner and their sons and daughters under the age of five. Similarly, information on anthropometric measurements of all under-5s and their mothers, including height, weight and waist measurements, was also gathered.

The DHS sample was obtained using a stratified, multistage, cluster sampling design. The sample included 51,447 households in both urban and rural areas of 258 municipalities. Within the municipalities, households with geographical proximity (approximately two blocks) were grouped to form clusters (primary sampling units; PSUs) with an average of 10 households. In this study these sampling clusters are used as a proxy for community, as is usual in the empirical literature using DHS.

The sample selection process is showed in Figure 3. The Colombian DHS included 17,443 children aged between 0 and 59 months who were alive at the time of the interview. The data on antenatal care, delivery conditions and

postpartum care was collected only for the last child born alive (n=14,296). For all variables included in the study, values of "don't know" or "missing" were excluded without finding any significant differences between these cases and those included in the final sample. Thus, our sample included children who were alive at the time of the interview and for whom we had complete information.

Figure 3. Flow chart for sample selection



The sample used for the analysis in Chapter 3 comprised 12,719 children aged between 0 and 59 months nested in 3,688 communities. To verify that our sample was still representative by departments, we compared the relative frequencies by department, in both the full and the final samples. We observed that the order of departments based on the relative frequencies was the same

in both samples. Furthermore, the differences between both relative frequencies were compared. The greatest was found to be 0.005.

For the analysis presented in Chapter 4, the sample was restricted to 6,610 children aged between 6 and 36 months nested in 3,023 communities since the data on supplementary food was collected only for children under 36 months (n=7445). In Chapter 5, our final sample comprised 10,165 children aged between 0 and 59 months nested in 3,481 communities.

In order to investigate the effect of father's education on child health, the samples used in Chapters 4 and 5 were restricted to those children whose mothers had a 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, having obtained the samples, the weights were corrected so that they added up to the final sample size in each analysis.

Table 3 shows the distribution of children by Colombian departments. In all samples used for the analysis, the distribution of children is quite similar. The departments with the largest proportion of children compared to the national average are Bogota D.C., with 17.5%, Antioquia, with 12.7%, and Valle del Cauca, with 8.1%. Tables 4, 5 and 6 show a description of the samples used in each chapter by selected demographic characteristics. By sex, 51% are boys and 49% are girls. On average, the mothers included in the samples were 21 years old when they had their first child. Most of the children live in urban areas (73%) and approximately 30% live in poor or very poor households.

The software programs used for data analysis were Stata 12.0 version 12.0, and SAS version 9.2. All maps were drawn using ArcGis, version 10.

Table 3. Distribution (%) of children by Colombian departments

Departments	Sample chapter III	Sample chapter IV	Sample chapter V
Amazonas	0.003	0.003	0.003
Antioquia	0.127	0.126	0.128
Atlántico	0.049	0.052	0.051
Arauca	0.004	0.005	0.005
Bogotá	0.175	0.172	0.160
Bolívar	0.043	0.046	0.044
Boyacá	0.031	0.028	0.029
Caldas	0.016	0.017	0.016
Caquetá	0.007	0.008	0.008
Casanare	0.008	0.007	0.009
Cauca	0.027	0.029	0.027
Cesar	0.026	0.026	0.029
Córdoba	0.032	0.034	0.035
Cundinamarca	0.059	0.053	0.051
Chocó	0.012	0.015	0.013
Guainía	0.001	0.001	0.001
Guajira	0.017	0.020	0.018
Guaviare	0.001	0.001	0.001
Huila	0.025	0.027	0.025
Magdalena	0.030	0.036	0.035
Meta	0.019	0.015	0.018
Nariño	0.033	0.038	0.031
Norte de Santander	0.034	0.034	0.037
Putumayo	0.009	0.009	0.009
Quindío	0.012	0.010	0.012
Risaralda	0.017	0.015	0.017
San Andrés	0.001	0.001	0.001
Santander	0.049	0.047	0.050
Sucre	0.018	0.020	0.020
Tolima	0.033	0.030	0.032
Valle	0.081	0.074	0.083
Vaupés	0.001	0.001	0.001
Vichada	0.002	0.002	0.002

Table 4. Descriptive statistics by selected demographic characteristics for the sampled used in Chapter III (n=12,719)

Departments	Mean	SD	Min	Max
Child's age (months)	26.49	16.81	0	59
Child's sex				
boy	0.51	0.50	0	1
girl	0.49	0.50	0	1
Mother's age at first birth (years)	20.51	4.74	10	43
Place of residence				
urban	0.74	0.44	0	1
rural	0.26	0.44	0	1
Socioeconomic status				
very poor	0.11	0.32	0	1
poor	0.19	0.40	0	1
medium	0.28	0.45	0	1
rich	0.28	0.45	0	1

Table 5. Descriptive statistics by selected demographic characteristics for the sample used in Chapter IV (n=6,610)

Departments	Mean	SD	Min	Max
Child's age (months)	19.52	8.62	6	36
Child's sex				
boy	0.50	0.50	0	1
girl	0.50	0.50	0	1
Mother's age at first birth (years)	20.37	4.59	11	42
Place of residence				
urban	0.72	0.45	0	1
rural	0.28	0.45	0	1
Socioeconomic status				
very poor	0.11	0.32	0	1
poor	0.16	0.37	0	1
medium	0.21	0.41	0	1
rich	0.38	0.49	0	1

Table 6. Descriptive statistics by selected demographic characteristics for the sample used in Chapter V (n=10,165)

Departments	Mean	SD	Min	Max
Child's age (months)	27.47	16.51	0	59
Child's sex				
boy	0.51	0.5	0	1
girl	0.49	0.5	0	1
Mother's age at first birth (years)	20.4	4.6	10	43
Place of residence				
rural	0.28	0.45	0	1
urban	0.72	0.45	0	1
Socioeconomic status				
very poor	0.11	0.32	0	1
poor	0.16	0.37	0	1
medium	30.47	0.46	0	1
rich	26.82	0.44	0	1

Chapter 3:

A composite index of intermediary determinants of early childhood health

3. A composite index of intermediary determinants of early childhood health

This chapter presents a composite index of intermediary determinants of child health using a multivariate statistical approach. The index shows how specific determinants of child health vary across Colombian departments. Adapting the conceptual framework of Commission on Social Determinants of Health (CSDH), five dimensions related to intermediary determinants of child health are represented in the index: material circumstances, behavioural factors, psychosocial factors, biological factors and the health system. We used data collected from the 2010 Colombian Demographic and Health Survey (DHS) for 32 departments and the capital city, Bogotá. The sample used in this chapter included 12,719 children aged between 0 and 59 months (for a full description of the database and sub-sample used, see Chapter 2).

In recent years there has been a growing interest in measuring and quantifying well-being of children and its main determining factors through the construction of child well-being indicators (Ben-Arieh, 2000, 2008a, 2008b). Several international studies, mainly on developed countries, confirm this interest. It is worth highlighting the research of the UNICEF Innocenti Research Centre (2007, 2010) for industrialized countries, the studies by Bradshaw et al. (2007) and Bradshaw and Richardson (2009) for European countries, the annual reports from the KIDS COUNT Data Book by the Annie E. Casey Foundation (2010) and the study by Land et al. (2001) for the United States, and recently, the research on countries located on the Pacific Rim by Lau and Bradshaw (2010). All of these studies built composite indices that sought to capture multiple dimensions that affect children's well-being, from material well-being, health and education to the perspectives children have of their lives and living conditions. In this study, we focus on one of the dimensions of child well-being: early childhood health.

It is widely accepted that the first years of life are critical in child development. The vast majority of aspects related to child health are determined in the antenatal, delivery and perinatal period (Rigby & Köhler, 2002). Child health begins at conception, with antenatal care followed by delivery conditions. After birth, child health is determined by, among other things, adequate nutrition, a healthy environment and access to health services. Child health is a basic indicator of child well-being and is closely related to poverty and the

ability to afford health-related services (Spencer, 2000). Through the analysis of child health it is possible to identify deficit situations concerning access to and the provision of key health facilities. These deficits pose great challenges for public policy and dealing with them points out the priority that childhood well-being represents in the social and economic agendas of nations.

Composite indicators have proven to be an efficient tool for analysing and formulating public policies, as well as for bench-marking country performances (Saltelli, 2007). They are useful tools for simplifying complex or multidimensional phenomena and for making it easier to measure, visualize, monitor and compare trends in several distinct indicators over time and/or across geographic regions (Michalos et al., 2006). However, they may send misleading messages in terms of policy-making if they are not constructed correctly or if they are misinterpreted (OECD, 2008).

Some of the most significant limitations in the construction of composite indicators are related to criteria selection and the number of variables included, the well-being dimension that a variable represents, the weighting and aggregation of the variables and the use of different data sources (Hagerty & Land, 2007; Moore, 1997). Similarly, the aim and interpretation of the index are also subject to discussion (Moore et al., 2003).

Nevertheless, despite the above limitations, composite indicators are an important tool for public policy because they allow us to evaluate how far the policy interest expressed in legislation is reflected in better living conditions for children. They do not necessarily provide an assessment of the results achieved, but they can reflect gaps and deficiencies and make it easier to understand complex phenomena such as child health.

Most of the studies focus on only one determinant, with no relation to other intermediary factors (Solar & Irwin, 2010). However, although we recognize the importance and causal priority of the structural determinants, in this chapter we focus on intermediary determinants. These are the most immediate mechanisms through which socioeconomic position operates on child health inequities and their identification may, therefore, contribute to determining intervention policies at this level. Additionally, the analysis by department and type of place of residence above national average—as proposed here—not only allows us to analyse territorial disparities in key areas for child

development, but also leads to differential strategies in order to reduce place-based inequalities (Coulton & Fischer, 2010; Coulton et al., 2009).

In this chapter, we first define the variables used in the index construction; secondly, the methods (polychoric principal component analysis and the hierarchical cluster analysis) are presented, followed the results, and finally the discussion of the main findings.

3.1 Variables

The variables included in the index are shown in Table 7. A set of 15 variables related to children, their mothers and family environment are considered. We selected the variables according to both their relevance to the study and the availability of data. The variables selected aim to represent the five categories included as intermediary determinants of health, according to the CSDH conceptual framework.

As indicators of *material circumstances*, we included as a proxy for living conditions whether the child lives in overcrowded housing and whether the child is underweight (defined as weight-for-age z-score below minus two standard deviations). Being underweight or overall undernutrition may be the result of both chronic and acute malnutrition (Fotso & Kuate-Defo, 2006) and, therefore, can reflect lack of adequate food or poor sanitary conditions and socioeconomic circumstances.

As a proxy for *biological factors*, we included three dummy variables for recent illnesses: whether the child had fever, cough or diarrhoea in the two weeks preceding the interview. Apart from reflecting the current health status of the child, recent illnesses can reflect children's living conditions, since they reflect a lack of safe drinking water, sanitation and hygiene.

Given that parental behaviours and psychosocial characteristics can be hard to operationalize and measure, we grouped together a set of variables representing nutritional habits, parenting style and stressful events that can influence a child's development, as part of the single category termed *behavioural and psychosocial factors*. As a measure of nutritional habits we included months of breastfeeding. Breastfeeding reduces infant mortality and has

benefits for child health in both the short and long term. The WHO recommends that infants should be exclusively breastfed for the first six months with continued breastfeeding for up to two years or longer (UNICEF, 2009b). This variable is measured by duration in months and is arranged into three categories: never breastfed, up to two years and more than two years.

One of the aspects that characterises parenting style is parent's involvement. To measure this aspect, the frequency with which mother played with the child and the frequency of child's physical activity were included. Play has a decisive role in the child's development and is linked to secure attachment with caregivers and relationships with other children (Irwin et al., 2007). It is well known that physical activity has a positive effect on child health (Boreham & Riddoch, 2001). Sixty minutes daily at least twice a week are recommended (Strong et al., 2005).

Psychosocial factors include psychosocial stressors, as well as stressful living circumstances and relationships. Physical punishment, despite being a socially acceptable practice as a way to discipline children in many countries (Deater-Deckard et al., 2003; Gershoff, 2002; Graziano & Namaste, 1990), can be a stressful life event that may affect a child's health. This category includes whether the mother physically punished children with spanking, pushing, depriving them of food, hitting with objects, giving them inappropriate work to do or throwing water at them.

As indicators of the *health system* category, variables related to maternal and child care, as well as the use of and access to the health system, were taken into account. As an indicator of antenatal care the number of antenatal visits during pregnancy was included. It is estimated that at least four visits during pregnancy improves a range of health outcomes for women and children (WHO, 2005). This variable is, therefore, categorized into no antenatal visits, one to three visits and four or more visits.

Likewise, whether the mother received a tetanus injection during pregnancy, the person who attended the delivery (doctor or others) and the place of delivery (health institution or others) were included in the analysis. In addition to this, a child's access to health system and immunization were also included. The scope of immunization services and the quality of preventive care provided by health services to children under the age of five are reflected in

the coverage of specific vaccines. Whether or not the child received the third dose of polio vaccine was included as measure of the child's immunization.

Table 7. Definition of variables included in the Intermediary Determinants of Early Childhood Health Index –IDECHI

Variable	Description	Values
A. Material circumstances		
Living conditions		
Overcrowding	Housing with more than 3 persons per room	0=No 1=Yes
Under weight	Child's weight for age is below -2SD	0=No 1=Yes
B. Biological factors		
Recent illnesses		
Diarrhoea	Child had diarrhoea in last two weeks	0=No 1=Yes
Fever	Child had fever in last two weeks	0=No 1=Yes
Cough	Child had cough in last two weeks	0=No 1=Yes
C. Behavioural and psychosocial factors		
Nutritional habits		
Breastfeeding	Months of breastfeeding	0=Never breastfed 1=Up to 2 years 2=More than 2 years
Parenting style		
Play	Frequency mother played with child last week	0=Not carried out 1=once a week 2=2-4 times per week 3=5+ times per week
Physical activity	Frequency time spent with child in physical activities last week	0=Not carried out 1=once a week 2=2-4 times per week 3=5+ times per week
Physical punishment	Mother punished children physically	0=No 1=Yes
D. Health system		
Maternal healthcare		
Doctor	Doctor assisted the delivery	0=No 1=Yes
Delivery place	Place of delivery	0=Home and others 1=Health institution
Antenatal care	Number of antenatal visits	0=No antenatal visits 1=1-3 visits 2=4 or more
Tetanus injection	Mother received tetanus injection	0=No 1=Yes
Child healthcare		
Immunization	Child received third dose of polio	0=No 1=Yes
Health Card	Child has health card	0=No 1=Yes, seen

3.2 Methods

With the aim of constructing a composite index of intermediary determinants of early childhood health, a multivariate statistical approach was used. Adopting a statistical approach is another way of selecting and aggregating variables without a priori assumptions in the weighting scheme (Lockwood, 2004; Njong & Ningaye, 2008). In order to generate the weight of the variables, and taking into account the discrete nature of the data, principal component analysis (PCA) method using polychoric correlations was employed in constructing the index. In addition, a hierarchical cluster analysis was carried out in order to identify groups of departments according to child health conditions. These two methods are described in this section.

3.2.1 Principal Component Analysis and polychoric correlations

One of the most widely used multivariate techniques in composite indexing is principal components analysis (PCA). The PCA was originally conceived by Pearson (1901) and further developed by Hotelling (1933). PCA is a multivariate statistical technique of dimensionality reduction, which allows a set of k original correlated variables $X = \{X_1, X_2, \ldots, X_k\}$ to be transformed into a new set of uncorrelated variables called principal components $PC = \{PC_1, PC_2, ..., PC_k\}$. Each component is independent and is a linear weighted combination of the original variables. The first principal component explains the largest proportion of the total variance; the second is orthogonal to the first, with maximal remaining variance, and so on.

The classical PCA assumes that the variables are multivariate normal distributed and therefore work best on continuous data. A solution as to how to incorporate discrete data into PCA was proposed by Filmer and Pritchett (2001). The authors suggested breaking down the categorical variables into a set of dummy variables. However, the use of dummy variables in PCA introduces spurious correlations, loses all the ordinal information, biases toward the covariance structure and lowers the proportion of explained variance (Kolenikov and Angeles 2004).

Kolenikov and Angeles (2009) recently described a technique to incorporate categorical variables into PCA using polychoric correlations. They concluded that the proportion of explained variance estimated is more accurate using this method than others. Therefore, if the proportion of explained variance is important to the analysis, polychoric PCA should be used.

The polychoric correlations concept refers to the correlation between two observed variables x and y with r and s ordinal categories, respectively. Polychoric correlation coefficients are estimated by the maximum likelihood method. The aim is to maximize the probabilities that categories r and s are given jointly, weighted by the number of observations (Olsson 1979; Olsson et al. 1982).

Suppose that x and y are the result of two latent variables, X and Y, which are bivariate normally distributed. Further, x and y are obtained by categorizing these latent variables according to a set of thresholds $a_i, i = 0,\ldots,s$ and $b_j, j = 0,\ldots,r$, respectively, where $a_0 = b_0 = -\infty$ and $a_s = b_r = +\infty$. If we have a cross-table of x by y, with observed frequencies n_{ij}, then the probability π_{ij} that an observation falls in cell (i, j) is given by

$$\pi_{ij} = \Phi_2(a_i, b_j; \rho) - \Phi_2(a_{i-1}, b_j; \rho) - \Phi_2(a_i, b_{j-1}; \rho) + \Phi_2(a_{i-1}, b_{j-1}; \rho) \tag{1}$$

where Φ_2 is the bivariate normal distribution function with correlation ρ

$$\Phi_2(a_i, b_j; \rho) = \int_{-\infty}^{a_i} \int_{-\infty}^{b_j} \frac{1}{2\pi\sqrt{1-\rho^2}} \exp\left[-\frac{t^2 - 2\rho tz + z^2}{2(1-\rho^2)} \right] dtdz \tag{2}$$

Therefore, the log-likelihood can be written as

$$\ln L \equiv \sum_{i=1}^{s} \sum_{j=1}^{r} n_{ij} \ln \pi_{ij} \tag{3}$$

This likelihood function depends on ρ and thresholds a_i and b_j. Maximizing likelihood function, we obtain the polychoric correlation between x and y.

For example, in our application the variables "breast" (Months of breastfeeding) and "play" (Frequency played with child last week) are categorical variables with 3 and 4 ordinal categories, respectively. To obtain polychoric correlations, it was assumed that these categorical variables have been obtained by defining 3 and 4 value ranges in two continuous variables, respectively. The aim is to estimate the correlation between these two continuous variables. However, if such variables are known, the Pearson's correlation coefficient could be used. Note that, like other correlation coefficients (e.g. Pearson), when $x = y$ the polychoric correlation is 1.

Finally, having obtained the polychoric correlations among pairwise variables x and y, the correlation matrix is constructed. The PCA is then performed in the usual way. STATA (version 12) commands *"polychoric"* and *"polychoricpca"* are used to estimate the polychoric correlations and perform the PCA.

3.2.2 Hierarchical cluster

In addition to the polychoric PCA, a hierarchical cluster analysis was carried out based on the selected principal components. In order to group departments together according to the similarity between the values of estimated principal components, the average of the principal component scores of the individuals within each department was calculated. A hierarchical agglomerative linkage method is used, which considers that at the beginning, each department is a group, and in the later stages, the departments are linked using a criterion of similarity between them. A known criterion of hierarchical agglomerative linkage is Ward's method. This method forms clusters by maximizing within-cluster homogeneity, i.e. minimizing the variance within the groups formed at each stage (Timm, 2002). The hierarchical cluster was estimated using the "PROC CLUSTER" procedure of the software SAS (version 9.2).

3.3 Results

3.3.1 Descriptive analysis

All the descriptive and statistical analyses were corrected by the STATA command *"svy"*, which takes into account the survey design. The sample proportions by departments and regions of some categories of the variables included in the analysis are shown in Tables 8 and 9. The selected categories for each variable are in agreement with those necessary for a child to enjoy good health during childhood. The data shows some notable facts, underlining the importance of the analysis by departments rather than by region or at the national level. For instance, at the regional level, Bogotá has the best performance in child health in the majority of categories; however, it is the region with the lowest proportion of third doses of polio and time spent on children's physical activity. On the other hand, Amazon and Orinoco are the regions with the highest number of underweight children, children with diarrhoea, mothers without tetanus injections, physically-abused children, and the poorest health systems.

Nevertheless, as stated above, the results by regions should be treated with caution as they may mask substantial differences among departmental conditions. A case in point is the Pacific region, where the departments of Valle and Chocó, in spite of their geographical proximity, have quite different socioeconomic levels. While in Valle, roughly 96% of the deliveries are attended by a physician in a health institution, in Chocó these indicators only reach 70%. Differences are also observed in terms of health infrastructure and access: despite almost all children having health insurance, there are departments where deliveries taking place in a health institution only reach 72%.

The variables with the greatest contrast among departments are the number of antenatal visits and crowded housing. While 95% of mothers attended 4 or more check-ups during pregnancy and 87% of housing has less than three persons per room in Quindío, in Vaupés these figures were 55% and 52%, respectively. It is worth mentioning the case of Chocó. This department exhibits low rates in almost all health indicators, but the percentage of mothers who breastfed their children up to 2 years is the highest (97%), which may reflect the economic restraints in acquiring mother's milk supplements.

Table 8. Sample proportions of variables included in the IDECHI by Colombian Departments (DHS 2010, 0-59 month-old Colombian children, n=12,719)

Departments	Housing not over crowded	Child not under weight	Child not had diarrhoea	Child not had fever	Child not had cough	Breastf. up to 2 years	Play with child 5+/week	Physical activities with child 5+/week	Mother not punish physically	4+ antenatal visits	Mother received tetanus toxoid injection	Doctor attended delivery	Delivery in health facility	Child received Polio3	Child has health card
Atlantic region															
Atlántico	0.70	0.97	0.88	0.66	0.41	0.92	0.11	0.28	0.23	0.94	0.94	0.99	0.99	0.79	0.96
Bolívar	0.62	0.96	0.85	0.68	0.40	0.93	0.08	0.22	0.32	0.90	0.97	0.95	0.97	0.70	0.97
Cesar	0.60	0.94	0.81	0.71	0.47	0.93	0.13	0.35	0.33	0.90	0.96	0.95	0.96	0.73	0.98
Córdoba	0.58	0.95	0.85	0.70	0.50	0.90	0.12	0.21	0.37	0.86	0.91	0.93	0.94	0.69	0.96
Guajira	0.45	0.89	0.82	0.62	0.43	0.92	0.10	0.28	0.43	0.81	0.87	0.81	0.86	0.69	0.96
Magdalena	0.56	0.92	0.78	0.68	0.39	0.91	0.09	0.29	0.29	0.89	0.94	0.93	0.95	0.70	0.99
Sucre	0.56	0.94	0.80	0.63	0.45	0.87	0.08	0.14	0.40	0.88	0.94	0.93	0.95	0.74	0.99
San Andrés	0.84	0.97	0.88	0.72	0.55	0.89	0.17	0.27	0.31	0.91	0.90	0.99	1.00	0.64	0.98
Eastern region															
Boyacá	0.85	0.95	0.86	0.81	0.69	0.87	0.14	0.30	0.33	0.91	0.90	0.97	0.97	0.65	0.99
Cundinamarca	0.79	0.97	0.86	0.80	0.67	0.86	0.16	0.36	0.32	0.90	0.89	0.94	0.98	0.66	0.97
Meta	0.79	0.98	0.86	0.77	0.57	0.87	0.09	0.32	0.27	0.89	0.86	0.95	0.97	0.72	0.98
Norte de Santander	0.60	0.95	0.84	0.70	0.56	0.88	0.07	0.33	0.20	0.87	0.95	0.94	0.94	0.74	0.99
Santander	0.82	0.95	0.86	0.76	0.63	0.84	0.13	0.39	0.25	0.90	0.87	0.94	0.97	0.77	0.96
Central region															
Antioquia	0.78	0.97	0.85	0.69	0.57	0.92	0.13	0.42	0.20	0.91	0.82	0.96	0.97	0.77	0.98
Caldas	0.84	0.95	0.83	0.67	0.54	0.89	0.11	0.30	0.21	0.91	0.88	0.95	0.98	0.78	1.00
Caquetá	0.73	0.95	0.81	0.72	0.48	0.91	0.08	0.34	0.08	0.81	0.92	0.83	0.86	0.73	0.97
Huila	0.74	0.96	0.85	0.75	0.60	0.90	0.13	0.43	0.26	0.93	0.97	0.94	0.97	0.77	1.00
Quindío	0.87	0.95	0.88	0.75	0.57	0.90	0.17	0.22	0.28	0.95	0.91	0.98	0.98	0.79	0.98

Table 8.
(continued)

Department	Housing not over crowded	Child not under weight	Child not had diarrhoea	Child not had fever	Child not had cough	Breastf. up to 2 years	Departments	Physical activities with child 5+/week	Mother not punish physically	4+ antenatal visits	Mother received tetanus toxoid injection	Doctor attended delivery	Delivery in health facility	Child received Polio3	Child has health card
Risaralda	0.80	0.96	0.87	0.73	0.66	0.90	0.16	0.26	0.23	0.92	0.95	0.97	0.99	0.73	0.99
Tolima	0.74	0.98	0.83	0.74	0.62	0.85	0.15	0.31	0.28	0.91	0.93	0.91	0.93	0.61	0.98
Pacific region															
Cauca	0.79	0.95	0.82	0.76	0.56	0.92	0.06	0.24	0.25	0.82	0.88	0.76	0.77	0.78	0.99
Chocó	0.77	0.94	0.79	0.67	0.47	0.97	0.03	0.17	0.17	0.69	0.86	0.68	0.72	0.69	0.97
Nariño	0.70	0.96	0.87	0.80	0.59	0.94	0.10	0.19	0.31	0.86	0.84	0.88	0.89	0.82	0.99
Valle	0.87	0.98	0.90	0.75	0.58	0.89	0.13	0.27	0.23	0.94	0.93	0.95	0.97	0.73	0.98
Amazon and Orinoco region															
Arauca	0.78	0.96	0.92	0.69	0.64	0.88	0.14	0.16	0.34	0.89	0.86	0.97	0.96	0.80	1.00
Casanare	0.68	0.96	0.90	0.75	0.56	0.88	0.14	0.37	0.20	0.84	0.86	0.92	0.95	0.77	0.96
Putumayo	0.72	0.93	0.81	0.67	0.65	0.93	0.09	0.22	0.24	0.82	0.82	0.86	0.87	0.70	0.99
Amazonas	0.45	0.94	0.71	0.60	0.47	0.90	0.08	0.33	0.21	0.68	0.84	0.64	0.68	0.70	0.97
Guainía	0.63	0.92	0.82	0.70	0.63	0.81	0.11	0.45	0.33	0.65	0.68	0.73	0.76	0.70	0.96
Guaviare	0.81	0.96	0.82	0.73	0.69	0.86	0.14	0.23	0.22	0.90	0.84	0.93	0.96	0.67	0.99
Vaupés	0.55	0.96	0.84	0.66	0.59	0.78	0.04	0.30	0.24	0.52	0.85	0.69	0.71	0.70	0.98
Vichada	0.65	0.93	0.73	0.73	0.60	0.88	0.06	0.42	0.26	0.58	0.78	0.73	0.75	0.68	0.97
Bogotá	0.86	0.96	0.91	0.80	0.64	0.89	0.13	0.23	0.29	0.94	0.91	0.98	0.99	0.68	0.98
Colombia	0.76	0.96	0.86	0.74	0.57	0.90	0.12	0.30	0.27	0.90	0.90	0.94	0.95	0.72	0.98

Table 9. Sample proportions of variables included in the IDECHI by Colombian regions (DHS 2010, 0-59 month-old Colombian children, n=12,719)

Region	Housing not overcrowded	Child not under weight	Child with no diarrhoea	Child with no fever	Child with no cough	Breastf. up to 2 years	Play with child 5+/week	Physical activities with child 5+/week	Mother not punishing physically	4+ antenatal visits	Mother received tetanus toxoid injection	Doctor attended delivery	Delivery in health facility	Child received Polio3	Child has health card
Atlantic	0.61	0.95	0.84	0.67	0.43	0.91	0.1	0.25	0.32	0.89	0.94	0.94	0.96	0.72	0.97
Eastern	0.77	0.96	0.86	0.77	0.63	0.86	0.12	0.35	0.28	0.89	0.89	0.94	0.96	0.71	0.98
Central	0.78	0.97	0.85	0.71	0.58	0.78	0.13	0.37	0.22	0.91	0.87	0.95	0.96	0.75	0.98
Pacific	0.81	0.97	0.76	0.87	0.57	0.91	0.10	0.24	0.25	0.88	0.87	0.88	0.90	0.75	0.98
Amazon and Orinoco	0.68	0.94	0.84	0.69	0.60	0.89	0.11	0.29	0.24	0.80	0.84	0.85	0.86	0.73	0.98
Bogotá	0.86	0.96	0.91	0.8	0.64	0.89	0.13	0.23	0.29	0.94	0.91	0.98	0.99	0.68	0.98
Colombia	0.76	0.96	0.86	0.74	0.57	0.9	0.12	0.3	0.27	0.9	0.9	0.94	0.95	0.72	0.98

3.3.2 Construction, components and dimensions represented by the Intermediary Determinants of Early Childhood Health Index-IDECHI

Given the discrete nature of the data, two methods of dimensionality reduction of the data matrix were employed: principal component analysis (PCA) using binary variables and PCA using polychoric correlations (polychoric PCA). Of these two, polychoric PCA proved to be the method which explains a greater percentage of variance with a lower number of components. Therefore, the subsequent analysis is based on the polychoric PCA method (the eigenvalues and eigenvectors of the correlation matrix of the binary PCA method are presented in Appendix A).

A widely used criterion for selecting the number of retained principal components is that proposed by Kaiser (1960), which suggests retaining components with eigenvalues greater than 1.0. Based on this criterion and analysing the minimal number of principal components which incorporate the 15 original variables included in the IDECHI, we identified five components: PC1, PC2, PC3 PC4 and PC5. These components explain 60% of the total variance (see Table 10). Additionally, to maximize the correlation between original variables and principal components, the latter have been rotated using VARIMAX criteria (Kaiser, 1958).

Table 10. Eigenvalues of IDECHI

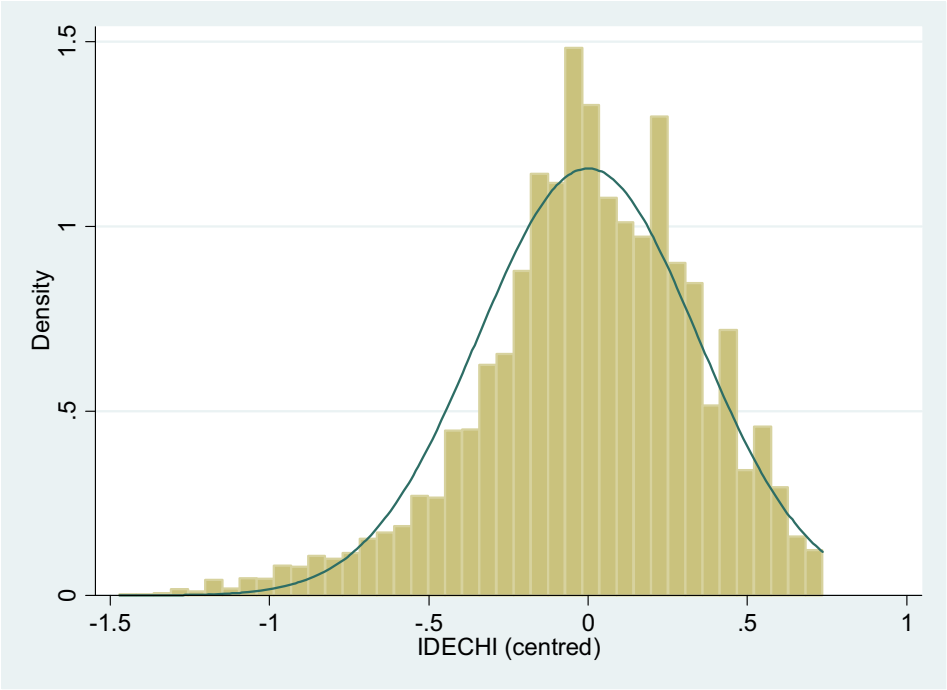
k	Eigenvalues	Proportion explained	Proportion Cumulative
1	3.0326	0.201	0.201
2	1.8929	0.127	0.328
3	1.5726	0.105	0.433
4	1.2762	0.088	0.520
5	1.1465	0.076	**0.596**

Having obtained the principal components, two indices were estimated. The first index was calculated giving equal weights to each component. The second was estimated as a weighted average of the retained components, taking into account the proportion of explained variance by each dimension. The weightings were calculated by dividing each eigenvalue into the sum of the

eigenvalues retained. Using equal weights as the method for estimating the index, the departments' positions did not change significantly. In fact, the positions of the departments at the top and bottom of the ranking remained practically the same with both methods (the rankings of departments of the index with equal weights are showed in Appendix B). Nevertheless, regardless of which weighting method is used, weights are essentially value judgements (OECD, 2008). Therefore, the analysis in this chapter has been performed using the results of the weighted indicator.

Figure 4 shows the index scores distribution. The indicator is centred on zero; more positive scores indicate departments that have better child health conditions, whereas those with more negative scores have a worse performance. The indicator allows us to identify the health dimensions in which a department presents deficits with respect to the rest of the country.

Figure 4. Distribution of the Intermediary Determinants of Early Childhood Health Index-IDECHI scores



The variables and dimensions represented by each component and the rotated matrix of correlations between PC and original categorical variables are

presented in Tables 11 and 12. Within each PC, the variables with the greatest correlation were selected (see values highlighted in Table 12). The components are interpreted positively, i.e. the higher the score, the better the child's health.

The results show that the first component, PC1, is related to maternal care and use of health facilities. This component includes the person who attended the delivery, the place of the delivery and the antenatal care. Variables that can reflect biological factors, such as recent illnesses, are grouped together in the second component, PC2. In the third component, PC3, factors related to parenting style such as playing, physical exercise and punishment are represented. The fourth component, PC4, is associated with material circumstances and encompasses household living conditions and nutritional status. It is important to bear in mind that although the *play* variable has the strongest correlation with the third component, it is also strongly associated with PC4. Finally, child health insurance and immunization are represented in the fifth component, PC5.

Table 11. Variables and dimensions represented in the IDECHI by Principal Component (PC)

Component	Dimension	Indicator	Variables
PC1	Health System	Maternal care and use of health facilities	Doctor assisted delivery Place of delivery Antenatal care Tetanus injection
PC2	Biological factors	Recent illnesses	Fever Diarrhoea Cough
PC3	Behavioural and psychosocial factors	Parenting style	Play Physical activity Physical punishment
PC4	Material circumstances	Living conditions Nutritional habits	Overcrowding Being underweight Breastfeeding
PC5	Health system	Child care and access to health system	Immunization Health card

Table 12 indicates that not having appropriate antenatal care, giving birth at home and without help from a doctor, are the variables that most differentiate child health. As we expected, mothers not having received antenatal care negatively affects child health. Moreover, although the correlation is lower, attending fewer antenatal visits than recommended has an equally negative impact on child health.

Likewise, breastfeeding for more than two years correlates negatively with child health. In conditions of poverty an increase in breastfeeding may mean that it is not possible to supplement the child's diet with other foods.

The magnitude and sign of the correlations associated with the *play* variable suggest that participating in this type of activity—as opposed to not doing it—positively affects child health. Furthermore, the more frequent the activity, the stronger the relationship to child health. At the same time, we observe that this variable is closely related to household material circumstances (PC4). This may indicate that the *play* variable could be connected to parenting style but, at the same time, is positively linked to parental socioeconomic status, as demonstrated in some studies (Guryan et al., 2008).

The results show the positive effect of physical activity on child health. However, it would seem that performing this activity once a week is not sufficient to influence child health in a positive way.

The correlation matrix also suggests that physical abuse is linked to parenting style. Nevertheless, the relatively low correlation of this variable may show the ambiguity of its effect on child health. On the one hand, we might expect that given its physical and psychological consequences, physical abuse would have a negative effect on child health. On the other hand, however, punishment as a way of disciplining a child would reflect stricter parents and therefore would have a positive influence on child health (Deater-Deckard et al., 2003; Gershoff, 2002).

Table 12. Rotated Principal Component matrix

Variable		PC1	PC2	PC3	PC4	PC5
Overcrowding						
	No	0.1743	0.1227	0.2147	0.8669	0.1774
	Yes	-0.1743	-0.1227	-0.2147	-0.8669	-0.1774
Under weight						
	No	0.1868	0.1228	0.0350	0.6297	-0.2718
	Yes	-0.1868	-0.1228	-0.0350	-0.6297	0.2719
Breastfeeding						
	Never breastfed	-0.0288	-0.1058	-0.1401	0.4407	0.2446
	Up to 2 years	0.0204	-0.0662	-0.2571	0.2336	-0.0157
	More than 2 years	-0.0141	0.1224	0.3630	-0.4335	-0.0609
Play						
	Not carried out	-0.0809	-0.0142	-0.8003	-0.7823	-0.3017
	once a week	-0.0024	-0.0010	0.1481	0.0823	0.1502
	2-4 times/week	0.0702	0.0012	0.5624	0.5535	0.2305
	>5 times/week	0.0751	0.0268	0.8083	0.8082	0.2136
Physical activity						
	Not carried out	0.0186	0.1938	-0.9111	-0.2126	-0.6019
	once a week	0.0778	-0.0169	-0.1009	0.0527	0.0042
	2-4 times/week	0.0042	-0.0658	0.3408	0.1057	0.2815
	>5 times/week	-0.0530	-0.1464	0.7938	0.1176	0.5441
Antenatal care						
	No antenatal visits	-0.6423	-0.0345	-0.2729	-0.5647	-0.1683
	1-3 visits	-0.3808	-0.0423	-0.2010	-0.3723	-0.1094
	4 or more	0.6905	0.0473	0.2719	0.5383	0.1623
Immunization						
	No	0.0474	0.1890	-0.4904	-0.0734	-0.9522
	Yes	-0.0474	-0.1890	0.4904	0.0734	0.9522
Diarrhoea						
	No	0.1271	0.6484	0.0271	0.2097	-0.1532
	Yes	-0.1272	-0.6484	-0.0271	-0.2097	0.1532
Fever						
	No	0.0255	0.8923	0.0021	0.0286	0.0317
	Yes	-0.0255	-0.8923	-0.0021	-0.0286	-0.0317
Cough						
	No	-0.0881	0.8527	-0.0017	0.0781	-0.0140
	Yes	0.0881	-0.8527	0.0017	-0.0781	0.0140
Physical punishment						
	No	0.0713	0.0525	0.4316	-0.0049	-0.2590
	Yes	-0.0713	-0.0525	-0.4316	0.0049	0.2590
Doctor						
	No	-0.8794	-0.0172	-0.1654	-0.3337	-0.1315
	Yes	0.8794	0.0172	0.1654	0.3337	0.1315
Delivery						
	Home and others	-0.9066	-0.0158	-0.1714	-0.3439	-0.1432
	Health institution	0.9066	0.0158	0.1714	0.3439	0.1432
Tetanus injection						
	No	-0.4126	-0.0064	-0.2132	-0.2201	-0.1440
	Yes	0.4126	0.0064	0.2132	0.2201	0.1440
Health card						
	No	-0.1735	0.0119	-0.1268	-0.1299	-0.8947
	Yes	0.1736	-0.0119	0.1267	0.1298	0.8947

3.3.3 Colombian departments' heterogeneity in intermediary determinants of early childhood health

The indicator of intermediary determinants of early childhood health (IDECHI) allows departments to be ranked and differences in child health across Colombian regions to be analysed. With the aim of showing the heterogeneity of the distribution of the departments among components, ranking by principal components is presented in Table 13. The departments best/worst ranked for each component are: Atlántico/Vaupés (maternal care and use of health facilities), Boyacá/Amazonas (biological factors), Antioquia/Chocó (behavioural and psychosocial factors), Quindío/Vaupés (material circumstances) and Antioquia/Guajira (child care and access to health system).

The analysis of the IDECHI by components shows heterogeneity in the health performance of the departments. There is no one department that ranks top in all five components. Bogotá, for instance, which is in first position in the global indicator, is ranked 19 out of 33 for child health insurance and immunization. Boyacá and Cundinamarca, in second and third place, are ranked 10 and 15 respectively for health at birth. In the case of the lowest ranking departments, we note that Vaupés is ranked 19 for recent illnesses but is in the lowest positions in the other health dimensions.

The IDECHI ranking of Colombian departments in 2010 is shown in Table 14. The departments are organized by region and the results are presented for urban and rural areas. The results indicate that Chocó, Vaupés, Guajira, Vichada and Guainía are ranked in the lowest positions, while Bogotá, Boyacá, Quindío, Huila and Risaralda are at the top of the ranking. In terms of place of residence, the bottom of the ranking is quite similar to the overall ranking. By contrast, some changes are observed at the top end. For example, Valle and Atlántico are in the top five of rural ranking, whereas in the urban ranking they lie in 21st and 15th place, respectively.

Table 13. Ranking of departments by Principal Components (PC) based on IDECHI scores

Department	PC1[a]	PC2[b]	PC3[c]	PC4[d]	PC5[e]
Atlantic Region					
Atlántico	1	29	18	19	9
Bolívar	5	28	29	24	29
Cesar	9	26	21	23	17
Córdoba	21	21	27	22	32
Guajira	26	31	30	32	33
Magdalena	12	32	26	28	20
Sucre	11	30	32	27	26
San Andrés	2	14	17	4	31
Eastern Region					
Boyacá	10	1	5	7	24
Cundinamarca	15	3	2	8	21
Meta	17	12	14	18	16
Norte de Santander	16	20	20	25	12
Santander	18	8	9	15	7
Central Region					
Antioquia	20	23	1	6	1
Caldas	13	24	23	10	2
Caquetá	25	25	28	20	10
Huila	8	15	3	16	3
Quindío	4	11	10	1	6
Risaralda	6	4	19	5	13
Tolima	19	10	6	11	28
Pacific Region					
Cauca	28	16	16	14	5
Chocó	29	27	33	26	25
Nariño	24	6	13	17	4
Valle	7	9	8	2	14
Orinoco and Amazon Region					
Arauca	14	7	22	12	11
Casanare	23	13	7	21	8
Putumayo	27	18	15	13	15
Amazonas	31	33	25	31	22
Guainía	30	17	11	29	27
Guaviare	22	5	12	9	18
Vaupés	33	19	31	33	30
Vichada	32	22	24	30	23
Bogotá	3	2	4	3	19

[a] Represents maternal care and use of health facilities
[b] Represents biological factors
[c] Represents behavioural and psychosocial factors
[d] Represents material circumstances
[e] Represents child care and access to health system

Table 14. Ranking of departments by total and urban-rural area based on IDECHI scores

Department			
Region	**Urban**	**Rural**	**Total**
Atlantic			
Atlántico	20	11	15
Bolívar	25	23	23
Cesar	23	10	20
Córdoba	22	19	22
Guajira	28	**29**	**29**
Magdalena	27	22	24
Sucre	**29**	25	26
San Andrés	16	**4**	9
Eastern			
Boyacá	6	**2**	**2**
Cundinamarca	**3**	**5**	**3**
Meta	17	14	14
Norte de Santander	21	20	19
Santander	11	9	11
Central			
Antioquia	**1**	12	6
Caldas	13	15	16
Caquetá	24	26	27
Huila	**4**	7	7
Quindío	7	**3**	**4**
Risaralda	10	6	8
Tolima	9	13	12
Pacific			
Cauca	12	24	25
Chocó	**31**	**31**	**32**
Nariño	**5**	18	18
Valle	8	**1**	**5**
Amazon and Orinoco			
Arauca	15	16	13
Casanare	14	17	17
Putumayo	19	21	21
Amazonas	**30**	**30**	**31**
Guainía	26	**28**	28
Guaviare	18	8	10
Vaupés	**32**	**32**	**33**
Vichada	**33**	27	**30**
Bogotá	**2**		**1**

3.3.4 Clustering of the Colombian departments according to the IDECHI

From the retained principal components, a hierarchical cluster analysis was carried out, based on the averages of the PCs in each department (see Appendix C). The dendogram and positioning of clusters in the component axes are presented in Figures 5 and 6, respectively. The cluster analyses allow us to generate an alternative classification of departments, taking into account the characteristics of child health rather than geographical location. The departments by cluster are shown in Table 15 and Figure 7.

The results indicate that Cluster 1 is formed by 13 departments that perform best in all components. Cluster 3 is formed by five departments with a good performance in the first four components. These clusters group those departments that are in the top 5 of the indicator. These are departments located in the centre of the country.

Clusters 2 and Cluster 4 show a heterogeneous performance in child health. Cluster 2, made up of five departments, performs better in health at birth and access to health care, whereas it has deficiencies in current health status, parenting style and living conditions. Cluster 4, also formed by five departments, is below the average in all components with the exception of the first. Eight of the ten departments that form these two clusters are located in the north of the country.

The departments in Cluster 5 are located in the peripheral region and show a poor performance in all dimensions of intermediary determinants of child health. The four departments in this group rank lowest in the IDECHI.

Figure 5. Dendogram for the Intermediary Determinants of Early Childhood Health Index-IDECHI

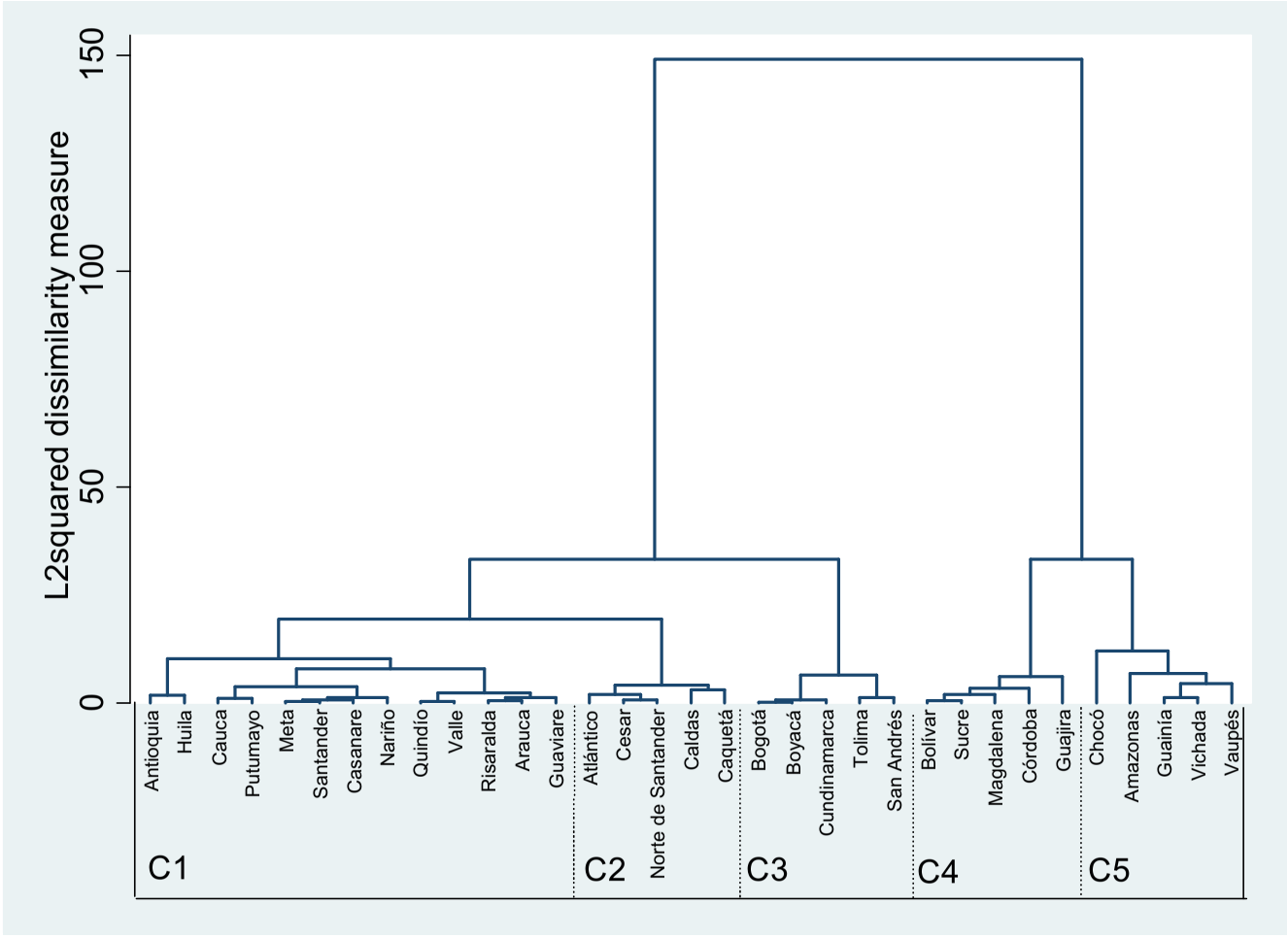


Figure 6. Positioning of cluster by Principal Component axes

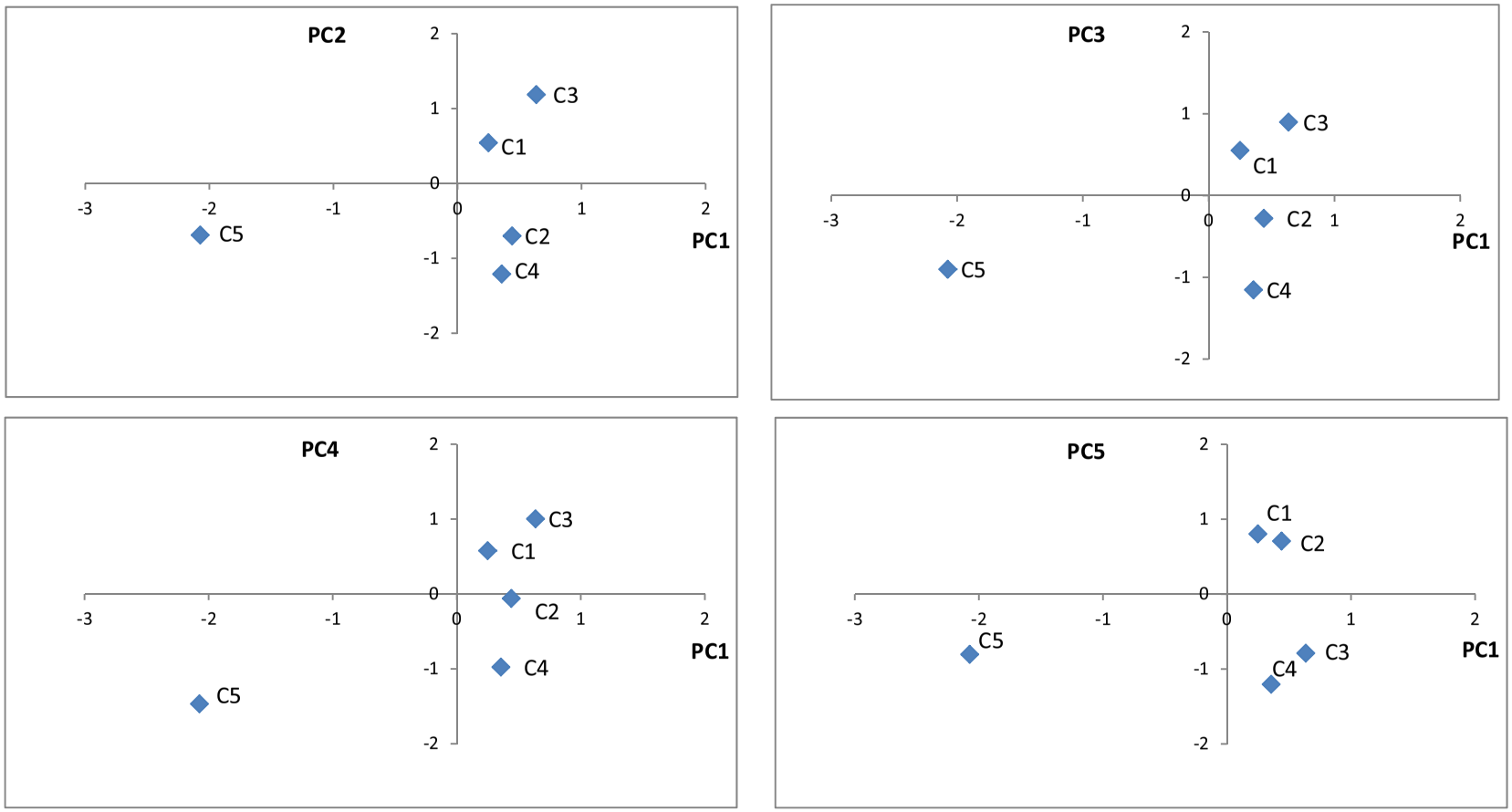
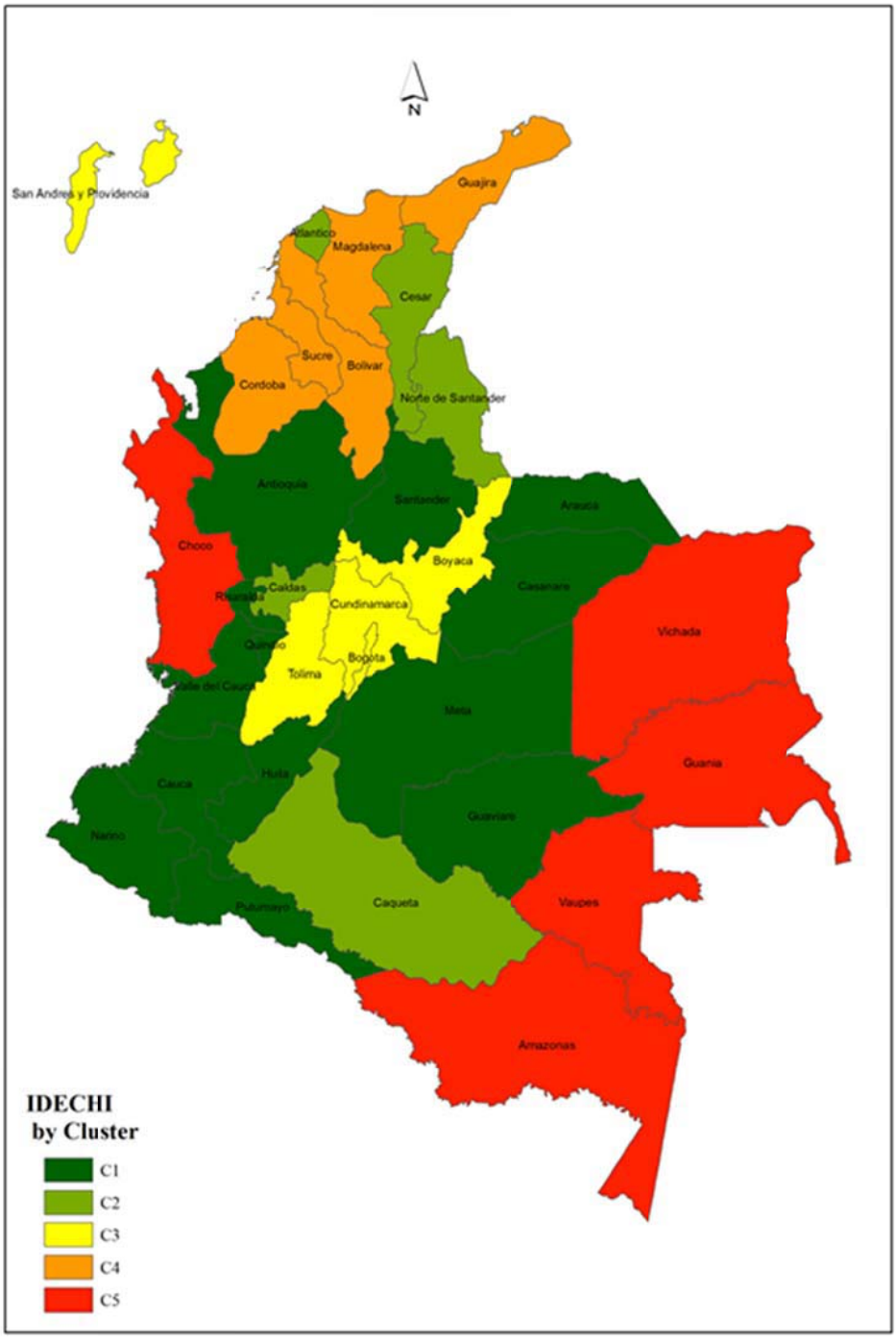


Table 15. Clustering of Colombian departments based on the IDECHI scores

Cluster	Department
C1	Antioquia
	Arauca
	Casanare
	Cauca
	Guaviare
	Huila
	Meta
	Nariño
	Putumayo
	Quindío
	Risaralda
	Santander
	Valle del Cauca
C2	Atlántico
	Caldas
	Caquetá
	Cesar
	Norte de Santander
C3	Bogotá
	Boyacá
	Cundinamarca
	San Andrés and Providencia
	Tolima
C4	Bolívar
	Córdoba
	Guajira
	Magdalena
	Sucre
C5	Amazonas
	Chocó
	Guainía
	Vaupés
	Vichada

Figure 7. Colombian–IDECHI (Departments grouped by cluster)



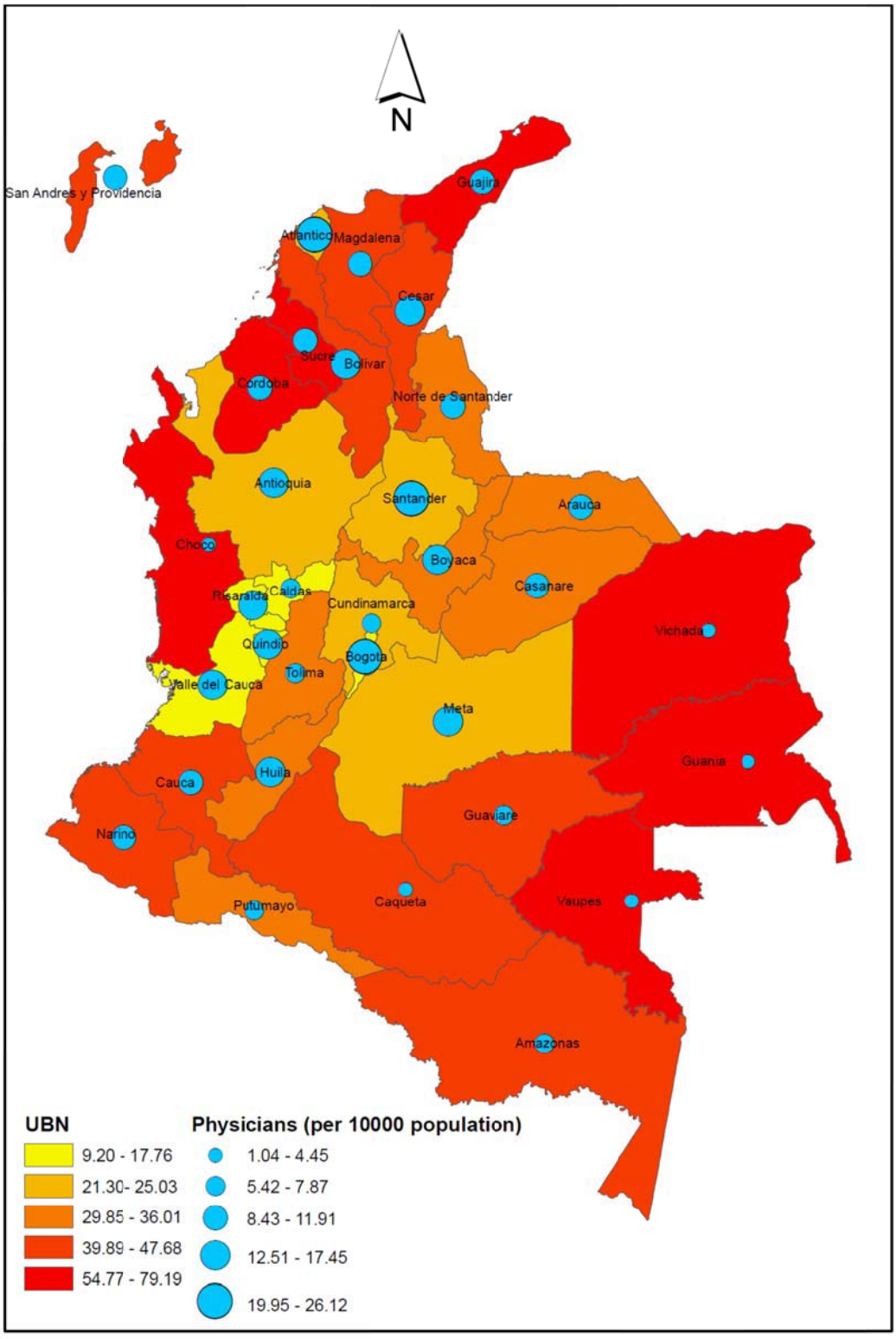
Source: own compilation

3.3.5 External validity of the IDECHI

One way to validate an indicator is to explore the relationship between the indicator itself and other index scores and variables that are not included in it (Booysen, 2002). Firstly, in order to contextualize the departments, an indicator of socioeconomic conditions (Unsatisfied Basic Needs, UBN) and an indicator of health infrastructure (physicians per 10000 population) are shown in Figure 8. The map indicates that departments with the greatest needs in child health are departments characterised by a health infrastructure well below national average and the highest levels of poverty.

It is widely accepted that health inequalities can be explained by the level of wealth (Marmot, 2004). We explore the relationship between our index and the socioeconomic status (SES) of the household. We used a proxy measure of SES based on ownership of consumer durable goods (such as radio, television, refrigerator, motorcycle and car) and quality of housing (type of drinking water, type of toilet facility, main floor and wall material and whether the household has electricity). The SES index is constructed using polychoric PCA. We fitted a linear regression between IDECHI and SES. The estimated slope is 0.355 and is statistically significant at 1% level, so there is a positive and significant relationship between child health and socioeconomic status (see Table 16).

Figure 8. Unsatisfied Basic Needs and number of physicians (per 10000 population) by Colombian departments



Source: own compilation from DANE, Census 2005 and *Ministry of Social Protection* Colombia.

Table 16. Coefficient for Intermediary Determinants of Early Childhood Health Index on Socioeconomic Status

	Coefficient	Standard errors
SES	0.355	(0.006)***
Constant	0.422	(0.004)***
Number of obs.	12,719	
R-squared	0.2160	

***Significance at 1%.

3.4 Summary and discussion

In this chapter, we have presented a description of intermediary determinants of early childhood health in Colombia by department and place of residence (urban/rural) through the construction of a composite indicator of child health. We have used data from the 2010 Colombian Demographic Health Survey (DHS), taking into account several dimensions of children's health throughout their first five years of life, including antenatal health. The index has been computed using polychoric PCA. From this method five principal components were selected. The index grouped together variables related to intermediary factors of child health, such as the use of health facilities at birth, recent illnesses, parenting style, living conditions and nutritional habits, and more general access to health services.

The analysis of the IDECHI indicated that department performance varies according to component. A department can perform very well in one dimension but at the same time may rank in lowest position in another child health dimension. With regard to place of residence, the results show that rural areas have more child health needs compared to urban areas. Furthermore, according to the evidence of economic and social indicators in Colombia, we find a positive association between performance in intermediary determinants of child health, socioeconomic conditions and the health infrastructure of the departments. Although this issue is not dealt with in depth here, some conclusions can be drawn.

The departments with the best child health conditions are those where the economic activity of the country is concentrated and poverty rates are lower.

The departments ranking at the bottom have the highest levels of poverty. The results suggest that the regional disparities in child health may be associated with differences in parental characteristics, household conditions and economic development levels, which highlight the importance of context in the study of child health in Colombia. In this vein, our indicator can provide relevant information and may be a useful tool for designing public programmes and allocating resources in favour of children.

On the other hand, the results of the hierarchical cluster show that departments that perform well in most of the specific determinants of early childhood health are located in the centre of the country. These are the departments with the greatest economic competitiveness. In contrast, those departments where intermediary determinants of child health perform worst are located in the Amazon and Orinoco, Pacific and Atlantic regions, which together are known as the peripheral region. This region is characterized as having per capita GDP levels well below the national average, little State presence, a hostile environment and a large proportion of the ethnic minorities (Galvis & Meisel, 2010). For these reasons, in this region priority should be given to designing policies aimed mainly at the health care of mothers and children at birth, as well as the development of programmes that aim to improve departmental equity in access to key goods and facilities for child well-being.

To sum up, in answer to our research questions, we found that: i) intermediary determinants that correlate strongest with child health are those associated with health before and during delivery, ii) department performance in intermediary determinants of child health varies significantly by dimension. With regard to place of residence, urban areas have advantages in intermediary determinants of child health compared to rural areas, and iii) in relation to their child health, departments grouped differently to the geographical regions traditionally established in regional studies and in other surveys in the country, such as the Quality Life Survey.

Chapter 4:

The influence of structural determinants on intermediary determinants of early childhood health: exploring the role of community socioeconomic context

4. The influence of structural determinants on intermediary determinants of early childhood health: exploring the role of community socioeconomic context

The purpose of this chapter is to examine the pathways through which structural determinants influence different dimensions of intermediary determinants of child health and how they operate according to the communities where children live. "The socioeconomic context of the communities may affect characteristics of the social, service and physical environments of communities to which all community residents are exposed, regardless of their own socioeconomic position. These patterned community exposures in turn affect the individuals' biological, psychosocial, behavioural and social characteristics, conditions and experiences that are more proximate determinants of individual health" (Robert, 1999, p. 495).

We adapt the conceptual framework proposed by the Commission on Social Determinants of Health for the study of child health (see section 1.3). The data were drawn from the 2010 Colombian DHS as described in Chapter 2. The sample used in this study comprised 6,610 children aged between 6 and 36 months, nested in 3,023 communities.

Osorio et al. (2012) determined that intermediary factors of child health can be represented in a global index, which in turn can be divided into independent components. The study provided evidence of the relationship between intermediary determinants of child health and the place of residence in Colombia, finding a central-peripheral pattern. Considering the above results, the study presented in this chapter contributes to filling the knowledge gap in the literature by exploring the association between community level characteristics and a composite index that quantitatively measures intermediary determinants of child health in Colombia. Furthermore, taking into account that community context can exert different influences on these intermediary factors, the index constructed is broken down into two sub indices. While the first of these includes variables linked to the use of and access to the health system, the second groups together psychosocial and behavioural factors.

Although previous empirical research has investigated contextual effects on child health outcomes (mainly on mortality and nutrition) in developing countries (e.g. Sastry, 1996; Fotso and Kuate-Defo, 2006; Linnemayr et al.,

2008; Luke and Xu, 2011), few studies have considered the effect of community context on intermediary factors such as parenting style and child care that can influence child well-being. Moreover, this study is not aware of any research that has explored the role of community socioeconomic context on child health in Colombia in the last thirty years.

The indexes are constructed using polychoric PCA (a complete description of which is outlined in section 3.2). Weighted multilevel models are used to examine the community level effects, since the data are not self-weighting. Using the overall index and the two sub-indices as dependent variables, we investigate the impact of individual characteristics, family socioeconomic position and community socioeconomic context on intermediary determinants of child health.

The rest of this chapter presents a description of the variables included in the models, the multilevel modelling methodology, the results obtained and the discussion of the main findings.

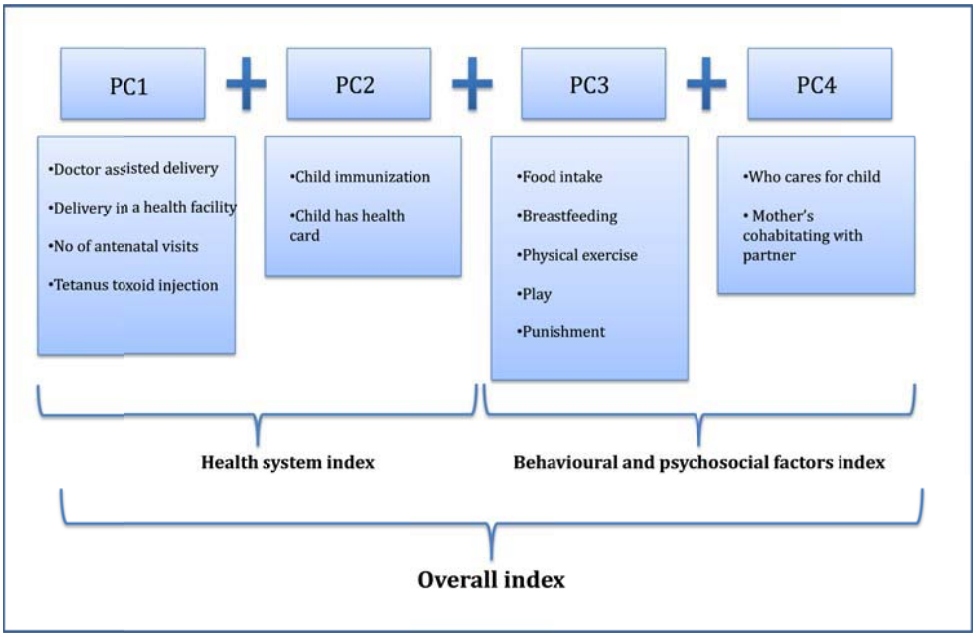
4.1 Variables

4.1.1 Dependent variables

The dependent variable is a composite index that takes into account behavioural and psychosocial factors as well as characteristics linked to the health system. Based on Kaiser criterion (Kaiser, 1960), four principal components—PC1, PC2, PC3 and PC4—were selected. These four PCs represent variables related to maternal health (PC1), child immunization and access to the health system (PC2), nutritional habits and parenting style (PC3), and child care (PC4). Additionally, in order to examine the influences that communities may have on different dimensions of intermediary determinants, we used two sub-indices as dependent variables. The health system index is constructed by aggregating PC1 and PC2, while PC3 and PC4 are combined into one sub-index representing behavioural and psychosocial factors index. The overall index was estimated using a weighted average of the components retained. The index scores range from 0 to 1, where 1 represents the best health conditions in intermediary determinants and 0 the worst circumstances.

The dimensions and variables represented by each component are presented in Figure 9.

Figure 9. Variables and dimensions represented by the overall index of the health system and behavioural and psychosocial factors categories



The description of the variables included in the index is showed in Table 17. In addition to the variables included in the category of behavioural and psychosocial factors described in section 3.1, in this study we add information about food intake and the child care provider. Specifically, we included whether the mother gave children vitamin A fruits in the last 24 hours. Vitamin A plays a critical role during the first three years of life, as it helps in boosting the immune system and, therefore, protects the child against diseases such as diarrhoea and acute respiratory infections (UNICEF, 2009b).

In order to take into account aspects related to child care, the person (mother, partner, grandparents or others such as older siblings, relatives, neighbours, etc.) who cares for child when mother is out of home was considered in the index construction. It has been demonstrated that loving, stable, secure and stimulating relationships with caregivers and family members in early childhood is critical for a child's development (UNICEF, 2008).

Table 17. Description of the variables included in the composite index

Indicator	Variable	Description	Values
A. Behavioural and psychosocial factors			
	Food intake	Mother gave child mangoes, papayas or other vitamin A fruits in the last 24 hours	0=No 1=Yes
	Breastfeeding	Months of breastfeeding	0=Never breastfed 1=Up to 2 years 2=More than 2 years
	Physical activity	Mother or household member spent time with child in physical activities last week:	0=Not carried out 1=Once a week 2=2-4 times per week 3=5+ times per week
	Play	Frequency mother played with child last week	0=Not carried out 1=Once a week 2=2-4 times per week 3=5+ times per week
	Punishment	Mother punishes children physically	0=No 1=Yes
	Care provider	Who cares for child when respondent is out of home	0=Mother 1=Father 2=Grandparents 3=Others
	Partner at home	Mother is cohabitating with partner	0=No 1=Yes
B. Health system			
	Doctor	Doctor assisted the delivery	0=No 1=Yes
	Delivery place	Delivery in a health facility	0=No 1=Yes
	Antenatal care	Number of antenatal visits	0= No antenatal visits 1= 1-3 visits 2=4 or more
	Tetanus injection	Mother received tetanus injection	0=No 1=Yes
	Immunization	Child received third dose of polio	0=No 1=Yes
	Health Card	Child has health card	0=No 1=Yes

4.1.2 Independent variables

A set of variables was selected based on the conceptual framework proposed earlier (Figure 1) and a literature review of social determinants of child health. The variables are grouped as background controls and structural determinants. Within the structural determinants, the variables are divided into family-level variables and community-level variables. The variables are described below.

Background controls

Several specific characteristics of children, their mothers and the household where they live were included in the models.

In the case of child-specific variables, we controlled for: i) *child's age,* measured in months, ii) *child's age squared*, iii) *child's sex*, coded as 0 for boys and 1 for girls, iv) *child's birth order and interval,* constructed by combining birth order and preceding birth interval in five categories: first birth, 2nd-3rd birth order and short birth interval (<2 years), 2nd-3rd birth order and long birth interval (>2 years), 4th or higher birth order and short birth interval (<2 years), and 4th or higher birth order and long birth interval (>2 years). Finally, we included v) *child's exposure to community nurseries,* a continuous variable defined as the fraction of a child's life spent in a community nursery (HCB) and created by dividing the months that the child has attended an HCB during his or her life by the child's age in months.

As mothers' background characteristics, the following variables were included: i) *mother's age at first birth* (in years) and ii) *mother's autonomy index*. The DHS does not include any direct measure of autonomy, so in order to investigate the link between female autonomy and intermediary determinants of child health, we construct a composite index based on women's decisions on their own health care, large and daily household purchases, visits to family or relatives, food to be cooked, money husband earns, studying and having sexual intercourse. The weights of the variables were generated using polychoric PCA and the index scores were rescaled to range from 0 to 1.

Household characteristics were assessed by*:* i) *number of children under the age of five* and ii) *place of residence*, a binary variable indicating whether the household is located in an urban or rural area.

Structural determinants

At the *family-level*, the variables of interest were: i) *mother's education* (no education, primary, secondary, higher), ii) *mother's occupation* (not working, professional/technical/manager, clerical/sales/services/skilled manual or agricultural and unskilled manual), iii) *partner's education* (no education, primary, secondary or higher) and iv) *household socioeconomic status (SES) index*.

Household wealth indices are proxy measures of household socioeconomic status (SES) widely used in developing countries. While direct measures of households SES, such as income or consumption expenditure, can be expensive to collect or are not available and in some cases unreliable, proxy measures have been claimed to be more reliable and easier to observe than income (Filmer & Pritchett, 2001; Rutstein, 2008). Household wealth is measured in DHS surveys through a composite index following the Filmer and Pritchett (2001) procedure. This wealth index includes a set of durable consumer goods, housing characteristics and access to basic services.

Using polychoric principal component analysis (PCA), we constructed a similar SES index based on ownership of consumer durable goods such as radio, TV, fridge, motorcycle and car/truck, as well as characteristics of the dwelling, such as source of drinking water, type of toilet facility, floor and wall material and electricity. The index is categorized in quintiles (very poor, poor, medium, rich and very rich). We used polychoric PCA, which breaks down the categorical variables into a set of dummy variables, as opposed to the strategy proposed by Filmer and Pritchett (2001), since the latter does not perform well with ordinal data and the proportion of explained variance estimated by this method is underestimated (Kolenikov & Angeles, 2009).

At the *community-level* we tested specific characteristics of the community socioeconomic context that might influence intermediary determinants of child health. Community-level variables were derived by aggregating individual-level data and using information from the total of mothers included in the full sample (53,521 women). In order to avoid an overlap of the measures between the two levels studied (family and community), the values of the community-level variables were derived from non-self means or proportions. Non-self means is a method that assigns each woman a value

representing the average of all the other women in her community and therefore, does not include her own value.

Structural determinants at the community-level were assessed using the following indicators: i) *Community maternal education*, defined as the mean number of years of the mother's education in the community, ii) *Community socioeconomic status,* constructed as the mean level of the socioeconomic status index in the community, iii) *Community maternal employment*, measured as the proportion of women currently working in the community, iv) *Community exposure to community nurseries*. The influence of community child care programmes was assessed through the mean level of children's exposure to the community nurseries programme (HCB).

4.2 Methods

4.2.1 Multilevel modelling

The role played by communities on intermediary determinants of child health was examined using multilevel models. These allow us to take into account the hierarchical structure of the data and to explore variations between and within clusters. When using hierarchical data, such as DHS data, individuals from the same cluster tend to be more similar to each other 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, 2002). That is, we are able to investigate the extent to which differences in intermediary determinants of child health are accounted for by contextual characteristics, such as the level of community socioeconomic development. Furthermore, estimating the variance at each level allows us to differentiate between the variation in child health due to differences at the community level and those that are the result of differences in family characteristics.

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 6,610 families at level 1, nested within 3,023 communities at level 2. The models had the following general specification:

$$y_{ij} = \beta_0 + \sum_{k=1}^{p} \beta_k X_{kij} + \sum_{l=1}^{q} \beta_l Z_{lj} + (u_j + e_{ij}), i = 1,\ldots,6610, j = 1,\ldots 3023, \qquad (4)$$

where y_{ij} is the score of the intermediary determinants of the early childhood health index for the ith child in the jth community; β_0 is the intercept parameter; X_{kij}, $k = 1,\ldots,p,$ are the family-level covariates; Z_{lj}, $z = 1,\ldots,q,$ are the community-level covariates; and e_{ij} and u_j are 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. Thus, the total variance is partitioned into: the between-community variance σ_u^2 and the within-community or between-family variance σ_e^2 .

Partitioning variance

The random effects can be expressed through the variance partition coefficient (VPC). The VPC measures the proportion of total variance $(\sigma_e^2 + \sigma_u^2)$ that is attributed to differences between groups (in our case between communities) σ_u^2:

$$VPC = \frac{\sigma_u^2}{\sigma_e^2 + \sigma_u^2} \qquad (5)$$

The VPC ranges from 0 to 1, where 0 indicates that there are no between-groups differences and 1, that there are no within-group differences.

For example, a VPC of 0.3 indicates that 30% of the variation in intermediary determinants of child health is due to community characteristics. That is, the correlation between randomly chosen pairs of children living in the same community is 0.3.

Sample design: weighting and scaling in multilevel modelling

The use of multilevel statistical techniques to estimate contextual effects in health research is now widespread in the demographic literature (Diez Roux, 2000; Duncan et al., 1998; Pickett & Pearl, 2001; Rice & Jones, 1997). However, the majority of empirical studies use unweighted data even when the units present unequal selection probabilities. This failure to account for the design weights in multilevel models can lead to biased parameter estimates. Nevertheless, recent software developments allow us to incorporate design weights and other complex survey design features, including clustering and stratification, into our analysis, thereby minimizing biases.

Like most of the samples from the DHS, the sample design of the Colombian DHS incorporates sampling weights in order to reduce the estimation bias due to unequal selection probabilities. However, as many authors have argued, 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. Hence, the sole inclusion of level-1 weights is insufficient. Moreover, in order for design weights to be properly incorporated, they must also be scaled (Carle, 2009).

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

$$w_j = \frac{\sum_i w_{ij}/n_j}{\left(\sum_j \sum_i w_{ij}/n_j\right)/J} \tag{6}$$

where J is the total number of clusters. Given that we have small cluster sizes, we used the "effective" method for standardizing weights so that the level-1 weights sum to the effective cluster size (Carle, 2009). All multilevel analyses were performed in Stata version 12 using "xtmixed" command and included sampling weights.

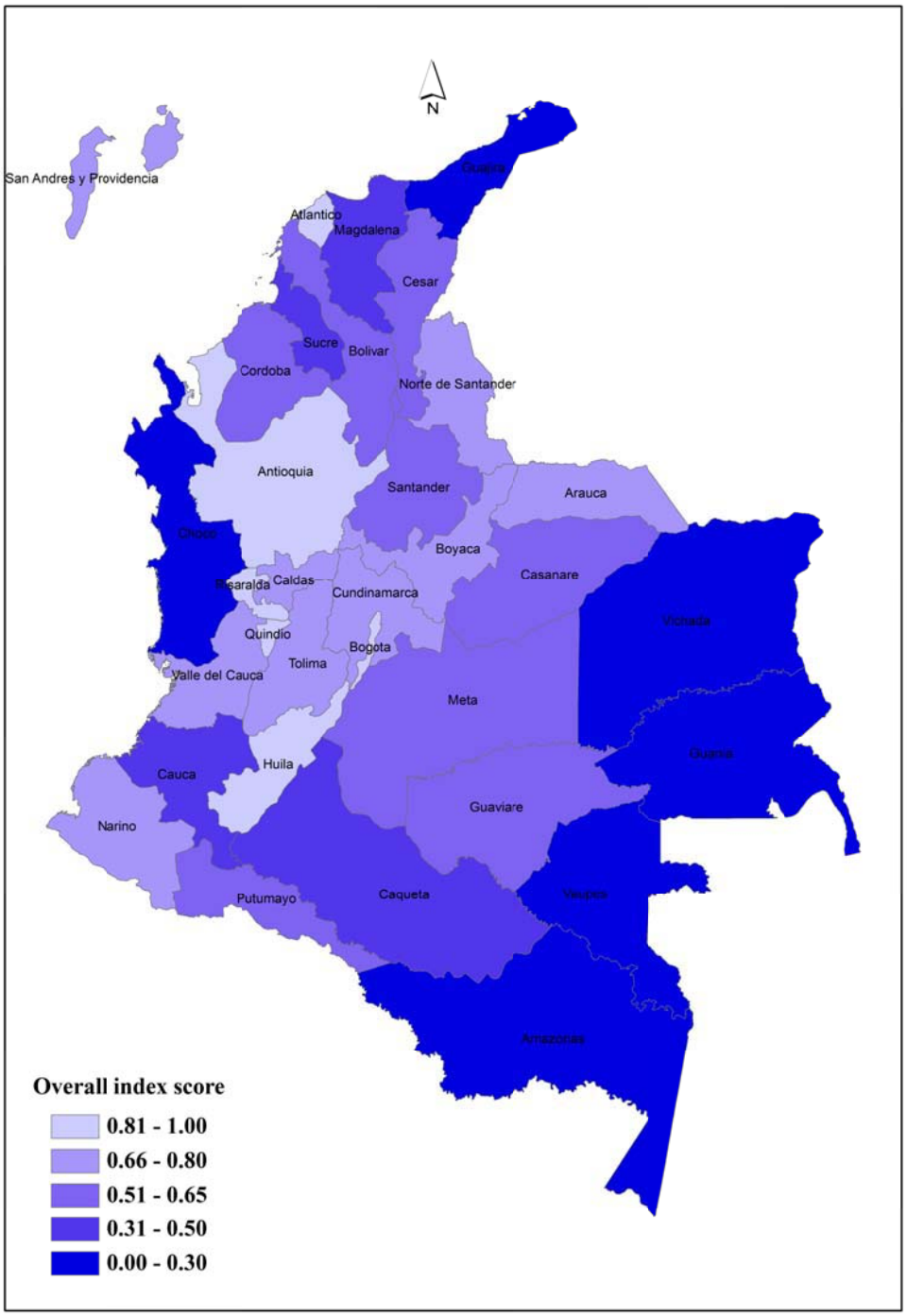
4.3 Results

4.3.1 Descriptive analysis

The distribution of the overall index by Colombian departments is illustrated in Figure 10. The map shows that the departments that perform best in relation to most of the specific determinants of early childhood health are located in the centre of the country. In contrast, the departments that perform worst are located in the peripheral region. The overall index shows evidence of a socioeconomic gradient in intermediary determinants of child health, i.e. the better the education and socioeconomic status, the higher the index score. For instance, the overall index is 30% higher among children born to parents with higher education than among those born to uneducated parents.

The characteristics of the sample used in this section are shown in Table 18. All descriptive statistics are weighted by sampling weights. The average age of the children included in the sample is 20 months. They are almost evenly distributed between boys and girls. About 40% of the children do not have siblings and have been exposed for 6% of their lives to a community nursery. In terms of a family's socioeconomic characteristics, most children were born to mothers and fathers with secondary education and to mothers employed mainly in activities that require skilled labour. Furthermore, while about 28% of the children live in poor or very poor households, about 12% live in the wealthiest households. The majority of children (72%) reside in urban areas.

Figure 10. Distribution of the overall index (health system and behavioural and psychosocial factors categories) by Colombian Departments (n=6,610)



Source: own compilation

Table 18. Sample characteristics for 6-36 month-old Colombian children (n=6,610)

Variables	Mean/ Proportion
Dependent	
Overall index	0.6
Health system index	0.8
Behavioural and psychosocial factors index	0.4
Independent	
Background controls	
Child's age in months	19.5
Child's sex	
boy	50.4
girl	49.6
Child's birth order/preceding birth interval	
first-birth	39.9
2nd-3rd and <2 years	4.3
2nd-3rd and >2 years	41.6
4th + and <2 years	2.9
4th + and >2 years	11.3
Child's exposure to community nurseries programme	0.06
Mother's age at first birth in years	20.4
Mother's autonomy index	0.6
Number of children under five in household	1.5
Place of residence	
rural	27.9
urban	72.1
Structural determinants:	
Family-level socioeconomic characteristics	
Mother's education	
no education	1.8
primary	23.7
secondary	55.3
higher	19.1
Mother's occupation	
not working	14.9
professional/technical/manager	5.5
clerical/sales/services/skilled manual	73.9
agricultural/unskilled manual	5.8
Partner's education	
no education	2.7
primary	27.6
secondary	45.1
higher	12.3
Socioeconomic status	
very poor	11.5
poor	16.2
medium	21.3
rich	38.3
very rich	12.6
Community-level socioeconomic characteristics	
Mean years of mother's education	8.9
Mean level of SES	0.7
Proportion of women currently working	0.4
Mean fraction of child's life spent in a community nursery (HCB)	0.06

4.3.2 Multilevel analysis

Tables 19, 20 and 21 show the results of multilevel models for the overall index and the two sub-indices. Note that all indicators range from 0 to 1 and are interpreted positively; therefore, a positive regression coefficient can be interpreted as increasing the index score and, therefore, correlates with better child well-being.

In order to explore the extent to which the between-community variation changes when individual, family and community characteristics are added, four sequential models were fitted. Model 0 (null model) included no explanatory variables; Model 1 incorporated background controls; Model 2 included the family's socioeconomic characteristics; and, finally, Model 3 accounted for community characteristics. The community effects are discussed in section 3.4. Here we focus on the results of the models for the overall index and the sub-indices.

The overall index

When the overall index was controlled for by background controls (Model 1a), the findings showed that, except for the child's sex and the mother's autonomy index, all coefficients are statistically significant. However, when the family's socioeconomic characteristics were added (Model 2a), the effect of higher birth orders (4th +), the child's exposure to the community nurseries programme and the association with the mother's age and place of residence disappeared.

As expected, the mother's education and household socioeconomic status were strongly associated with intermediary determinants of child health. Mothers working in skilled sectors positively influenced the overall index performance compared to mothers who do not work. As for the partner's education, the coefficient for higher educational level was found to be statistically significant.

Finally, when controlling for community characteristics (Model 3a), few changes were observed in the background and socioeconomic variables. The most notable change was observed in the significance and magnitude of the wealth quintile coefficients. Generally, the significance of these was weaker

and the effect was reduced by almost half. Community characteristics showed that children living in communities with higher levels of education and socioeconomic status have a higher index. By contrast, children living in communities with greater exposure to the community nurseries programme present a lower score in the overall index.

The health system index

The results of the models for the health system dimension indicated that when background controls are considered (Model 1b), only the coefficient for child's sex was not statistically significant. In contrast to the models for the overall index, the coefficient for mother's autonomy was statistically significant in the case of the health system index.

With the introduction of the family's socioeconomic characteristics (Model 2b), the effects of background controls remained almost unaltered. The mother's education and occupation and the household's SES were found to be strongly associated with the health system index. However, when community characteristics were included (Model 3b), the effect of household wealth was not so great. In relation to community variables, only the mean years of maternal education in the community and the mean level of SES were found to be associated with the health system index.

The behavioural and psychosocial factors index

In Model 1c, the child's sex, the child's exposure to community nurseries, the number of children under the age of five in the household and the place of residence were not associated with the behavioural and psychosocial factors index. Nevertheless, when a family's socioeconomic characteristics were included in Model 2c, the sex of the child reached statistical significance. As in the other indices, the mother's education, her occupation and the household's SES were associated with the behavioural and psychosocial dimensions. Finally, in Model 3c, with the inclusion of community characteristics, the effect of household wealth practically disappeared. The community variables that were associated with the index were the proportion of women currently working in the community and the child's exposure to the HCB programme.

Comparing the health system and the behavioural and psychosocial factors dimensions

Comparing Models 3b and 3c, our results indicate that a child's sex was only associated with the behavioural and psychosocial factors index. Girls performed worse than boys in the indicators of behavioural and psychosocial factors. On the other hand, a child's exposure to the HCB programme was only positively associated with the health system index.

In general, a child's age presented a curvilinear association with the intermediary determinants of child health. However, the effect was observed as being very small. There was a significant association between a mother's age at first birth and the two sub-indices. This showed that the older the mother, the better the performance of the intermediary factors related to health system, but the worse the performance of the indicator of the psychosocial and behavioural factors. A mother's autonomy and the number of children under the age of five in the household, on the other hand, were only associated with the health system dimension.

Regarding the health system indicator, unlike the indicator for the behavioural and psychosocial factors, living in an urban area has a positive influence even after controlling for the family's socioeconomic characteristics. Nevertheless, in both cases, the effect disappears once the community socioeconomic characteristics are included.

In the case of the family's socioeconomic characteristics, the mother's education and occupation were significantly associated with the two sub indices. However, in Model 3c the occupation effect was stronger and the educational effect was weaker than in Model 3b. In addition, the results suggest that household socioeconomic status is more closely associated with the health system than it is with the index of behavioural and psychosocial factors.

In relation to community characteristics, community maternal education and community SES were positively associated with the health system index. In the case of the index of behavioural and psychosocial factors, the results showed that while women's employment was positively associated with the index,

community exposure to the HCB child care programme was negatively associated with the indicator.

Contextual effects

The last rows of Tables 19, 20 and 21 present the variances (random effects) at the community and family level, as well as the variance partition coefficient (VPC). The VPC permits identification of the extent to which between-community variation is explained by individual and community characteristics. All estimated coefficients for the community level variances were significant, indicating that there is some variance in intermediary determinants of child health that is attributed to unobserved heterogeneity at the community level.

The VPC for the overall index showed that 17% (Model 0a) of the variability in the overall index is explained by community characteristics, while this variability is 21% when the health system dimension is taken into account (Model 0b). In the case of behavioural and psychosocial dimension, the variability due to community characteristics is almost half of the health system model (Model 0c).

When background controls are added to the models, the variability in intermediary determinants attributable to between-communities differences is reduced to approximately 12% in Model 1a and 1b. In contrast, in Model 1c such variability remains practically constant. In comparison to Models 1a, 1b and 1c, with the inclusion of family socioeconomic variables (Models 2a, 2b and 2c), the VPC is reduced by about 45% in the models for the overall and health system indices, and 38% for the behavioural and psychosocial factors model.

Finally, when community characteristics are included (Models 3a, 3b and 3c), the greatest reduction in the VPC is observed with the health system index, where it is reduced to 9% (14% of change in variance compared to Model 2b). For the overall index, the variance is reduced by 9%, while for the behavioural and psychosocial index, the community effect remains almost constant.

Table 19. Weighted multilevel models for the overall index of intermediary determinants of early childhood health (6-36 month-old Colombian children, n=6,610)

	Overall Index			
Variable	Model 0a	Model 1a	Model 2a	Model 3a
Background controls				
Child's age (months)		0.005***	0.005***	0.005***
Child's age squared		-0.000***	-0.000***	-0.000***
Child's sex				
boy (reference)				
girl		-0.0070	-0.009*	-0.010*
Birth order/preceding birth interval				
first-birth (reference)				
2nd-3rd and <2 years		-0.049***	-0.030**	-0.031**
2nd-3rd and >2 years		-0.030***	-0.015**	-0.015**
4th + and <2 years		-0.061***	-0.0180	-0.0190
4th + and >2 years		-0.055***	-0.0140	-0.0140
Child's exposure to community nurseries programme		0.032*	0.0170	0.046**
Mother's age at first birth (years)		0.002***	0.0000	-0.0010
Mother's autonomy index		0.0040	0.0100	0.0080
Number of children under five in household		-0.015***	-0.012***	-0.011***
Place of residence				
rural (reference)				
urban		0.046***	0.0060	-0.0010
Structural determinants				
Family-level				
Mother's education level				
no education (reference)				
primary			0.068***	0.061***
secondary			0.099***	0.087***
higher			0.113***	0.096***
Mother's occupation				
not working (reference)				
professional, technical, manager			0.048***	0.043***
clerical, sales, services, skilled manual			0.030***	0.026***
agricultural, unskilled manual			0.0130	0.0100
Partner's education level				
no education (reference)				
primary			0.0150	0.0140
secondary			0.0240	0.0220
higher			0.046**	0.042*
Socioeconomic status				
very poor (reference)				
poor			0.037***	0.021*
medium			0.045***	0.021*
rich			0.058***	0.028**
very rich			0.069***	0.031*
Community-level				
Mean years of mother's education				0.01*
Mean level of SES index				0.083***
Proportion of women currently working				0.0100
Children exposure to community nurseries programme				-0.060*
Random effect variances				
Community level	0.0034***	0.0021***	0.0012***	0.0011**
Family level	0.0172***	0.0148***	0.0140 ***	0.0139***
Variance partition coefficient (VPC)				
Community level	0.170	0.120	0.080	0.071

* p<0.05, ** p<0.01, *** p<0.001.

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

Table 20. Weighted multilevel models for the health system index (6-36 month-old Colombian children, n=6,610)

	Health system index			
Variable	Model 0b	Model 1b	Model 2b	Model 3b
Background controls				
Child's age (months)		0.002***	0.002***	0.002***
Child's age squared		-0.000***	-0.000***	-0.000***
Child's sex				
boy (reference)				
girl		-0.0050	-0.0060	-0.0060
Birth order/preceding birth interval				
first-birth (reference)				
2nd-3rd and <2 years		-0.034**	-0.030**	-0.030**
2nd-3rd and >2 years		-0.012***	-0.009*	-0.009*
4th + and <2 years		-0.047***	-0.0210	-0.0230
4th + and >2 years		-0.047***	-0.023**	-0.023**
Child's exposure to community nurseries programme		0.027*	0.0180	0.035*
Mother's age at first birth (years)		0.002***	0.001**	0.001*
Mother's autonomy index		0.050***	0.033***	0.031***
Number of children under five in household		-0.023***	-0.020***	-0.019***
Place of residence				
rural (reference)				
urban		0.046***	0.014**	0.0070
Structural determinants				
Family-level				
Mother's education level				
no education (reference)				
primary			0.075***	0.068***
secondary			0.102***	0.089***
higher			0.107***	0.091***
Mother's occupation				
not working (reference)				
professional, technical, manager			0.020*	0.021*
clerical, sales, services, skilled manual			0.013**	0.014**
agricultural, unskilled manual			-0.0100	-0.0080
Partner's education level				
no education (reference)				
primary			0.0220	0.0220
secondary			0.0280	0.0260
higher			0.032*	0.0290
Socioeconomic status				
very poor (reference)				
poor			0.034***	0.018*
medium			0.050***	0.026**
rich			0.058***	0.027**
very rich			0.060***	0.023*
Community-level				
Mean years of mother's education				0.002*
Mean level of SES index				0.088***
Proportion of women currently working				-0.0090
Children exposure to community nurseries programme				-0.0310
Random effect variances				
Community level	0.0029***	0.0016***	0.0011***	0.0009**
Family level	0.0113***	0.0105***	0.0102***	0.0102***
Variance partition coefficient (VPC)				
Community level	0.21	0.13	0.10	0.09

* p<0.05, ** p<0.01, *** p<0.001.

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

Table 21. Weighted multilevel models for the behavioural and psychosocial factors index (6-36 month-old Colombian children, n=6,610)

Variable	Behavioural and psychosocial factors index			
	Model0c	Model 1c	Model 2c	Model 3c
Background controls				
Child's age (months)		0.007***	0.008***	0.008***
Child's age squared		-0.000***	-0.001***	-0.001***
Child's sex				
boy (reference)				
girl		-0.0090	-0.011*	-0.011*
Birth order/preceding birth interval				
first-birth (reference)				
2nd-3rd and <2 years		-0.054***	-0.0230	-0.0240
2nd-3rd and >2 years		-0.043***	-0.018**	-0.019**
4th + and <2 years		-0.065***	-0.0100	-0.0110
4th + and >2 years		-0.053***	-0.0010	-0.0010
Child's exposure to community nurseries programme		0.0310	0.0120	0.0500
Mother's age at first birth (years)		0.0010	-0.002**	-0.002**
Mother's autonomy index		-0.048***	-0.0170	-0.0200
Number of children under five in household		-0.0030	0.0000	0.0000
Place of residence				
rural (reference)				
urban		0.036***	-0.0050	-0.0110
Structural determinants				
Family-level				
Mother's education level				
no education (reference)				
primary			0.045*	0.040*
secondary			0.075***	0.066**
higher			0.094***	0.081***
Mother's occupation				
not working (reference)				
professional, technical, manager			0.071***	0.059***
clerical, sales, services, skilled manual			0.042***	0.035***
agricultural, unskilled manual			0.037**	0.029*
Partner's education level				
no education (reference)				
primary			0.0040	0.0030
secondary			0.0150	0.0130
higher			0.052*	0.049*
Socioeconomic status				
very poor (reference)				
poor			0.031**	0.0200
medium			0.029**	0.0120
rich			0.045***	0.0230
very rich			0.064***	0.034*
Community-level				
Mean years of mother's education				0.0010
Mean level of SES index				0.0580
Proportion of women currently working				0.029***
Children exposure to community nurseries programme				-0.081*
Random effect variances				
Community level	0.0032***	0.0029***	0.0015***	0.0015***
Family level	0.0334***	0.0281***	0 .0263***	0.0263***
Variance partition coefficient (VPC)				
Community level	0.09	0.10	0.06	0.05

* p<0.05, ** p<0.01, *** p<0.001.

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

4.4 Summary and discussion

In this chapter we have explored individual, family and community level characteristics associated with a composite indicator that quantitatively measures intermediary determinants of early childhood health. To our knowledge, this is the first study that operationalizes the CSDH framework and focuses on disentangling the pathways through which the family and the community's socioeconomic context influence more downstream determinants of child health in Colombia.

Intermediary determinants refer to those most immediate mechanisms through which the socioeconomic position operates on child health inequities, and their identification may, therefore, contribute to determining intervention policies at this level. Such intermediary factors encompass different dimensions, ranging from the material circumstances to the physical and psychosocial environment surrounding the child. Furthermore, the health system by its own constitutes a significant determining factor of child health inequities (Solar & Irwin, 2010).

In contrast to earlier studies that mainly focus on individual intermediary indicators, this study tries to compile into a single index different dimensions of intermediary determinants of child health outcomes. Beyond the intermediary factors of child health usually studied in the literature, such as the use of maternal health facilities (Ahmed et al., 2010; Johnson et al., 2009; Magadi et al., 2000; Sagna & Sunil, 2012; Stephenson et al., 2006), this study includes psychosocial and behavioural factors that can be associated with child health.

The composite indicators approach may contribute towards a better understanding and visualization of differences in intermediary determinants of child health, since it enables us to analyse the phenomenon, both in an overall perspective and by exploring its dimensions. In view of this, we have fitted weighted multilevel models for our overall index of intermediary determinants of child health and for the two dimensions represented by constructed sub-indices: health system dimension and the dimension of behavioural and psychosocial factors.

The results demonstrate that intermediary factors of child health in Colombia are associated with individual characteristics as well as family and community characteristics. Variables positively associated with the overall index include the child's exposure to community nurseries program, the mother's education, the mother's occupation as professional, technical or manager and clerical, sales, services or skilled manual activities, partners with a higher educational level, households in higher economic quintiles and communities with higher mother's education and higher mean levels of SES.

In general, our results suggest that, regardless of the dimension taken into account, the family's socioeconomic position, measured as the educational level of the mother and her partner, the mother's occupation and the household's SES, exert a fundamental role on the mediation of child health outcomes.

The main purpose of this study focuses on the role of communities in different intermediary factors and our results demonstrate an important point in this vein. The effect of household's SES is attenuated when community characteristics are added, indicating the importance that the level of community development may have in mediating individual and family characteristics. Similar results were found in previous studies that examined the role of the community's SES (Fotso & Kuate-Defo, 2005, 2006). This result suggests that the physical and socioeconomic environment and the facilities available in the residential communities can substantially influence early childhood development (Irwin et al., 2007). Children from households with a low SES, living in mixed communities in terms of socioeconomic conditions, generally have develop better than children from households with a low SES who reside in poor communities (Kohen et al., 2002).

With respect to the health system indicator, the findings show that, in addition to the influence of socioeconomic characteristics, the mother's autonomy, as measured by women's decisions on their own health, purchases, visits to family, cooking, studying and having sexual intercourse, has a positive effect on factors linked to child and maternal health care. These results are consistent with the findings of other studies on the use of maternal health facilities (Ahmed et al., 2010; Stephenson et al., 2006) and underline the importance of women empowerment within the household, since it allows them to have a greater power of decision in both their own health and that of their children.

The positive association between variables linked to maternal-child care and maternal education has been examined in previous studies (Addai, 2000; Elo, 1992; Sagna & Sunil, 2012). The mother's education enables greater access to and knowledge of the practices during pregnancy, enhances a woman's empowerment and is also associated with income level. However, the effect of the partner's education has been less explored in the literature. Our results suggest that more educated partners of mothers can contribute to a better performance in intermediary factors of child health, reflecting the direct or indirect influence that they might have on maternal and child care. It is likely that the partner, although not the child's primary caregiver, makes decisions that directly or indirectly affect the child's health, highlighting the role that other adults can exert on children's health (Moestue & Huttly, 2008).

Furthermore, the positive effect of community maternal education is consistent with other studies (Corsi et al., 2011; Stephenson et al., 2006), suggesting that beyond the positive influence of the mother's education, there may be a positive externality in terms of community education that can help in the performance of intermediary factors of child health.

In terms of the index of behavioural and psychosocial factors, our results point out the importance of the mother's occupation. While it is clear that parental education affects the style of parenting, some aspects of education are mediated by the type of occupation. Menagahan & Parcel (1995) found that the working conditions of parents are linked to child outcomes. In particular, mothers with jobs requiring more complex activities are capable of providing home environments that are cognitively, emotionally and physically better suited for child development (Whitbeck et al., 1997).

In addition, our results show that the household's SES is not strongly associated with the dimension of behavioural and psychosocial factors. This may be due to the fact that wealth can positively influence parenting style, but once a certain threshold is reached, additional income does not produce significant changes in the parents' behaviours (Hoff et al., 2002). In fact, too much wealth might have a negative psychosocial effect, especially if children spend more time watching TV or playing video games than interacting with parents and other siblings.

On the other hand, it is perhaps not surprising to find a negative effect of community exposure to HCB programme, since this programme is mainly aimed to the poorest households, and hence, it is likely that such a result is capturing the impact of community socioeconomic level. Nevertheless, further work is required in order to evaluate the programme and its impact on psychosocial factors.

Regarding to the community effects, our results are consistent with the findings of previous studies that analyse the contextual effects on child health (Griffiths et al., 2004; Uthman, 2009). Although variations in intermediary determinants among communities are explained above all by family characteristics, our results indicate that there is a significant between-communities variance in intermediary determinants of child health, especially for those determinants linked to the health system, even after controlling for individual, family and community characteristics. These results may reflect the fact that whilst the community context can exert a greater influence on intermediary factors linked directly to health, in the case of psychosocial factors and the parent's behaviours, the family context can be more important. This underlines the importance of distinguishing between community and family intervention programmes.

However, it is worth noting that there are also other community characteristics that are not accounted for in this study. For instance, socially accepted behaviours and practices within the community can affect the child's environment, as well as conditions of violence and safety. Additionally, community access barriers to health facilities and nurseries can be important intermediary factors of child health.

It is clear that those environments responsible for promoting healthy conditions for childhood development go from the immediate context, i.e. the family, to the socioeconomic context of the communities, municipalities and departments. Our indicator of intermediary determinants of early childhood health reflects that, firstly, maternal access to reproductive health services is fundamental, followed by child immunization and access to health system and in addition, that parents' practices and behaviours provide the appropriate environments for child development.

Chapter 5:

Structural and intermediary determinants of early childhood health: exploring the role of community education

5. Structural and intermediary determinants of early childhood health: exploring the role of community education

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; Ana María 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.

In this chapter, firstly, the variables used in the analysis are defined. Secondly, we describe the interaction terms introduced into the models. Thirdly, the results derived from the descriptive and multilevel analysis are presented. Finally, the main findings are discussed.

5.1 Variables

5.1.1 Dependent variables

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, 2009b; 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.

5.1.2 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. The variables included in this study have been described in previous chapter (see section 4.1), so in this section they will be only briefly mentioned.

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.

5.2 Methods

5.2.1 Multilevel modelling

In this chapter we fitted a series of weighted multilevel models to examine the role of maternal own education and community maternal education on child nutrition outcomes. Refer to section 4.2.1 for a complete description of multilevel modelling. In addition, this study took into account important methodological issues such as second level endogeneity in multilevel modelling, which have not been addressed in the empirical literature and can lead to biases in the estimates.

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:

$$y_{ij} = \beta_0 + \sum_{k=1}^{p} \beta_k X_{kij} + \sum_{l=1}^{q} \beta_l Z_{lj} + \sum \beta_{kl} X_{kij} Z_{lj} + (u_j + e_{ij}), i = 1,\ldots,10165, j = 1,\ldots 3481, \quad (7)$$

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 a 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.

Cross-level interactions

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.

Multilevel modelling and endogeneity problems: Level 2 endogeneity

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).

5.3 Results

5.3.1 Descriptive analysis

As in most countries, chronic malnutrition (stunting) in Colombia persists as a problem of greater magnitude than underweight or wasting. Figure 11 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.

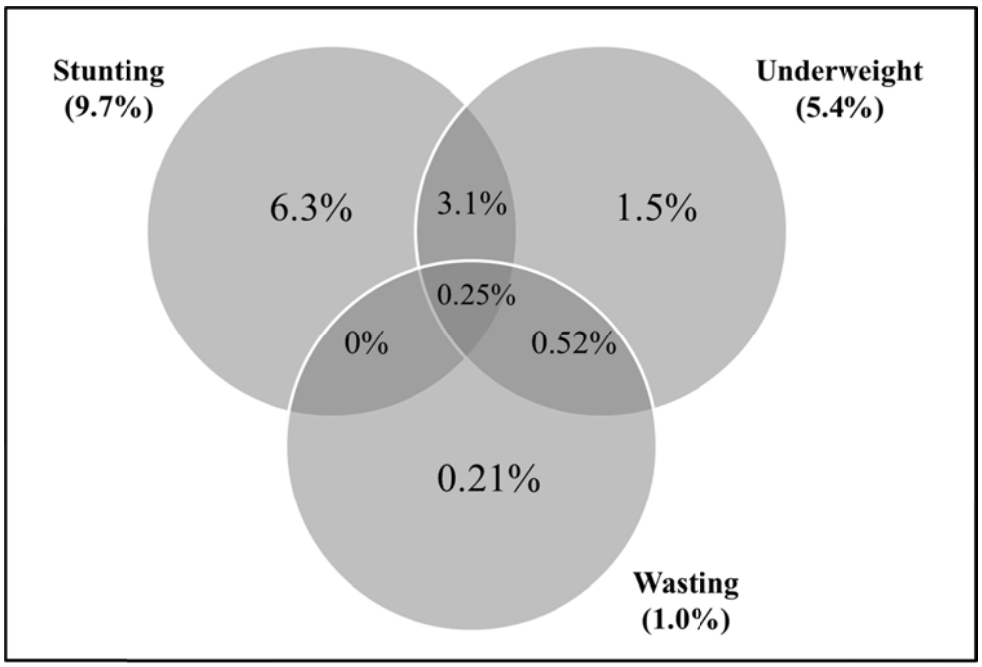
Figure 12 and Figure 13 illustrate the prevalence of stunted and underweight children by Colombian departments and municipalities. The maps show the great heterogeneity both between departments and within them. Some municipalities, for example, record no stunted children, whereas in others, the prevalence 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 22 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

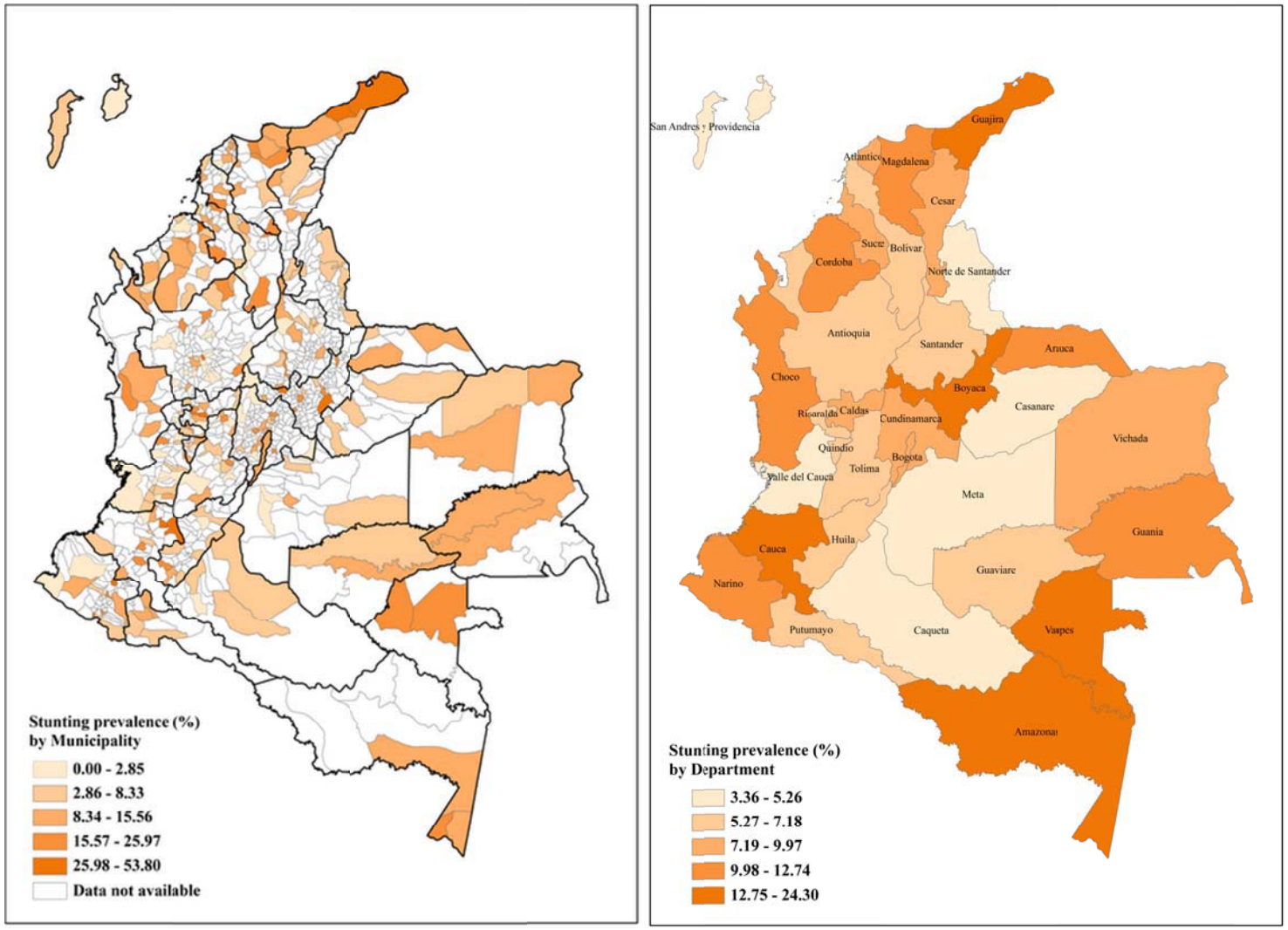
family socioeconomic background, most children were born to mothers and fathers with 9 and 10 years of schooling on average, respectively. Furthermore, while about 27% of the children live in poor or very poor households, about 14% live in the wealthiest households. The average female education in the community is 8.5 years, ranging from 0.4 to 18.2 years.

Figure 11. Percentage of 0-59 month-old stunted, underweight and wasted Colombian children (n=10,165)



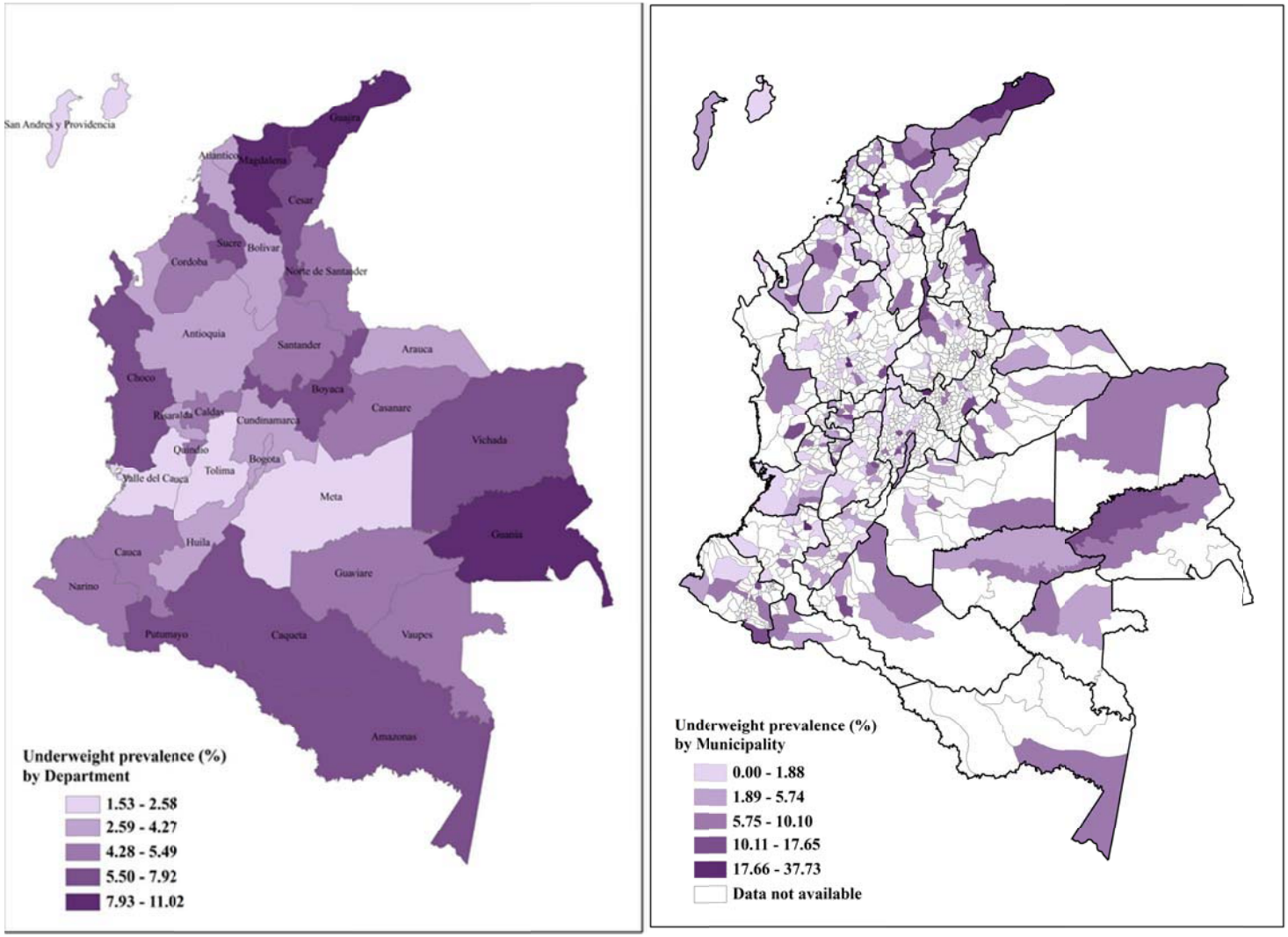
Source: Own compilation

Figure 12. Percentage of 0-59 month-old stunted Colombian children by Departments and Municipalities (n=10,165)



Source: Own compilation

Figure 13. Percentage of 0-59 month-old underweight Colombian children by Departments and Municipalities (n=10,165)



Source: Own compilation

Table 22. 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

5.3.2 Multilevel analysis

Tables 23 and 24 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 23 and 24 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.

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.

[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.

Community effects

The last rows of the Tables 23 and 24 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.

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 14, 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 15 and 16 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 23. 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<0.05, ** p<0.01, *** p<0.001.

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

Table 24. 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<0.05, ** p<0.01, *** p<0.001.

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

Table 25. Models height and weight-for-age Z-scores for 0-59month-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<0.05, ** p<0.01, *** p<0.001.

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

Figure 14. Interaction of mother's education and community maternal education: Height-for-age Z-scores of 0-59 months old Colombian children

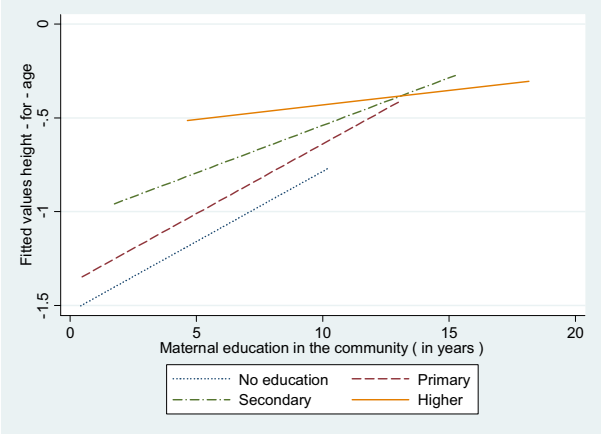


Figure 15. Interaction of mother's autonomy and community maternal education: Height-for-age Z-scores of 0-59 months old Colombian children

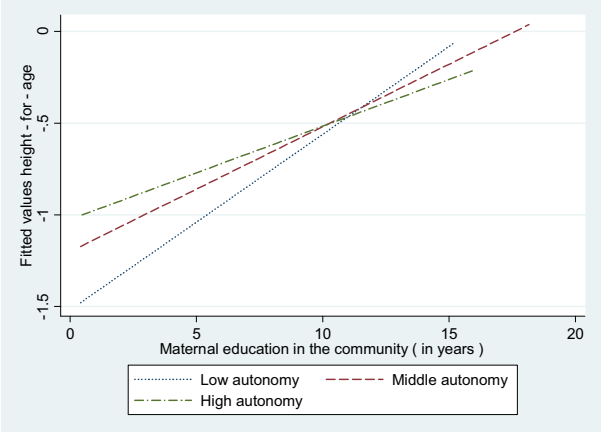
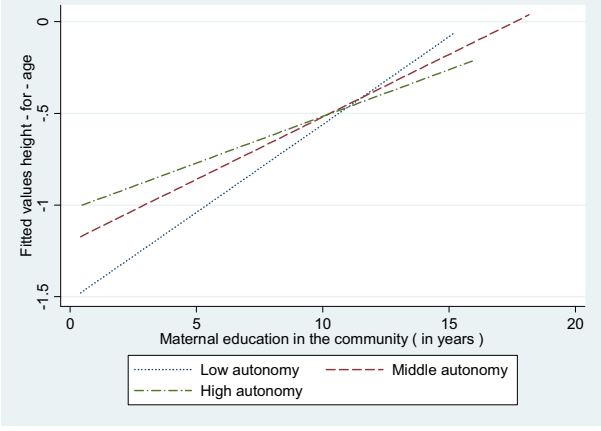


Figure 16. Interaction of mother's autonomy and community maternal education: Weight-for-age Z-scores of 0-59 months old Colombian children



5.4 Summary and 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.

Chapter 6:

Conclusions

6. Conclusions

The social determinants of child health include the quality and access to the health system, but also the environment in which the children are born, grow up and live. They are the largest cause of poor health and inequalities between and within countries. The socioeconomic and political context, the structural stratifiers—such as income, education, occupation, gender and ethnicity—, as well as the resulting socioeconomic position are the "structural determinants" of health inequalities. However, these upstream determinants operate through a set of "intermediary determinants" such as living conditions, behavioural and psychosocial factors, and the health system itself, to shape health outcomes.

The aim of this thesis was to investigate the social determinants—both intermediary and structural—of early childhood health in Colombia and explore the role that community context plays in shaping health inequalities. To fulfil this objective the first part of this thesis (Chapter 3) focused on the identification and description of the more immediate determinants of child health in Colombia, through the construction of an innovative composite index, termed IDECHI. A multidimensional approach and the weighting procedure used in this research for the construction of the index provided an opportunity to identify key intermediary factors of child health and their relative importance among Colombian regions.

These kinds of indicators may help identify potential intervention strategies for more downstream determinants of child health, highlighting the relevance these factors have in terms of public policy since they can be modified more easily through, for instance, child care programmes. Furthermore, the index allowed us to analyse relative differences in child health among Colombian departments, which can send important policy messages that may contribute to the reduction of location-based inequities.

Although these intermediary factors are important (in that they may be more easily modifiable and, therefore, have a direct effect on child health), the underlying causes of health inequalities need to be analysed. The second part of this thesis (Chapter 4), therefore, focuses on studying the effects that structural factors—such as the family's socioeconomic position—have on different intermediary determinants, taking into account the community context and how this may affect children's well-being.

From the results obtained in this second part, we find that, in addition to the importance of the family's socioeconomic characteristics, the community socioeconomic context may play a decisive role in aspects related to characteristics associated with the child's immediate context—such as parenting style—, as well as with the characteristics of access to and coverage of the health system. Our findings provide relevant information on the role of communities for the improvement of child health and highlight the importance, in terms of policy, of targeting programmes towards communities. In addition to being ground-breaking, being able to differentiate between categories of intermediary determinants and the effects that the community characteristics have on each of these separately allows us to capture a wider range of distinct aspects of child health that could shed light on research into the inequalities of child health in other Latin American and developing countries.

As our results indicate, community maternal education is a factor that contributes to a better performance of intermediary determinants of child health. Better-educated mothers will have access to better job opportunities, which in turn will be reflected in higher household income. It may also mean lower stress levels and, therefore, a home environment more appropriate for child development. However, the negative effect that having a greater proportion of women working in the community may have on psychosocial factors highlights the importance of having child care centres in the community that promote psychosocial qualities, as well as training programmes aimed at parents that promote good parenting practices.

In this context, a considerable body of literature finds that the mother's education positively influences child health. The role played by the education of other women in the community has, however, been explored less. The identification and analysis of the effects of community education is important not only in terms of the contributions to the literature on maternal education and child health, but may also give a useful insight, in terms of policy, into which key aspect(s) require intervention in a given community in order to improve child health.

Thus, the third part of this thesis (Chapter 5) focuses on the analysis of the role of community maternal education and how it may moderate the impact of individual characteristics on child health. Furthermore, we examine the effect

of structural and intermediary determinants on two important indicators of child health in the medium and long term: weight and height for age.

The results of this chapter show that maternal education plays a protective role in child health. However, mothers and, therefore, their children, can benefit from the education of other women in the community. Different ways through which community education can substitute for the effect of family characteristics on child nutrition were identified, again suggesting that childhood care programmes should be targeted not only towards individuals but should also be focused on the broader context of the communities. In particular, those communities with less educated mothers, with low female autonomy and high levels of poverty are those which could benefit more from intervention policies that focus on encouraging female education. Clearly, the level of education in the community is a crucial aspect of child health, since intervention in this area could lead to an improvement in child well-being.

Summarizing, the results of this thesis demonstrate that community context is a key component in determining intermediary determinants of child health, as well as child nutrition outcomes, both in the medium and long term. Community contexts are eminently changeable and responsive to economic and social policy (Diez Roux, 2007). It is, therefore, necessary that municipal and departmental governments involve local communities in the development, execution, monitoring and evaluation of childhood care policies. We hope that this study helps to draw the attention of Colombian policy makers to this vulnerable population and that it may be used as a criterion for the allocation of public funds.

6.1 Policy implications

The results of this study have important implications in terms of policy making. 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 access to and coverage of health services.

The reduction of the number 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 child's first three years of life is necessary. The timely prevention and correction of nutritional deficiencies in this period is one of the interventions with higher returns, since it ensures that children develop to their full potential for adult life.

In this vein, the community context, and, especially, the context created by female education in the community, may be a key element for the implementation of programmes aimed at bringing about behavioural changes that contribute to the promotion of healthy habits, physical activity, breastfeeding and complementary 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 the women's overall education within communities. In particular, the programme *"Hogares Comunitarios de bienestar (HCB)"* prioritizes the promotion of women's education. In this respect, we recommend expanding the coverage of programmes such as "*Unidades pedagógicas de Apoyo (UPA)",* for example, through public-private partnerships. This is an educational support programme mainly targeted at urban children attending community nurseries (HCB), as well as their respective mothers. The programme seeks to add an educational component to care and nutrition services.

Additionally, a suitable, and relatively accessible, channel for providing information and educating families in the community is the media. One strategy would be to provide information and training via a mix of television, radio and illustrated magazines (with a large number of images and little supporting text), discussing: i) maternal health-seeking behaviour during pregnancy, childbirth and postpartum; ii) the rights and benefits of social security affiliation; iii) the services and programmes of the "*Instituto Colombiano de Bienestar Familiar (ICBF)"* available in the community; and iv) the importance of healthier nutritional habits, physical exercise and play for child development.

On the other hand, the analysis of the interactions between characteristics observed at the family level and the community level may be very useful for the design of more effective policies since these policies may be better targeted towards specific groups. According to our results, intervention programmes that aim to enhance women's education in a community may be particularly effective for the most disadvantaged mothers, i.e. the less-educated mothers with lower levels of autonomy and living in the poorest households.

Finally, one of the aims of the most recent childhood care strategy of the Colombian Government—*"De cero a siempre"*—is to strengthen the key role that the family plays in early childhood development. Our findings suggest that in addition to the family's 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.

6.2 Contributions and Limitations

A number of key issues have been addressed in this thesis. First, this is the first study to investigate community effects on child health in Colombia using a multilevel approach. Although previous studies on socioeconomic determinants of child health in Colombia have focused on individual-level factors, our research provides unique information about the potentially independent influence of the community context on child health. In terms of public policy, our findings shed light on the benefit of targeting the community context in order to improve child health in Colombia. Moreover, this research contributes to the literature on social determinants of health as well as the literature on community effects on child health in developing countries.

In terms of methodology, this thesis also makes important contributions since it uses statistical and econometric methods that are more sophisticated than those commonly used and which have not been used in other empirical studies. The different methodological approaches used here allow the nature and structure of the data to be considered. It also reduces biases in the estimations. For example, the construction of the indicators using polychoric

PCA allowed the discrete nature of the variables included to be taken into account. Moreover, the use of multilevel models allowed sample weights to be included in the analysis and, therefore, avoided biases and spurious associations.

The omission of variables at the community level may give rise to Level 2 endogeneity. Correcting this problem in the context of multilevel models is under development and has not been taken into consideration in empirical research. We have confirmed the absence of Level 2 endogeneity in our models for height and weight for age. These methodological advances and their empirical application may contribute to an improvement in the measurement of community effects and may, thus, shed light on the complex interdependencies between people, between locations, and between people and the locations they live in.

Another strength of this thesis lies in the use of a nationally representative database and good quality information, such as the DHS. The rigorously designed survey allows reliable, valid and widely applicable results to be obtained for the whole Colombian population. DHS surveys provide unique information about demographic and health characteristics and have similarly defined variables in all the countries in which they are carried out. Results obtained in one country are, therefore, easy to compare with those of other countries.

Nevertheless, despite the contributions of this research in methodological terms, and the identification of important contextual effects on child health in Colombia that had not been considered in previous studies, there are certain limitations to this thesis.

Firstly, it was impossible to compare the results of our index with previous Colombian DHS surveys due to the fact that previous DHS surveys did not include some of the psychosocial factors assessed here. It would be useful to replicate this analysis, perhaps with data from other Latin American countries. However, other DHS surveys conducted in the region do not have some of the variables that we have used. We recommend that questions regarding parenting practices and psychosocial factors should be included in future DHS surveys. Such information is, without doubt, very helpful for the analyses of child health and child well-being in general. Despite the limitation of the

index, the methodological approach employed here—through the empirical construction of a weighted composite index—makes it easier to understand the relative status of intermediary determinants of child health in Colombia.

Secondly, it is worth noting that there are other intermediary factors that are also not accounted for in this study due to the lack of available data, such as socially accepted behaviours and practices that may affect the child's environment, as well as levels of violence and safety of the child's community. In addition, barriers to accessing health facilities and nurseries may be important intermediary factors of child health.

Thirdly, the relationship between child health and community context may be much more complex than is considered in our models. There are other community-associated variables that are likely to affect child health, such as access to, availability and price of food, as well as climate characteristics and distance to health facilities and markets that were not available in our dataset.

Fourthly, 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.

6.3 Future research

First of all, further work is necessary in order to improve the index of intermediary determinants proposed here, its robustness and the validity of the results over time. It will be worth including other countries in the analysis in future studies, as well as identifying other dimensions that have an impact on child well-being.

The significant between-communities variation found throughout the different models analysed, even after controlling for individual, family and community characteristics, makes clear the need for further research on the ways through which communities influence intermediary factors of child health and child nutritional outcomes. The effect of the socioeconomic context of the community in our study may have been underestimated by not considering how long the mothers and their children had lived in the community. Future

studies should take into consideration residential history in the analysis of the relationship between the community socioeconomic context and child health.

Additionally, in order to unravel the contextual effects of education on child health, the inclusion and analysis of other contexts where women interact and, therefore, where they may benefit from the externalities of education, will be an important subject of future studies. For instance, mothers may benefit from the networks and social interaction processes that exist in work places, recreation areas or at public transports stops. These contexts, beyond the most proximate community context, may influence the health of children. Data on Global Positioning System (GPS) coordinates could provide useful information about other proximate contexts since these coordinates would allow approximate distances between all PSUs to be calculated. Although this data was collected in the Colombian DHS, it is currently unavailable. We hope to complete our study using this information in further research.

On the other hand, the 2010 Colombian DHS collected data for the first time on ethnicity. Nevertheless, no statistical significance was seen and neither was the expected sign obtained when this variable was included in the analysis and was, therefore, excluded from the analysis. It is possible that there were measurement errors in this variable since it was a self-reported variable. The majority of people surveyed (86%) did not identify themselves with any of the ethnic groups included. Given that in Colombia ethnic groups show clear localization patterns, inequalities in child health and differences in ethnic group should be investigated further.

Furthermore, it would be interesting to analyse further the differences between urban and rural areas, as well as internal migration, and their effects on child health in Colombia. We have not observed any differences in child health based on place of residence after controlling for the socioeconomic characteristics of the household. It is possible that in Colombia—as well as in other developing countries—the advantage urban areas have over rural ones in terms of health, which is commonly observed on other studies, is decreasing or indeed, even disappearing, because poverty and inequality within urban areas are, in fact, increasing.

At the methodological level, it is important to consider in future studies the correlation between the variables height- and weight-for-age, for example, estimating a system of seemingly unrelated equations.

Finally, replicating this type of analysis in other Latin American countries would be of enormous help in the reduction of inequalities and the fulfilment of the Millennium Development Goals in the region. Similarly, qualitative studies that complement quantitative studies would be extremely valuable for the analysis of community effects in Colombia and in Latin America as a whole.

Appendices

Appendix A

Eigenvalues of the IDECHI based on binary PCA method

k	Eigenvalues	Proportion explained	Proportion cumulative
1	4.70521	0.1307	0.1307
2	3.03903	0.0844	0.2151
3	2.79249	0.0776	0.2927
4	2.11574	0.0588	0.3515
5	2.07866	0.0577	0.4092
6	1.96543	0.0546	0.4638
7	1.93511	0.0538	0.5175
8	1.85786	0.0516	0.5692
9	1.72131	0.0478	0.617
10	1.67668	0.0466	0.6635
11	1.46175	0.0406	0.7041
12	1.44955	0.0403	0.7444
13	1.40817	0.0391	0.7835
14	1.3033	0.0362	0.8197
15	1.16079	0.0322	0.852
16	1.09773	0.0305	0.8825
17	1.05678	0.0294	0.9118
18	1.04558	0.029	0.9409
19	0.977453	0.0272	0.968
20	0.895295	0.0249	0.9929
21	0.256058	0.0071	1

Eigenvectors of the correlation matrix of the IDECHI based on binary PCA method

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8	Comp9	Comp10	Comp11	Comp12	Comp13	Comp14	Comp15	Comp16	Comp17	Comp18
overcrow1	-0.170	-0.063	0.108	-0.233	0.204	0.212	0.019	-0.301	-0.204	-0.359	-0.135	0.091	0.145	-0.032	-0.005	-0.038	-0.041	-0.029
overcrow2	0.170	0.063	-0.108	0.233	-0.204	-0.212	-0.019	0.301	0.204	0.359	0.135	-0.091	-0.145	0.032	0.005	0.038	0.041	0.029
undwt1	-0.092	-0.111	-0.014	-0.269	0.355	0.135	0.079	0.373	0.338	0.032	-0.030	0.028	0.004	0.008	-0.006	0.003	0.006	0.007
undwt2	0.092	0.111	0.014	0.269	-0.355	-0.135	-0.079	-0.373	-0.338	-0.032	0.030	-0.028	-0.004	-0.008	0.006	-0.003	-0.006	-0.007
breast1	-0.010	0.013	0.044	0.141	-0.029	0.091	0.173	0.074	-0.020	-0.192	-0.011	0.027	-0.062	-0.026	0.120	-0.060	0.404	0.609
breast2	-0.004	-0.040	-0.186	-0.318	0.089	-0.149	-0.425	-0.209	-0.014	0.327	-0.049	-0.016	0.072	0.014	-0.009	0.025	0.005	-0.046
breast3	0.010	0.038	0.184	0.278	-0.084	0.116	0.381	0.193	0.027	-0.260	0.061	0.002	-0.046	-0.001	-0.056	0.005	-0.227	-0.284
play1	0.127	-0.076	-0.275	-0.040	-0.200	-0.061	0.027	0.137	0.021	-0.198	-0.503	-0.118	0.068	0.032	-0.168	0.066	0.099	-0.180
play2	-0.018	0.033	0.091	-0.006	0.021	0.021	0.021	-0.020	0.007	0.067	0.149	0.067	-0.025	0.076	0.587	0.053	-0.555	-0.061
play3	-0.084	0.055	0.176	0.011	0.127	0.045	-0.025	-0.095	-0.034	0.166	0.315	0.252	-0.253	-0.056	-0.189	-0.570	0.158	-0.031
play4	-0.078	0.025	0.136	0.053	0.134	0.022	-0.026	-0.078	0.003	0.049	0.270	-0.176	0.222	-0.039	0.043	0.550	0.075	0.356
physact1	0.096	-0.162	-0.312	-0.068	-0.069	-0.086	-0.058	0.113	-0.075	-0.178	-0.002	-0.011	0.004	0.041	0.116	-0.309	-0.296	0.392
physact2	-0.023	0.033	0.023	0.008	0.020	0.011	0.030	-0.004	-0.014	0.024	-0.071	0.013	-0.004	0.075	0.635	-0.016	0.564	-0.353
physact3	-0.043	0.074	0.139	-0.007	0.034	0.034	-0.013	-0.070	-0.011	0.070	-0.141	0.393	-0.484	0.022	-0.238	0.459	-0.032	-0.032
physact4	-0.048	0.084	0.190	0.075	0.031	0.055	0.058	-0.052	0.099	0.110	0.178	-0.370	0.458	-0.108	-0.265	-0.095	0.022	-0.186
precare1	0.250	-0.018	0.042	0.025	0.001	0.160	-0.071	0.021	0.017	0.018	0.016	-0.020	-0.035	-0.024	-0.035	-0.029	0.013	0.029
precare2	0.154	-0.002	-0.033	0.063	-0.096	0.069	0.018	0.029	0.064	0.087	-0.011	0.551	0.452	0.007	0.003	0.030	0.014	0.009
precare3	-0.286	0.013	0.001	-0.067	0.078	-0.159	0.030	-0.037	-0.063	-0.083	-0.001	-0.442	-0.351	0.010	0.020	-0.007	-0.019	-0.026
immu1	0.078	-0.244	-0.347	0.064	0.140	-0.068	0.016	0.002	-0.100	-0.190	0.384	0.066	-0.042	-0.109	-0.046	0.131	0.085	-0.174
immu2	-0.078	0.244	0.347	-0.064	-0.140	0.068	-0.016	-0.002	0.100	0.190	-0.384	-0.066	0.042	0.109	0.046	-0.131	-0.085	0.174
diarr1	-0.058	-0.282	0.152	0.011	0.027	0.036	0.000	0.294	-0.488	0.204	-0.043	-0.016	0.056	0.135	-0.036	0.018	0.011	-0.010
diarr2	0.058	0.282	-0.152	-0.011	-0.027	-0.036	0.000	-0.294	0.488	-0.204	0.043	0.016	-0.056	-0.135	0.036	-0.018	-0.011	0.010
fever1	-0.043	-0.393	0.174	0.022	-0.150	-0.043	-0.020	-0.057	0.124	0.059	-0.098	0.009	-0.042	-0.498	0.080	-0.005	-0.017	0.010
fever2	0.043	0.393	-0.174	-0.022	0.150	0.043	0.020	0.057	-0.124	-0.059	0.098	-0.009	0.042	0.498	-0.080	0.005	0.017	-0.010
cough1	-0.014	-0.380	0.156	0.009	-0.133	-0.068	-0.015	-0.172	0.247	-0.073	0.078	-0.006	-0.005	0.450	-0.048	-0.006	0.039	0.001
cough2	0.014	0.380	-0.156	-0.009	0.133	0.068	0.015	0.172	-0.247	0.073	-0.078	0.006	0.005	-0.450	0.048	0.006	-0.039	-0.001
physical1	-0.041	0.016	0.137	0.361	0.258	-0.167	-0.419	0.124	0.050	-0.205	-0.111	0.043	0.042	0.004	0.012	-0.037	-0.022	-0.020
physical2	0.041	-0.016	-0.137	-0.361	-0.258	0.167	0.419	-0.124	-0.050	0.205	0.111	-0.043	-0.042	-0.004	-0.012	0.037	0.022	0.020
doctor1	0.396	0.007	0.178	-0.129	0.105	-0.099	0.023	-0.016	-0.041	-0.059	0.006	-0.065	-0.048	-0.019	0.017	0.004	0.013	-0.004
doctor2	-0.396	-0.007	-0.178	0.129	-0.105	0.099	-0.023	0.016	0.041	0.059	-0.006	0.065	0.048	0.019	-0.017	-0.004	-0.013	0.004
deliplace1	0.398	0.003	0.180	-0.130	0.109	-0.086	0.015	-0.009	-0.039	-0.063	0.011	-0.066	-0.045	-0.016	0.002	0.000	0.009	0.003
deliplace2	-0.398	-0.003	-0.180	0.130	-0.109	0.086	-0.015	0.009	0.039	0.063	-0.011	0.066	0.045	0.016	-0.002	0.000	-0.009	-0.003
tetanus1	0.152	-0.068	-0.078	0.127	-0.034	0.566	-0.233	-0.035	0.030	0.042	0.004	-0.149	-0.121	0.020	0.020	0.007	-0.013	-0.019
tetanus2	-0.152	0.068	0.078	-0.127	0.034	-0.566	0.233	0.035	-0.030	-0.042	-0.004	0.149	0.121	-0.020	-0.020	-0.007	0.013	0.019
hcard1	0.079	-0.117	-0.148	0.279	0.353	-0.024	0.275	-0.251	0.012	0.241	-0.220	-0.035	0.001	0.039	0.009	-0.044	-0.051	0.044
hcard2	-0.079	0.117	0.148	-0.279	-0.353	0.024	-0.275	0.251	-0.012	-0.241	0.220	0.035	-0.001	-0.039	-0.009	0.044	0.051	-0.044

Appendix B

Ranking of departments by total and urban-rural area based on the IDECHI considering equal weights

Department	Urban	Rural	Total
Atlantic Region			
Atlántico	20	12	18
Bolívar	27	24	25
Cesar	24	13	21
Córdoba	25	22	23
Guajira	29	30	30
Magdalena	26	23	26
Sucre	30	27	27
San Andrés	19	5	11
Eastern			
Boyacá	6	3	4
Cundinamarca	3	4	3
Meta	15	14	14
Norte de Santander	21	20	20
Santander	10	9	10
Central			
Antioquia	1	10	2
Caldas	13	16	16
Caquetá	23	25	24
Huila	5	8	7
Quindío	7	2	5
Risaralda	9	6	8
Tolima	11	11	12
Pacific			
Cauca	12	21	22
Chocó	31	31	32
Nariño	2	15	15
Valle	8	1	6
Amazon and Orinoco			
Arauca	16	19	13
Casanare	14	17	17
Putumayo	18	18	19
Amazonas	28	29	31
Guainía	22	28	28
Guaviare	17	7	9
Vaupés	33	32	33
Vichada	32	26	29
Bogotá	4		1

Appendix C

Mean index scores by principal components (PC) and Colombian Departments

	PC1	PC2	PC3	PC4	PC5
Antioquia	0.34192	-0.3949457	1.918007	1.009314	1.788758
Arauca	0.5064132	0.903915	-0.2293184	0.4842617	0.5623368
Casanare	0.1601109	0.4215753	0.754617	-0.2478389	0.7694461
Cauca	-1.089849	0.2547573	0.0912164	0.3388379	1.133457
Guaviare	0.2929789	0.9642797	0.4790391	0.826039	-0.1177089
Huila	0.6734402	0.3801997	1.272676	0.2455276	1.46962
Meta	0.4377414	0.4792385	0.3396029	0.1841998	0.3252225
Nariño	-0.2112802	0.913818	0.4607868	0.2197448	1.215322
Putumayo	-0.4894034	0.0264663	0.3220275	0.3880112	0.3941725
Quindío	0.7923886	0.5726117	0.5544748	1.365999	1.076133
Risaralda	0.7350973	0.9974941	-0.0002023	1.087257	0.528849
Santander	0.3980699	0.7780169	0.5756422	0.2473703	0.7807689
Valle	0.6855856	0.7602136	0.6347355	1.356264	0.5182709
Atlántico	0.987927	-1.293773	0.0631462	0.0666929	0.762334
Caldas	0.5555326	-0.4960851	-0.2636417	0.7816713	1.483986
Caquetá	-0.4476157	-0.6911487	-1.017987	-0.1217917	0.7280008
Cesar	0.6496037	-0.8086039	-0.1551654	-0.4206004	0.0396731
Norte de Santander	0.4476821	-0.2110269	-0.0150344	-0.6017236	0.5299563
Bogotá	0.8365423	1.707065	1.071674	1.292922	-0.3586303
Boyacá	0.603405	1.741071	1.014642	1.006165	-0.505355
Cundinamarca	0.4909269	1.459392	1.497272	0.8314292	-0.406866
San andrés	0.8771781	0.3974413	0.0810254	1.216307	-1.470587
Tolima	0.3625926	0.6302605	0.8232186	0.6651891	-1.203252
Bolívar	0.7784585	-1.164126	-1.260841	-0.5738087	-1.223159
Córdoba	0.3180505	-0.2966731	-0.8339227	-0.3601428	-1.567686
Guajira	-0.4785268	-1.587129	-1.382796	-1.959691	-1.961375
Magdalena	0.5581311	-1.676033	-0.6592844	-1.084473	-0.3612701
Sucre	0.6004459	-1.325969	-1.629001	-0.9052728	-0.9097426
Amazonas	-2.090919	-2.144633	-0.3575897	-1.556604	-0.4592547
Chocó	-1.816558	-1.057319	-2.888382	-0.6603712	-0.7249784
Guainía	-1.981827	0.1824708	0.5002494	-1.471294	-0.9294288
Vaupés	-2.356194	-0.0656974	-1.415994	-2.142204	-1.425777
Vichada	-2.128109	-0.3571281	-0.3449704	-1.507376	-0.4813765

Appendix D

Sample proportions of variables included in the index constructed in Chapter 4 (DHS 2010, 6-36 month-old Colombian children, n=6,610)

	Behavioural and psychological factors							Health system					
Departments	Child received vitamin A fruits	Breastfeeding up to 2 years	Physical activities with child 5+ times/week	Play with child 5+ times/week	Mother not punishing physically	Mother care for child	Mother is cohabitating with partner	Doctor assisted delivery	Delivery in a health facility	4+ antenatal visits	Mother received tet.tox injection	Child received Polio3	Child has health card
Atlantic Region	**0.29**	**0.92**	**0.26**	**0.09**	**0.31**	**0.18**	**0.80**	**0.94**	**0.95**	**0.89**	**0.93**	**0.82**	**0.98**
Atlántico	0.13	0.92	0.30	0.08	0.24	0.12	0.81	0.98	0.99	0.95	0.93	0.90	0.98
Bolívar	0.18	0.96	0.21	0.10	0.32	0.19	0.76	0.96	0.96	0.91	0.96	0.80	0.99
Cesar	0.57	0.93	0.37	0.11	0.31	0.26	0.81	0.95	0.97	0.87	0.94	0.85	1.00
Córdoba	0.50	0.89	0.24	0.10	0.33	0.16	0.83	0.92	0.93	0.85	0.91	0.77	0.96
Guajira	0.16	0.94	0.27	0.08	0.43	0.21	0.82	0.78	0.85	0.80	0.88	0.78	0.98
Magdalena	0.37	0.91	0.27	0.07	0.31	0.23	0.82	0.94	0.96	0.89	0.95	0.74	0.99
Sucre	0.28	0.89	0.12	0.06	0.36	0.15	0.80	0.93	0.95	0.87	0.92	0.82	1.00
San Andrés	0.32	0.90	0.29	0.16	0.27	0.35	0.67	0.98	0.99	0.88	0.89	0.72	0.99
Eastern	**0.30**	**0.90**	**0.39**	**0.11**	**0.26**	**0.32**	**0.76**	**0.95**	**0.97**	**0.89**	**0.90**	**0.79**	**0.98**
Boyacá	0.34	0.90	0.34	0.14	0.33	0.32	0.73	0.97	0.98	0.89	0.90	0.72	0.99
Cundinamarca	0.37	0.90	0.37	0.16	0.27	0.32	0.75	0.94	0.97	0.89	0.89	0.74	0.99
Meta	0.19	0.88	0.35	0.07	0.25	0.39	0.78	0.94	0.98	0.91	0.87	0.82	0.98
Norte de Santander	0.28	0.90	0.40	0.06	0.21	0.24	0.79	0.94	0.95	0.86	0.96	0.79	0.99
Santander	0.23	0.90	0.44	0.09	0.25	0.34	0.78	0.94	0.96	0.89	0.87	0.87	0.97
Central	**0.28**	**0.92**	**0.39**	**0.13**	**0.21**	**0.19**	**0.68**	**0.94**	**0.96**	**0.91**	**0.85**	**0.82**	**0.98**
Antioquia	0.29	0.93	0.42	0.12	0.18	0.18	0.65	0.95	0.97	0.90	0.79	0.83	0.98
Caldas	0.19	0.91	0.33	0.09	0.19	0.20	0.67	0.97	0.97	0.89	0.86	0.89	1.00
Caquetá	0.14	0.94	0.40	0.08	0.09	0.24	0.83	0.86	0.89	0.81	0.92	0.82	0.99
Huila	0.25	0.92	0.48	0.14	0.29	0.13	0.76	0.95	0.97	0.94	0.98	0.88	1.00
Quindío	0.36	0.89	0.26	0.18	0.27	0.19	0.68	0.97	0.97	0.95	0.89	0.88	0.98
Risaralda	0.33	0.95	0.31	0.16	0.23	0.20	0.67	0.96	0.99	0.93	0.96	0.85	0.99
Tolima	0.34	0.87	0.34	0.16	0.27	0.28	0.67	0.90	0.93	0.91	0.92	0.68	0.97
Pacific	**0.27**	**0.94**	**0.25**	**0.09**	**0.24**	**0.23**	**0.68**	**0.86**	**0.88**	**0.87**	**0.88**	**0.85**	**0.99**
Cauca	0.19	0.94	0.25	0.06	0.26	0.25	0.72	0.73	0.75	0.83	0.87	0.91	1.00
Chocó	0.29	0.97	0.18	0.03	0.18	0.19	0.69	0.66	0.72	0.66	0.86	0.73	0.99
Nariño	0.24	0.96	0.22	0.11	0.29	0.24	0.64	0.88	0.89	0.85	0.82	0.91	1.00
Valle	0.31	0.92	0.27	0.11	0.23	0.22	0.69	0.93	0.96	0.93	0.92	0.81	0.99
Amazon and Orinoco	**0.27**	**0.90**	**0.32**	**0.10**	**0.23**	**0.29**	**0.74**	**0.86**	**0.88**	**0.79**	**0.83**	**0.83**	**0.98**
Arauca	0.18	0.89	0.18	0.13	0.31	0.27	0.69	0.98	0.98	0.88	0.83	0.89	1.00
Casanare	0.19	0.90	0.41	0.14	0.22	0.33	0.79	0.93	0.97	0.85	0.84	0.85	0.95
Putumayo	0.34	0.92	0.24	0.07	0.22	0.27	0.70	0.86	0.87	0.79	0.83	0.81	0.98
Amazonas	0.26	0.91	0.40	0.08	0.20	0.25	0.80	0.64	0.68	0.68	0.87	0.85	0.99
Guainía	0.12	0.83	0.49	0.10	0.34	0.25	0.78	0.74	0.78	0.69	0.71	0.77	0.97
Guaviare	0.32	0.85	0.27	0.10	0.23	0.47	0.70	0.93	0.96	0.89	0.84	0.81	0.99
Vaupés	0.14	0.83	0.32	0.05	0.23	0.24	0.72	0.70	0.73	0.54	0.87	0.81	0.99
Vichada	0.56	0.89	0.51	0.06	0.22	0.24	0.82	0.75	0.75	0.60	0.76	0.77	0.98
Bogotá	**0.23**	**0.89**	**0.27**	**0.13**	**0.27**	**0.34**	**0.73**	**0.98**	**0.99**	**0.93**	**0.91**	**0.78**	**0.99**
Colombia	0.28	0.91	0.32	0.11	0.26	0.25	0.73	0.93	0.95	0.89	0.89	0.81	0.99

Appendix E

Results based on the overall index constructed in Chapter 4

Eigenvalues

k	Eigenvalues	Proportion explained	Proportion cumulative
1	2.73269	0.2102	0.2102
2	1.64479	0.1265	0.3367
3	1.53773	0.1183	0.455
4	1.27179	0.0978	**0.5528**

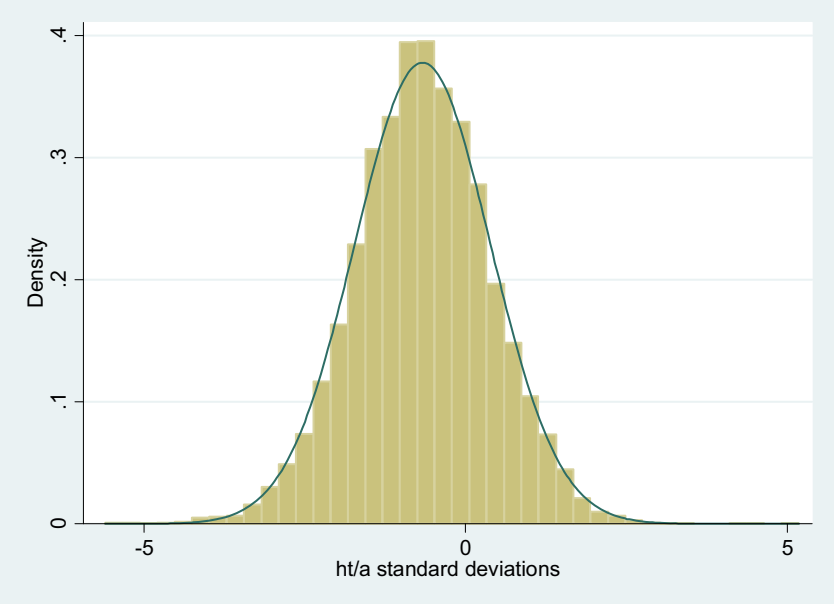
Correlation matrix

Variable		PC1	PC2	PC3	PC4
VAfruits					
	No	-0.1445	0.0138	-0.2936	0.0018
	Yes	0.1445	-0.0138	0.2936	-0.0018
Breastfeeding					
	Never breastfed	0.1281	0.1194	-0.2109	-0.1637
	Up to 2 years	0.0536	0.0366	0.1776	-0.0576
	More than 2 years	-0.1093	-0.0951	-0.3269	0.1472
Physical activity					
	Not carried out	-0.1572	-0.3159	-0.9050	0.0613
	Once a week	0.0517	-0.0429	-0.1975	-0.0126
	2-4 times/week	0.0606	0.1250	0.2767	-0.0546
	>5 times/week	0.1020	0.2725	0.7899	-0.0098
Play					
	Not carried out	-0.5114	-0.5271	-0.7661	0.2019
	Once a week	0.0589	0.1044	0.1315	-0.0777
	2-4 times/week	0.4103	0.3901	0.5348	-0.1535
	>5 times/week	0.6328	0.5785	0.7983	-0.1472
Physical punishment					
	No	0.0952	-0.0373	0.3152	-0.1308
	Yes	-0.0952	0.0373	-0.3152	0.1308
Child care					
	Mother	-0.2456	0.0039	0.1041	0.9341
	Father	-0.1059	0.0137	0.0598	0.4492
	Grandparents	0.1681	0.0251	0.0018	-0.4080
	Others	0.1645	-0.0427	-0.1495	-0.8750
Partner at home					
	No	0.0029	-0.0181	0.0426	-0.7094
	Yes	-0.0029	0.0181	-0.0426	0.7094
Doctor assisted delivery					
	No	-0.8461	-0.0824	-0.1658	0.0756
	Yes	0.8461	0.0823	0.1658	-0.0756
Delivery in a health facility					
	No	-0.8782	-0.0961	-0.1574	0.0843
	Yes	0.8783	0.0961	0.1574	-0.0843
Antenatal visits					
	0	-0.7019	-0.2535	-0.1789	-0.1503
	1-3 visits	-0.4102	-0.1561	-0.1212	-0.0609
	4 or more	0.7443	0.2446	0.1728	0.1156
Tetanus toxoid injection					
	No	-0.4351	-0.1690	-0.0728	-0.1631
	Yes	0.4351	0.1690	0.0727	0.1630
Child's immunization					
	No	-0.0735	-0.9457	-0.1910	-0.0048
	Yes	0.0735	0.9457	0.1910	0.0048
Child's health card					
	No	-0.1208	-0.7278	-0.0261	0.0324
	Yes	0.1208	0.7304	0.0261	-0.0323

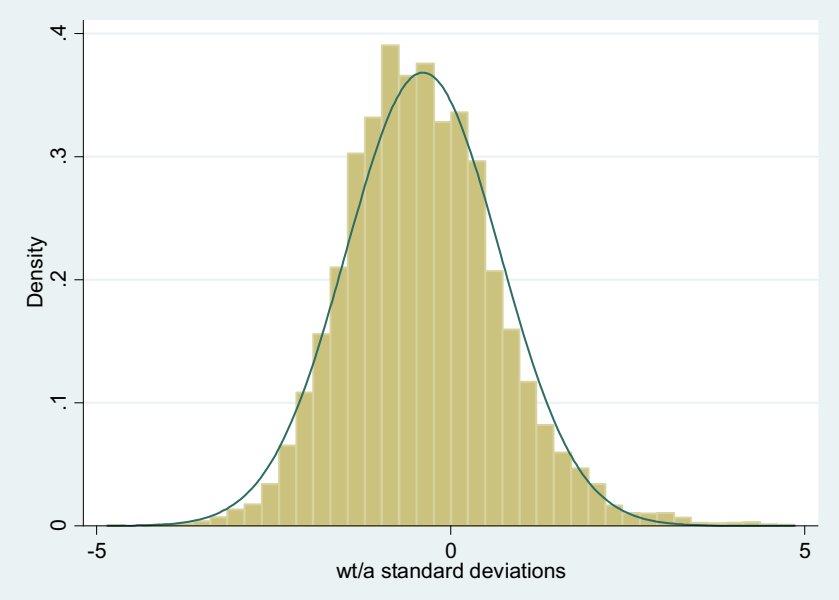
Appendix F

Distribution of the anthropometric measures studied in Chapter 5

Height-for-age Z-scores distribution for 0-59 month-old Colombian children (n=10,165), DHS 2010



Weight-for-age Z-scores distribution for 0-59 month-old Colombian children (n=10,165), DHS 2010



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