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# Mind the Gap! Socioeconomic Determinants of the Stunting Urban-Rural Gap for Children in Colombia

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## Abstract

Stunting (low height for age) is a crucial indicator for measuring child well-being and economic and social development of a country. Despite a decrease in overall children's stunting in the last decades, there are still significant geographic disparities between urban and rural areas in Colombia. This paper aims to identify the role of the main determinants of children's stunting in explaining the urban-rural stunting gap. We use data from the 2015 National Nutritional Situation Survey (the most recent available dataset) and the Yun's statistical decomposition technique. We find that the urban-rural gap in child stunting is 7.2 percentage points. Three determinants: household wealth, maternal education, and health services utilization, explain most of the gap (92%). Each determinant explains 54%, 26%, and 12% of the *characteristics effect*, respectively. Public health policies aiming to reduce the gap must seek improvements in access to institutional delivery and education services for mothers in rural areas in the short term. In the long term, increasing economic wealth in rural areas is essential.

**Keywords** Stunting · Urban-rural gap · Decomposition · Socio-economic determinants · Colombia

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## 1 Introduction

Stunting (low height for age) is not only a good indicator of children's well-being, but it can also be seen as a good predictor of poverty and geographic socioeconomic inequalities (De Onis & Branca, 2016; Flores-Quispe et al., 2019; Prendergast & Humphrey, 2014). Stunting prevents economic development for at least two reasons: i) it is highly correlated with other co-morbidities that reduce life expectancy and ii) it negatively affects productivity levels and income in the future (Victora et al., 2008). In tandem, these two associations reduce the possibility of escaping poverty, improving quality of life and achieving economic development (UNICEF, 2019).

Globally, in almost all countries, geographic disparities in stunting can be observed and characterized by children in rural areas as being the most affected (Paciorek et al., 2013; Paraje, 2009; Van de Poel et al., 2007). This urban-rural gap is particularly large in the Latin American and the Caribbean region. For instance, in Bolivia and Peru, children in rural areas are nearly 2 and 3.5 times more likely to be stunted compared with their counterparts in urban areas, respectively (UNICEF/WHO/World Bank Group, 2020).

According to Smith et al. (2005) the advantage for urban children is the result of a cumulative effect of better socioeconomic and environmental conditions rather than the nature of the determinants themselves. Generally, urban areas offer greater access to; food, water, sanitation, health and education facilities, and better employment opportunities which translate into better care, nutrition, and health conditions for children (Garrett & Ruel, 1999; Smith et al., 2005).

Colombia has made significant progress in terms of economic development. For example, according to the World Bank Group (2020), Colombia reduced poverty from 50% in 2002 to 27% in 2018 (measured by the poverty head count ratio index), increased the life expectancy index from 73 to 77 years old between 2002 and 2017, and has officially become an OECD member since April 2020 (OECD, 2020). However, these achievements are not equally distributed throughout the country. For example, the multidimensional poverty in rural areas (34.5%) was almost three times that of urban areas (12.3%) in 2019 (DANE, 2019).

The country has set the Sustainable Development Goal (SDG) of reducing stunting among children under 5 years old to 8% by 2020, and to 5% by 2030 (DNP, 2018). The accomplishment of this goal will depend crucially on the capacity for implementing public policies that address significant health inequalities that exist between urban and rural areas in the country. But it is possible that the relative importance of stunting's determinants in rural areas may differ from that in urban areas. In fact, despite a reduction in the national prevalence of stunting among children (25.6% in 1986 to 10.8% in 2015) (ICBF, 2015), the relative gap between rural and urban stunting increased from 1.4 to 1.7 between 2010 and 2015 (Fig. 1).

Some studies have broken down the urban-rural gap in child malnutrition using decomposition techniques such as Blinder-Oaxaca, Nopo and other decompositions based on quantile regression, mainly for African and Asian countries (Liu

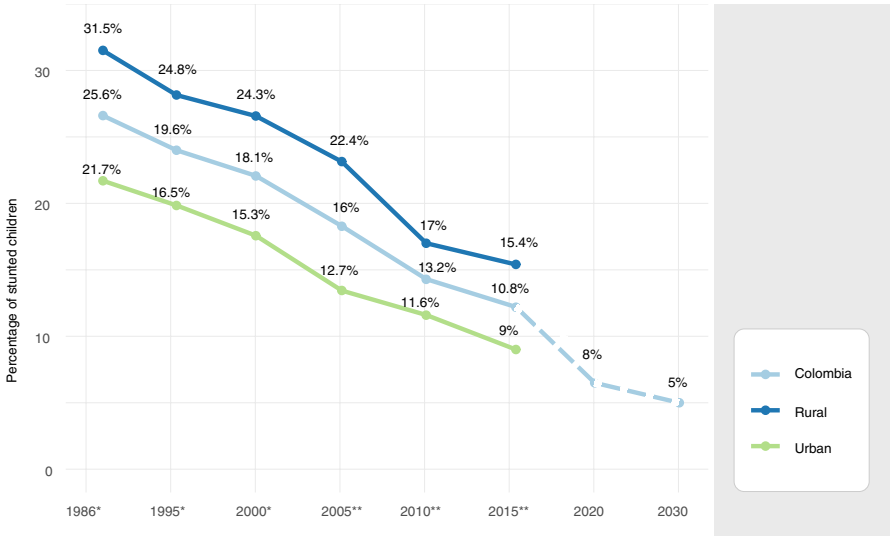


**Fig. 1** Stunting trends and urban-rural differences in Colombia 1986-2015. Source: *The Demographic and Health Surveys (DHS) program, statcompiler. ** https://www.icbf.gov.co/sites/default/files/portada-ensin4.jpg

et al., 2013; Mussa, 2014; Sharaf & Rashad, 2016; Srinivasan et al., 2013). The rationale behind decomposition techniques is to explain the gap as the sum of two main components: the characteristics and coefficient components.

In Colombia, previous studies (Garcia et al., 2013; Larrea & Freire, 2002) have identified the existence of rural-urban disparities in children's health by regressing the health outcome variable against an urban/rural indicator variable and other covariates. By finding statistical significance for the urban/rural indicator variable, these studies indicate that on average children's health outcomes behave differently between urban and rural areas. In this study we contribute to a better understanding of these disparities by measuring and explicitly analyzing the socioeconomic determinants of the stunting urban-rural gap for children in Colombia. In so doing, first, we estimate the difference in stunting for children under 5 years old living in urban and rural areas. Then, we use Yun's (2004) decomposition technique in order to identify the part of the gap that can be explained by differences in the set of socioeconomic determinants of children's stunting, and the part that results from structural, unobserved, factors. Then, we analyse the relative importance of each socioeconomic determinant within the *characteristics effect* by estimating the so-called detailed decomposition. The detailed decomposition allows us to provide empirical evidence for guiding public policies attempting to reduce the urban-rural gap. Finally, and based on the detailed decomposition analysis, we keep the three main characteristics explaining the gap and estimate their incidence on the probability of children to be stunted within each population subgroup by using a logistic regression model. This exercise allows us to identify if heterogeneous public policies regarding the main determinants explaining the gap are necessary.

To the best of our knowledge this is the first study identifying the role of the main determinants of children's stunting in explaining the urban-rural stunting gap and its relative importance, in the context of one of the most unequal countries in Latin American and the world: Colombia. We identify factors that can reduce the gap in the short run and differ from those that can do so in the long run, conditional on the urban-rural characteristic. This provides inputs for policy makers in Colombia to accomplish the goal of reducing stunting among children under 5 years old to 5% by 2030. If the goal is to be achieved, then, mind the gap!

## 2 Literature Review on Urban-Rural Disparities in Children's Stunting

Stunting has been identified as a global priority for public health and development. It is caused by a set of immediate, underlying, and basic determinants (UNICEF, 1991, 2020). A large body of literature has addressed the determinants and drivers of stunting in different developing countries, especially in African and Asian countries, where more than 80% of the cases are concentrated (UNICEF/WHO/World Bank Group, 2020). In general, results show that individual factors (e.g., child's age, sex, birth interval, breastfeeding practices, maternal education, household' wealth and use and access of health care), and contextual factors (e.g., community education; water, sanitation, and hygiene (WASH); agricultural productivity; and living in rural areas), are associated with stunting (Prendergast & Humphrey, 2014; Vilcins et al., 2018).

Empirical studies have demonstrated that, on average, urban children have less likelihood of being stunted than their rural counterparts (Paciorek et al., 2013). However, studies that decompose the malnutrition urban-rural gap find mixed results regarding whether the characteristics effect or the coefficients effect predominates in explaining the gap. For instance, Srinivasan et al. (2013), applying quantile regression-based counterfactual decomposition methods, conclude that urban-rural disparities in the lowest quantiles of Height-for-Age Z scores (HAZ) are explained by differences in the level of socioeconomic determinants (parents' education and household's wealth index) in Bangladesh and Nepal. Mussa (2014), using the non-parametric Nopo decomposition method, investigates the rural-urban nutrition gap in Malawi. He finds that for HAZ, 91% of the urban-rural gap is explained by the effect of the characteristics. He also concludes that providing better parental education and household economic status for rural children could reduce the malnutrition gap in Malawi. Sharaf and Rashad (2016) find significant differences across urban and rural settings in child malnutrition for Yemen and Jordan using Blinder-Oaxaca decomposition. In the case of Yemen, the gap is explained mainly by the household's wealth index inequalities between urban and rural areas (characteristics effect). For Jordan, the coefficients effect explains most of the gap. Consequently, they suggested that reducing the urban-rural stunting gap would need in Yemen policies oriented to wealth redistribution, while behavioral and awareness programs in Jordan.

On the other hand, some countries have reduced child stunting prevalence by closing the urban-rural gap over the past few decades. For instance, Liu et al.

(2013) show that children living in urban areas have a better nutritional status than rural children in China. However, the child malnutrition urban-rural gap has declined between 1989 and 2006. This reduction was attributable to increased food consumption, such as proteins and fat, and health system reforms that permitted better access to preventive health services. Furthermore, the decomposition analysis suggested that the effect of the characteristics is more important than the coefficients effect in accounting for urban-rural disparities. In the context of a Latin American country, Ervin and Bubak (2019) analyze the main drivers that eliminated the urban-rural gap in Paraguay from 1997 to 2012. Using Blinder-Oaxaca decomposition, they find that improvements in health care services, family planning, and demographic variables are the main factors that have contributed to closing the urban-rural differential in HAZ and stunting.

Cross-country and case studies, using regression analysis, have also found significant differences in stunting between urban and rural children. Garrett and Ruel (1999) investigate the determinants of food security and nutritional status (measured by HAZ) in Mozambique. For models regarding nutritional status, they find that most of the differences observed are due to differences in the levels of socioeconomic determinants, such as income and maternal education. Similar findings are reported by Smith et al. (2005) using DHS for 36 developing countries. They find statistically significant differences between urban and rural areas in the level of critical socioeconomic determinants (women's education and decision-making, use and access of water and sanitation, and household's economic status) rather than differences in the determinants (coefficients effect). Menon et al. (2000) and Fotso (2006) analyze child malnutrition inequalities across urban and rural areas in developing countries. Their results show that child malnutrition inequalities are higher in urban than rural areas, and within-urban disparities are larger than overall urban-rural gaps. Van de Poel et al. (2007), using DHS for 47 countries, observe considerable rural-urban differences in stunting. However, after controlling for child, mother, and household characteristics, the relative rural-urban risk ratios of stunting decreased and even in some countries became insignificant. Mena-Meléndez (2020) explores the association between ethnicity/race and child health in Colombia, Guatemala, Peru, and Bolivia. The findings evidenced that indigenous and/or afro-descendant children living in rural areas have a 2.83 times higher risk of stunting than those in cities.

For Colombia, Garcia et al. (2013) and Osorio et al. (2018) for analyzing individual and community factors associated with child malnutrition used 2005 and 2010 DHS, respectively. Their results show that a social gradient between wealth and stunting remains even after controlling for the urban-rural area.

Although the studies reviewed in this section have contributed to a better understanding of the determinants of the urban-rural gap in stunting, most are for Asian and African countries. In the case of Colombia, little is known about the role of socioeconomic determinants of child malnutrition across urban and rural settings. Moreover, there is no evidence on the relative contribution of the determinants to the urban-rural gap in stunting. As previously mentioned, on average, Colombia has reduced the prevalence of stunting in the last decade, but not the stunting urban-rural gap. Understanding its main determinants of the gap and

identifying its individual contribution would help better and more effective interventions for closing the gap.

## 3 Data

We use data from the 2015 National Nutritional Situation Survey[1] (ENSIN, 2015, Spanish acronym) conducted by the Colombian Institute of Family Well-being (ICBF, Spanish acronym), the Ministry of Health, the National Health Institute (INS, Spanish acronym) and the Administrative Department for Social Prosperity. This dataset is the most recent survey in the country which provides reliable information about the nutritional situation of the Colombian population and was released in 2019. The survey is freely accessible to the public subject to a prescribed registration and approval process by the Colombian's Ministry of Health and Social Protection.

The survey is representative at a national level and covers urban and rural areas, six regions, 14 subregions and 33 departments (first administrative division), including the capital city: Bogotá. The survey collects information about body measurements and biological tests according to international standards, allowing for international comparisons. The survey uses a multistage, stratified, clustered and probabilistic sample. A total of 44,202 households were interviewed in 295 municipalities.

The number of children under five, that were the last born alive and with information about antenatal care and delivery in the survey were 9794. Multiple births were excluded to avoid bias, due to the fact that children born under multiple births are usually smaller. Observations with "missing values", or "don't know" answers, were excluded from the sample without significant differences between these cases and those included in the final sample ($n = 9644$). There is no information in the survey for rural areas from the Orinoquia and Amazonia regions (five departments in total) because of high dispersion and low population density. Therefore, the final sample used into the decomposition analysis consisted of 8557 children.

The outcome variable is stunting (yes; no). A child is considered stunted when the Z-score for height-for-age is below minus two standard deviations from the World Health Organization (WHO) 2006 growth standards median of reference. Our empirical analysis is based on the widely used conceptual framework on the determinants of child nutrition outlined by UNICEF (1991) and its variants UNICEF (2020). This conceptual framework identifies immediate, underlying, and primary or basic causes of malnutrition. Thus, based on UNICEF conceptual framework and according to the data's availability, 12 variables were included as explanatory variables. Child characteristics were: sex, age, birth interval and breastfeeding. Characteristics for mothers were: age at birth, level of education,

[1] In Colombia, since 2015, the nutritional information was separated from the Colombian DHS and is collected through the National Nutritional Survey (ENSIN), which uses an independent sample of the population.

Body Mass Index, type of health insurance, number of antenatal check-ups, whether the birth was assisted by a doctor and whether the place of delivery was a hospital, clinic or government health centre. As an indicator of household socioeconomic status, we used a wealth index included in the survey. This is a composite index based on dwelling characteristics, access to public services and tenure of durable goods. The index was categorized into quintiles.

Figure 2 depicts the percentage of stunted children by department. In general, panel 2a. shows that the percentage of stunting is greater at the periphery of the country. Panels 2b. and 2c. show that the percentage of stunted children is greater, and displays greater variance, in rural than urban areas. It is important to note that in certain rural areas the prevalence of stunting is greater than 30%, a very high-level even for international standards according to malnutrition estimates (UNICEF/WHO/World Bank Group, 2020).

Figures 3 and 4 present information about the gap between urban and rural areas by departments. Figure 3 contains information about the magnitude of the gap while Fig. 4 contains information about the intensity of the gap. For instance, in departments such as Guajira and Chocó the child stunting prevalence in rural areas is 4 and 6 times greater than that in urban areas, respectively.

Table 1 shows descriptive statistics for the complete sample and for urban and rural sub-samples. There is a significant statistical difference between the prevalence of stunting in urban and rural areas. On average, 9.9% of children in the sample are stunted, 8.4% in rural areas and 13.6% in urban areas. Near half of the stunted children (45%) were under 2 years old, 45.5% of them have no siblings and one third were breastfed. A further, 22% of the stunted children were born when their mother was under 19, 8.8% had a mother who had no education and 8.6% had no access to the number of antenatal check-ups recommended by the WHO. Additionally, almost 30% of households were poor or very poor. The mother's education, wealth and access to the health system are the socioeconomic determinants of children's stunting with greater differences between urban and rural areas.

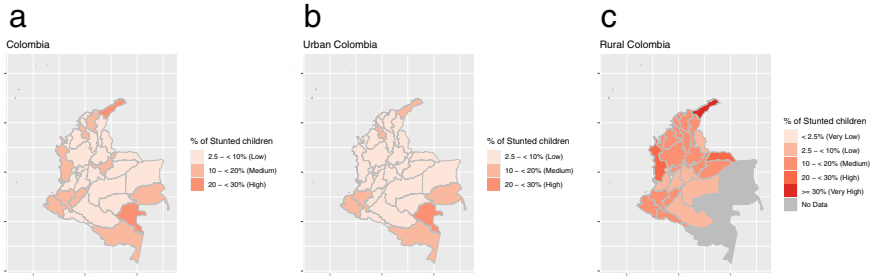


**Fig. 2** Percentage of stunted children by department, Colombia 2015. *As part of the ENSIN sample design, rural areas from the departments: Vichada, Vaupés, Guaviare, Guainía y Amazonas were excluded because of high dispersion and low population density. Note: The percentage band ranges for stunted children (very low, low, medium, high and very high) are based on the UNICEF scale (see https://data.unicef.org/topic/nutrition/malnutrition/)

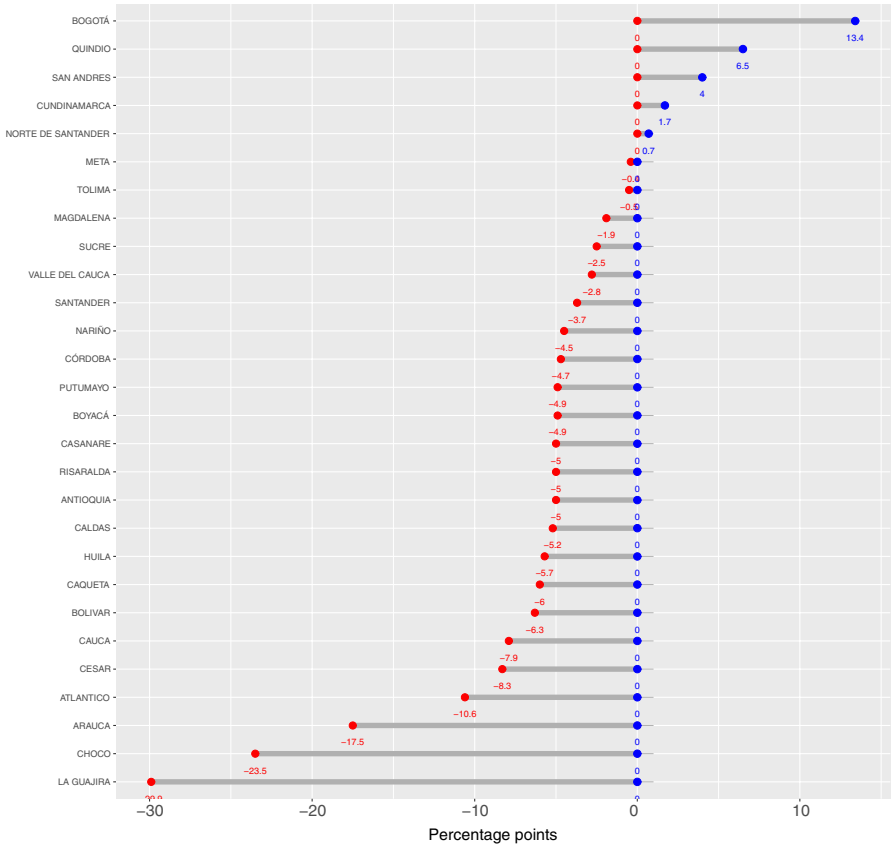


**Fig. 3** Urban-rural absolute stunting gap (percentage points) by department, Colombia 2015

## 4 Methodology

Considering that our outcome variable is a dichotomous variable (stunting: Yes; No), we use Yun's (2004) decomposition technique which is based on the seminal work by Oaxaca (1973) and Blinder (1973). Crucially, this technique allows us to identify the individual contributions of each characteristic to explain the difference in outcomes and a detailed decomposition that is free from the problem of path dependency present in alternative decomposing methodologies for discrete dependent outcome variables. These alternative decomposition techniques find the relative contribution of each characteristic in the detailed decomposition by sequential replacement of values from one group into the other. However, this method is sensitive to the order of switching, which is called the path dependency problem (Ham et al., 1998).

Thus, the Yun's non-linear decomposition allows us to explain, first, the difference in the probability of being stunted between our two groups of interest, i.e. urban and rural children, as the sum of two independent effects: characteristics

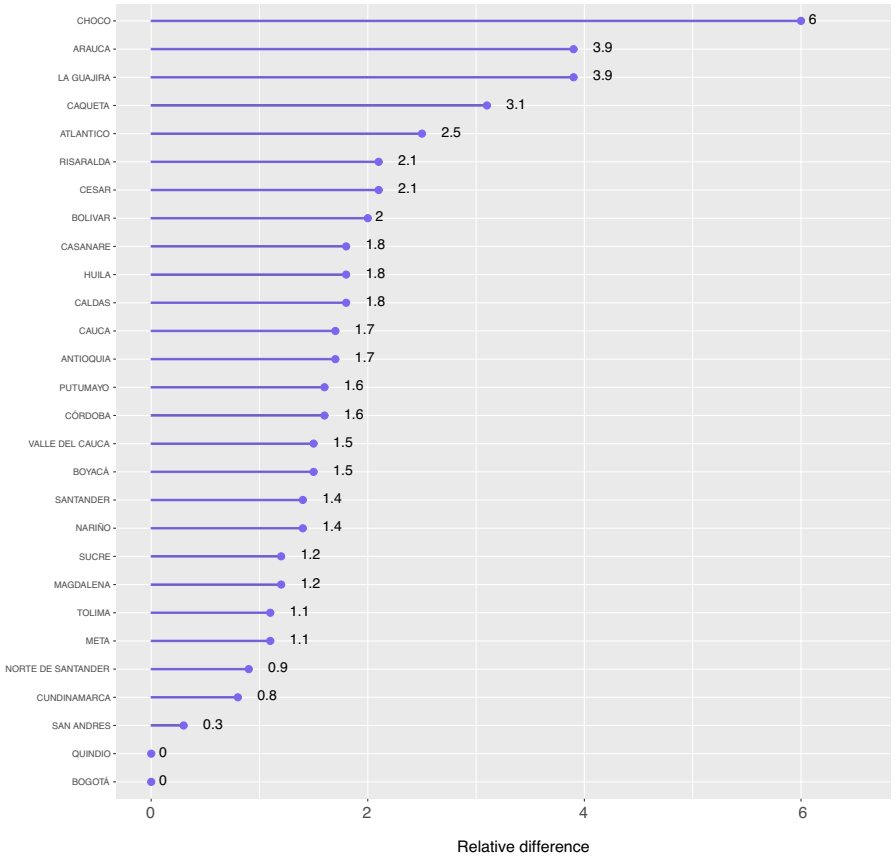


**Fig. 4** Urban-rural relative stunting gap by department, Colombia 2015

and coefficients. Second, the Yun's decomposition allows us to single out the relative importance of each individual characteristic at explaining the gap through the so-called detailed decomposition. The characteristics effect measures the portion of the gap that is explained by existing differences in the socioeconomic characteristics between the groups, while the coefficients effect measures the part of the gap that can be attributed to structural, unobservable differences.

Formally, stunting for a child $i$ is defined as a dummy variable, $Y_i$, that takes the value of one, $Y_i = 1$, if the height-for-age-Z score (HAZ) is below minus two standard deviations (SD), that is HAZ < -2SD. For any other value, $Y_i$ takes the value of zero ($Y_i = 0$). We denote by $j = 0, 1$ the condition of living in an urban or rural area. Specifically, $j = 0$ if a child lives in a rural area and $j = 1$ if a child lives in an urban area.

The likelihood of being stunted for children $i$ ($Y_i = 1$) is estimated by a non-linear relationship $F(X\beta)$, where $F$ is the logistic distribution function and $X$ is a

**Table 1** Descriptive statistics by urban-rural area, Colombia 2015

| | All ($n=8557$) | Urban ($n=5910$) | Rural ($n=2647$) | Urban –Rural difference (pp)[a] |
|---|---|---|---|---|
| Child characteristics | | | | |
| Sex | | | | |
| Male | 50.7% | 50.9% | 50.5% | 0.4 |
| Female | 49.3% | 49.2% | 49.6% | −0.4 |
| Age (in months) | | | | |
| 0 - 11 | 23.5% | 23.4% | 23.8% | −0.4 |
| 12 - 23 | 21.7% | 21.4% | 22.5% | −1.1 |
| 24 - 35 | 20.5% | 19.8% | 22.2% | −2.4** |
| 36 - 47 | 17.9% | 17.9% | 17.9% | 0.0 |
| 48 - 59 | 16.4% | 17.4% | 13.6% | 3.8*** |
| Birth interval | | | | |
| First Birth | 45.5% | 47.9% | 39.3% | 8.6*** |
| <24 months | 6.5% | 5.8% | 8.3% | −2.5*** |
| >24 months | 48.1% | 46.3% | 52.4% | −6.1*** |
| Currently breastfeeding | | | | |
| Yes | 32.9% | 31.8% | 35.6% | −3.8*** |
| No | 67.1% | 68.2% | 64.4% | 3.8*** |
| Mother characteristics | | | | |
| Age at birth (years) | | | | |
| ≤19 | 22.0% | 21.3% | 24.0% | −2.7*** |
| 20-29 | 51.4% | 51.9% | 50.1% | 1.8 |
| 30-49 | 26.6% | 26.8% | 25.9% | 0.9 |
| Educational level | | | | |
| No education | 8.8% | 4.5% | 19.8% | −15.3*** |
| Primary | 30.5% | 25.5% | 43.4% | −17.9*** |
| Secondary | 53.6% | 60.5% | 35.7% | 24.8*** |
| Higher | 7.1% | 9.4% | 1.1% | 8.3*** |
| Number of antenatal check-ups | | | | |
| 0-3 | 8.6% | 6.8% | 13.1% | −6.3 |
| ≥4 | 91.4% | 93.2% | 86.9% | 6.3 |
| Type of health system | | | | |
| Not Affiliated | 4.3% | 3.8% | 5.6% | −1.8*** |
| Subsidized | 54.4% | 45.1% | 78.2% | −33.1*** |
| Contributory | 41.3% | 51.1% | 16.2% | 34.9*** |
| Doctor assisted delivery | | | | |
| Yes | 95.1% | 97.2% | 89.8% | 7.4*** |
| No | 4.9% | 2.8% | 10.2% | −7.4*** |
| Institutional delivery | | | | |
| Yes | 97.7% | 99.4% | 93.2% | 6.2*** |
| No | 2.3% | 0.6% | 6.8% | −6.2*** |

**Table 1** (continued)

| | All ($n=8557$) | Urban ($n=5910$) | Rural ($n=2647$) | Urban –Rural difference (pp)[a] |
|---|---|---|---|---|
| Household characteristics | | | | |
| Wealth index | | | | |
| Very poor | 13.0% | 2.2% | 40.5% | −38.3*** |
| Poor | 15.9% | 7.5% | 37.5% | −30.0*** |
| Middle | 18.0% | 18.1% | 17.6% | 0.5 |
| Rich | 23.9% | 31.8% | 3.6% | 28.2*** |
| Very Rich | 29.2% | 40.3% | 0.8% | 39.5*** |

[a]Level of significance of the urban-rural differences t-test. *** $p$ value <0.01; ** <0.05; * <0.10

vector with socioeconomic characteristics, that is, $F(X\beta) = 1/[1 + \exp(-X_i\beta)]$, and $\beta$ is the vector of associated coefficients.

Following Yun (2004) the differences in the estimated average likelihood of being stunted between urban ($j = 1$) and rural ($j = 0$) children, may be decomposed into the overall characteristics and coefficient effects as follows:

$$\overline{Y}_1 - \overline{Y}_0 = \left[\overline{F\left(X_1\beta_1\right)} - \overline{F\left(X_0\beta_1\right)}\right] + \left[\overline{F\left(X_B\beta_1\right)} - \overline{F\left(X_0\beta_0\right)}\right] \quad (1)$$

where $\overline{Y}_j = \overline{F(X\beta)} = \frac{1}{N_j}\sum_{i=1}^{N_j} F\left(X_{i,j}\beta_j\right)$ is the estimated average of the likelihood of being stunted in group $j$. The first and second components in the right-hand side represent the characteristics and coefficient effects, and the "upper bar" represents the value of the sample's average.

In order to carry out the detailed decomposition and find the relative contribution of each variable to the estimated gap, we use a decomposition equation proposed by Yun (2004) as follows:

$$\overline{Y}_1 - \overline{Y}_0 = \sum_{k=1}^{K} W_{\Delta X}^k \left[\overline{F\left(X_1\beta_1\right)} - \overline{F\left(X_0\beta_1\right)}\right] + \sum_{k=1}^{K} W_{\Delta\beta}^k \left[\overline{F\left(X_0\beta_1\right)} - \overline{F\left(X_0\beta_0\right)}\right] \quad (2)$$

where

$$W_{\Delta X}^k = \frac{\left(\overline{X}_1^k - \overline{X}_0^k\right)\beta_1^k}{\left(\overline{X}_1 - \overline{X}_0\right)\beta_1}, W_{\Delta\beta}^k = \frac{\overline{X}_0^k\left(\beta_1^k - \beta_0^k\right)}{\overline{X}_0\left(\beta_1 - \beta_0\right)}, \text{and } \sum_{k=1}^{K} W_{\Delta X}^k = \sum_{k=1}^{K} W_{\Delta\beta}^k = 1,$$

where $\overline{X}_j^k$ is the average value of explanatory variable k for group $j = 0, 1$.

Once we identify the relative importance of each characteristic through the detailed decomposition, we estimate a set of logistic regressions for the whole sample, and for the urban and rural subsamples, to inquire about their particular incidence on the probability of being stunted within each subgroup. Technically, we are interested now in explaining a limited dependent variable (i.e. stunting) in terms of a

**Table 2** General and detailed decomposition of urban-rural gap in child stunting, Colombia 2015

| Stunting | Estimation | SE Robust | z | P>\|z\| | [95% CI] | |
|---|---|---|---|---|---|---|
| General | | | | | | |
| Rural | 0.1511 | 0.007 | 21.94 | *** | 0.138 | 0.165 |
| Urban | 0.0785 | 0.004 | 22.43 | *** | 0.072 | 0.085 |
| Difference | 0.0726 | 0.008 | 9.40 | *** | 0.057 | 0.088 |
| Explained (*characteristics effect*) | 0.0695 | 0.006 | 12.10 | *** | 0.058 | 0.081 |
| Unexplained (*coefficients effect*) | 0.0031 | 0.005 | 0.61 | | −0.007 | 0.013 |

Level of significance. *** $p$ value <0.01; ** <0.05; * <0.10

**Table 3** Contribution of socio-economic determinants to the total urban-rural gap in stunting

| | Estimation | Contribution | P>\|z\| |
|---|---|---|---|
| Explained (*characteristics effect*) | 0.0695 | 95.7% | *** |
| Unexplained (*coefficients effect*) | 0.0031 | 4.3% | |
| Detailed (Explained) | | | |
| Child sex | −0.0003 | −0.45% | |
| Child age | −0.0002 | −0.35% | |
| Child birth interval | 0.0011 | 1.62% | |
| Child breastfeeding | −0.0002 | −0.36% | |
| Maternal age at birth | 0.0003 | 0.50% | |
| Maternal BMI | 0.0001 | 0.20% | |
| Maternal education | 0.0178 | 25.60% | *** |
| Antenatal check-ups | 0.0035 | 5.00% | *** |
| Health system type | 0.0028 | 4.04% | |
| Doctor assisted delivery | 0.0020 | 2.85% | |
| Institutional delivery | 0.0050 | 7.16% | *** |
| Household wealth index | 0.0377 | 54.20% | *** |

Level of significance *** $p$ value <0.01; ** <0.05; * <0.10

specific set of independent variables (i.e. the subset of most relevant characteristics explaining the stunting urban-rural gap for children) for each population subgroup (i.e. urban, rural). Considering the drawbacks of linear models for modelling binary outcomes we use the logistic nonlinear model. Further, and aware of structural differences in Colombia between urban and rural areas, we assume some of the unobservable characteristics do not follow a normal distribution so, as a consequence, we estimate logit instead of probit regression models (Wooldridge, 2010).

## 5 Results

Tables 2 and 3 present the results of the general and detailed decomposition of the urban-rural stunting gap. Table 2 shows the proportion of children stunted by urban and rural area, and the gap between them. The general decomposition shows

a gap of 7.2 percentage points in the probability of being stunted between urban and rural children in Colombia. 95.7% of the gap (6.9 percentage points) is explained by the individual and household socioeconomic determinants included in the model (*characteristics effect*). The unexplained portion of the gap (*coefficients effect*) accounts for 4.3% of the gap (0.31 percentage points), however it is not statistically significant.

Table 3 presents which determinants contribute most of the explained urban-rural gap in stunting. The results from the detailed decomposition indicate that the most relevant determinants for explaining the gap are; the household wealth index, level of mother's education, and access to health services measured through institutional delivery and antenatal check-ups, which explain 54%, 26%, 7% and 5% of the total *characteristics effect*, respectively. The other child and maternal characteristics seem not to contribute to explaining the urban-rural gap in stunting.

It is important to consider the incidence of the main determinants of the gap within each population sub-group (e.g. urban and rural children). We estimate three logistic regressions with the probability of being stunted as the dependent variable. The results for these logistic regressions are displayed in Table 4.

As expected, all the factors included as explanatory variables are statistically significant for the whole sample (see first column in Table 4). Interestingly, however, the importance of some characteristics change, depending on the population sub-group. For example, high levels of wealth are relevant in urban but not in rural areas.

In addition, the importance of the mother's education is higher in rural areas than to urban ones. Attaining both primary and secondary school education appears to be important for rural areas, but not for urban. For example, secondary school reduces the probability of being stunted to 11% in rural areas and has high statistical significance, while it has low statistical significance and reduces the probability of being stunted to 4% in urban areas.

**Table 4** Logit models of child stunting for selected characteristics, Colombia 2015

| | Colombia dy/dx | Urban dy/dx | Rural dy/dx |
|---|---|---|---|
| Maternal education level (ref: no education) | | | |
| Primary | −0.044 ** | −0.023 | −0.059 ** |
| Secondary | −0.071 *** | −0.042 * | −0.112 *** |
| Higher | −0.062 ** | −0.037 | −0.069 |
| Household wealth index (ref: very poor) | | | |
| Poor | −0.039 ** | −0.042 | −0.030 |
| Middle | −0.055 *** | −0.047 * | −0.072 ** |
| Rich | −0.053 *** | −0.048 * | −0.072 |
| Very Rich | −0.075 *** | −0.070 ** | −0.019 |
| Number of antenatal check-ups (ref: 0-3) | | | |
| ≥4 | −0.036 ** | −0.019 | −0.058 ** |
| Institutional delivery (ref: no) | | | |
| Yes | −0.068 ** | 0.013 | −0.094 ** |

*** $p$ value <0.01; ** <0.05; * <0.10

In addition, access and use of health systems for the number of antenatal check-ups and institutional delivery are important for rural areas but not to urban. The former reduces the probability of being stunted in 6%, whereas the latter reduces it to 9% for rural areas.

## 6 Discussion

The aim of this study was to to identify the role of the main determinants of children's stunting in explaining the urban-rural stunting gap in Colombia, as well as to analyse the individual contribution of each determinant to explain the gap. This is particularly important in the context of a highly unequal country such as Colombia because it provides inputs for the design of more effective policies and programmes aimed at closing the territorial gap on child health outcomes. As stated above, despite a reduction in the level of stunting in Colombia, there was an increase in stunting's urban-rural gap between 2010 and 2015. Using Yun's decomposition analysis and the most recent data Available from in Colombia, we divided the urban-rural gap into two parts. The first part is the *characteristics effect*, can be explained by the determinants included in the model. The second part, the *coefficients effect*, is the part of the gap attributed to unobserved structural determinants.

The decomposition analysis shows that the probability of being stunted for children living in rural areas is mainly explained by the characteristics effect. This suggest that there are significant rural-urban disparities in the level of the socioeconomic determinants of stunting rather than in the nature of the determinants themselves. In other words, the distribution of the determinants plays a significant role in explaining urban-rural disparities in stunting in Colombia. Therefore, if we could give children in rural areas the characteristics of those in urban areas, then most of the gap, exactly 96%, would disappear. This result corroborates the historically observed socioeconomic inequalities between urban and rural areas in Colombia that affect the provision of public goods and services (Ocampo, 2014). Our findings are in line with previous studies for Mozambique (Garrett & Ruel, 1999), Bangladesh and Nepal (Srinivasan et al., 2013), China (Liu et al., 2013), Malawi (Mussa, 2014) and Yemen (Sharaf & Rashad, 2016), which demonstrate that the characteristics effect dominates the coefficients effect in explaining the stunting urban-rural gap.

According to our decomposition analysis, maternal education, household wealth index, antenatal check-ups, and institutional delivery are the most important determinants to bridging the stunting urban-rural gap. Our results are consistent with case country studies (Mussa, 2014; Sharaf & Rashad, 2016). A recent systematic review conducted by Vaivada et al. (2020) shows that, globally, improvements in household's socioeconomic status was a consistent and strong determinant of stunting reduction over time. Case country studies for Ethiopia, Peru, Kyrgyz Republic and Senegal have also showed that parental education, WASH and health services access have contributed for substantially improved child growth (Bhutta et al., 2020).

Regarding the mother's education, our findings coincide with results in previous studies that report significant association between low levels of maternal education

and child growth retardation in rural areas (Fotso, 2006; Jiang et al., 2015; Sohnesen et al., 2017; Srinivasan et al., 2013). We found that increases in education for mothers have different effects on children's stunting probability, depending on whether they are in urban or rural areas. Having access to primary, or more importantly to secondary school, is important for reducing stunting in rural areas. In fact, according to Tenjo and Jaimes (2018) the low returns to education in rural areas in Colombia may inhibit demand for further education. Thus, it seems necessary to create incentives for rural women to finish secondary school. Finishing secondary school in rural areas could be a public policy for the protection of children. Attending secondary school reinforces sexual and reproductive healthy behaviours, proper dietary practices and fosters women empowerment.

We found that access to the health system is also relevant at explaining the gap. Access through antenatal check-ups and institutional delivery of children are important to help to reduce health inequalities in the short run (Osorio et al., 2013; Solar & Irwin, 2010). The under-utilization of these services in rural areas in Colombia, as well as their limited supply (due to geographical barriers and administrative and economic limitations) has been well documented (Osorio et al., 2014; Páez et al., 2013).

This study faces some limitations. First, rural areas are not homogeneous among departments. In fact, due to the survey design, there are no data for rural areas in five departments as explained in the section data. Thus, our findings apply only for non-dispersed rural areas. Second, the construction of the household wealth index focuses on attributes (e.g. piped water, electricity, etc.) that are common in urban areas and that not necessarily in rural areas. Moreover, cultural factors can vary across different ethnic groups in rural areas as well as their connotation of wealth. Therefore, it is probable that the estimated importance of wealth at explaining the gap could change under other measures of wealth or income. Third, some variables are not included in the survey that could explain the urban-rural gap in stunting, such as whether the child had diarrhea and/or fever, child vaccination, or violence and forced displacement of peasants. Therefore, we cannot include them in our study. Finally, we use cross-section data for one period, so therefore we cannot explain changes about the stunting gap over time, nor changes in the importance of the determinants explaining the gap over time.

In terms of public policy implications, our results provide inputs for policies aimed at closing the current urban-rural gap, and in particular at achieving the Sustainable Development Goal (SDG) of reducing stunting among children under 5 years old to 8% by 2020, and to 5% by 2030 (ICBF, 2015). According to our results, improvements in access to education (at least until secondary school), and to the institutional delivery services for mothers in rural areas, are urgent to reduce the urban-rural gap in the short run. In the long run, structural changes making it possible to increase economic wealth in rural areas are still important. Furthermore, we would suggest incorporating children's stunting as a variable to keep track of the urban-rural gap in the National Plan for Rural Development (PNSR for its acronym in Spanish) (MSPS, 2018). This is a national policy that was launched in 2018 as part of the recent Peace Accords between the Colombian Government and the Revolutionary Armed Forces of Colombia (FARC). The aim of the policy is to close the

gap between urban and rural areas. As stated in the introduction, children's stunting is an important variable for understanding development, but it has not yet been included in the PNSR.

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**Code Availability** Not applicable.

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**Data Availability** Data are available upon request from the repository of the Ministry of Health and Social Protection of Colombia.

## Declarations

**Conflict of Interest** The authors declare that they have no conflict of interest.

## References

Bhutta, Z. A., Akseer, N., Keats, E. C., Vaivada, T., Baker, S., Horton, S. E., ... & Black, R. (2020). How countries can reduce child stunting at scale: Lessons from exemplar countries. *The American Journal of Clinical Nutrition, 112*(Supplement_2), 894S-904S.

Blinder, A. S. (1973). Wage discrimination: Reduced form and structural estimates. *The Journal of Human Resources, 8*(4), 436–455.

DANE. (2019). Pobreza Monetaria y Multidimensional en Colombia 2018. In: Estadísticas por tema. https://www.dane.gov.co/index.php/estadisticas-por-tema/pobreza-y-condiciones-de-vida/pobreza-y-desigualdad/pobreza-monetaria-y-multidimensional-en-colombia-2018. Accessed 22 Jul 2020.

De Onis, M., & Branca, F. (2016). Childhood stunting: A global perspective. *Maternal & Child Nutrition, 12*(Suppl 1), 12–26. https://doi.org/10.1111/mcn.12231

DNP (Departamento Nacional De Planeación). (2018). CONPES 3918. Estrategia para la implementación de los Objetivos de Desarrollo Sostenible (ODS) en Colombia. https://observatorioplanificacion.cepal.org/es/modalidades/documento-conpes-3918-estrategia-para-la-implementacion-de-los-objetivos-de-desarrollo. Accessed 22 Jul 2020.

ENSIN. (2015). Encuesta Nacional de Situación Nutricional 2015. In: ENSIN. https://www.icbf.gov.co/bienestar/nutricion/encuesta-nacional-situacion-nutricional. Accessed 14 Mar 2020.

Ervin, P. A., & Bubak, V. (2019). Closing the rural-urban gap in child malnutrition: Evidence from Paraguay, 1997–2012. *Economics and Human Biology, 32*, 1–10.

Flores-Quispe, M. D. P., Restrepo-Méndez, M. C., Maia, M. F. S., et al. (2019). Trends in socioeconomic inequalities in stunting prevalence in Latin America and the Caribbean countries: Differences between quintiles and deciles. *International Journal for Equity in Health, 18*(1), 156. https://doi.org/10.1186/s12939-019-1046-7

Fotso, J. C. (2006). Child health inequities in developing countries: Differences across urban and rural areas. *International Journal for Equity in Health, 5*(1), 9. https://doi.org/10.1186/1475-9276-5-9

Garcia, S., Sarmiento, O. L., Forde, I., & Velasco, T. (2013). Socio-economic inequalities in malnutrition among children and adolescents in Colombia: The role of individual-, household- and

community-level characteristics. *Public Health Nutrition, 16*(9), 1703–1718. https://doi.org/10.1017/S1368980012004090

Garrett, J. L., & Ruel, M. T. (1999). Are determinants of rural and urban food security and nutritional status different? Some Insights from Mozambique. *World Development, 27*(11), 1955–1975.

Ham, J. C., Svejnar, J., & Terrell, K. (1998). Unemployment and the social safety net during transitions to a market economy: Evidence from the Czech and Slovak republics. *American Economic Review, 88*(5), 1117–1142. https://doi.org/10.2139/ssrn.1540887

ICBF (Instituto Colombiano de Bienestar Familiar). (2015). Encuesta Nacional de la Situación Nutricional en Colombia. https://www.icbf.gov.co/sites/default/files/portada-ensin4.jpg. Accessed 22 Jul 2020.

Jiang, Y., Su, X., Wang, C., et al. (2015). Prevalence and risk factors for stunting and severe stunting among children under three years old in mid-western rural areas of China. *Child: Care, Health and Development, 41*(1), 45–51. https://doi.org/10.1111/cch.12148

Larrea, C., & Freire, W. (2002). Social inequality and child malnutrition in four Andean countries. *Revista Panamericana de Salud Publica/Pan American Journal of Public Health, 11*(5/6), 356–364. https://doi.org/10.1590/S1020-49892002000500010

Liu, H., Fang, H., & Zhao, Z. (2013). Urban–rural disparities of child health and nutritional status in China from 1989 to 2006. *Economics and Human Biology, 11*(3), 294–309. https://doi.org/10.1016/j.ehb.2012.04.010

Mena-Meléndez, L. (2020). Ethnoracial child health inequalities in Latin America: Multilevel evidence from Bolivia, Colombia, Guatemala, and Peru. *SSM-Population Health, 12*, 100673.

Menon, P., Ruel, M. T., & Morris, S. S. (2000). Socio-economic differentials in child stunting are consistently larger in urban than in rural areas. *Food and Nutrition Bulletin, 21*(3), 282–289. https://doi.org/10.1177/156482650002100306

MSPS (Ministerio de Salud y Protección Social). (2018). *Plan Nacional de Salud Rural*. Ministerio de Salud y Protección Social.

Mussa, R. (2014). A matching decomposition of the rural–urban difference in malnutrition in Malawi. *Health Economics Review, 4*(1). https://doi.org/10.1186/s13561-014-0011-9

Oaxaca, R. (1973). Male-female wage differentials in urban labor markets. *International Economic Review (Philadelphia), 14*(3), 693–709.

Ocampo, J. A. (2014). *Saldar La Deuda Histórica Con El Campo. Marco conceptual de la Misión para la Transformación del Campo*. Departamento Nacional de Planeación https://www.dnp.gov.co/DNPN/Paginas/default.aspx. Accessed 20 Aug 2020

OECD. (2020.) Global OECD welcomes Colombia as its 37th Member. https://www.oecd.org/colombia/global-oecd-welcomes-colombia-as-its-37th-member.htm. Accessed 22 Jul 2020.

Osorio, A. M., Bolancé, C., & Alcañiz, M. (2013). Measuring intermediary determinants of early childhood health: A composite index comparing colombian departments. *Child Indicators Research, 6*(2), 297–319. https://doi.org/10.1007/s12187-012-9172-4

Osorio, A. M., Tovar, L. M., & Rathmann, K. (2014). Individual and local level factors and antenatal care use in Colombia: A multilevel analysis. *Cadernos De Saude Publica, 30*(5), 1079–1092. https://doi.org/10.1590/0102-311X00073513

Osorio, A. M., Romero, G. A., Bonilla, H., & Aguado, L. F. (2018). Socioeconomic context of the community and chronic child malnutrition in Colombia. *Revista de Saúde Pública, 52*(73). https://doi.org/10.11606/S1518-8787.2018052000394

Paciorek, C. J., Stevens, G. A., Finucane, M. M., Ezzati, M., & Nutrition Impact Model Study Group. (2013). Children's height and weight in rural and urban populations in low-income and middle-income countries: A systematic analysis of population-representative data. *The Lancet Global Health, 1*(5), e300–e309.

Páez, G. N., Jaramillo, L. F., & Franco, C. (2013). *Estudio sobre la geografía sanitaria de Colombia*. Ministerio de Salud y Protección Social https://www.minsalud.gov.co/Documentos%20y%20Publicaciones/Estudio%20sobre%20la%20geograf%C3%ADa%20sanitaria%20de%20Colombia.pdf. Accessed 20 Aug 2020

Paraje, G. (2009). Desnutrición crónica infantil y desigualdad socioeconómica en América Latina y el Caribe. *Revista Cepal*, 43–63. http://hdl.handle.net/11362/11328

Prendergast, A. J., & Humphrey, J. H. (2014). The stunting syndrome in developing countries. *Paediatrics and International Child Health, 34*(4), 250–265. https://doi.org/10.1179/2046905514Y.0000000158

Sharaf, M. F., & Rashad, A. S. (2016). Regional inequalities in child malnutrition in Egypt, Jordan, and Yemen: A Blinder-Oaxaca decomposition analysis. *Health Economics Review, 6*(1). https://doi.org/10.1186/s13561-016-0097-3

Smith, L. C., Ruel, M. T., & Ndiaye, A. (2005). Why is child malnutrition lower in urban than in rural areas? Evidence from 36 developing countries. *World Development, 33*(8), 1285–1305. https://doi.org/10.1016/j.worlddev.2005.03.002

Sohnesen, T. P., Ambel, A. A., Fisker, P., et al. (2017). Small area estimation of child undernutrition in Ethiopian woredas. *PLoS One, 12*(4). https://doi.org/10.1371/journal.pone.0175445

Solar, O., & Irwin, A. (2010). *A conceptual framework for action on the social determinants of health*. WHO https://apps.who.int/iris/handle/10665/44489. Accessed 14 Jan 2018

Srinivasan, C. S., Zanello, G., & Shankar, B. (2013). Rural-urban disparities in child nutrition in Bangladesh and Nepal. *BMC Public Health, 13*(1). https://doi.org/10.1186/1471-2458-13-581

Tenjo, J., & Jaimes, C. A. (2018). Ingresos y educación en el sector rural colombiano. *Revista de Economía Institucional, 20*(38), 209–233. https://doi.org/10.18601/01245996.v20n38.09

United Nations Children's Fund. (1991). Strategy for improved nutrition of children and women in developing countries. *Indian Journal of Pediatrics, 58*, 13–24. https://doi.org/10.1007/BF02810402

UNICEF. (2019). *The state of the World's children 2019. Children, food and nutrition: Growing well in a changing world*. UNICEF https://www.unicef.org/reports/state-of-worlds-children-2019. Accessed 22 Jul 2020

UNICEF. (2020). *Nutrition, for every child: UNICEF nutrition strategy 2020–2030*. UNICEF, United Nations Children's Fund.

UNICEF/WHO/World Bank Group. (2020). Levels and trends in child malnutrition: Key findings of the 2020 Edition of the Joint Child Malnutrition Estimates. http://www.who.int/nutgrowthdb/estimates/en/. Accessed 22 Jul 2020.

Vaivada, T., Akseer, N., Akseer, S., Somaskandan, A., Stefopulos, M., & Bhutta, Z. A. (2020). Stunting in childhood: An overview of global burden, trends, determinants, and drivers of decline. *The American Journal of Clinical Nutrition, 112*(Suppl 2), 777S–791S.

Van de Poel, E., O'Donnell, O., & Van Doorslaer, E. (2007). Are urban children really healthier? Evidence from 47 developing countries. *Social Science & Medicine, 65*(10), 1986–2003. https://doi.org/10.1016/j.socscimed.2007.06.032

Victora, C. G., Adair, L., Fall, C., et al. (2008). Maternal and child undernutrition: Consequences for adult health and human capital. *The Lancet, 371*(9609), 340–357. https://doi.org/10.1016/S0140-6736(07)61692-4

Vilcins, D., Sly, P. D., & Jagals, P. (2018). Environmental risk factors associated with child stunting: A systematic review of the literature. *Annals of Global Health, 84*(4), 551.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT Press.

World Bank Group. (2020). Colombia | Data. In: World Bank data. https://datos.bancomundial.org/pais/colombia. Accessed 22 Jul 2020.

Yun, M.-S. (2004). Decomposing differences in the first moment. *Economics Letters, 82*(2), 275–280. https://doi.org/10.1016/j.econlet.2003.09.008