Small area vulnerability, household food insecurity and child malnutrition in Medellin, Colombia: results from a repeated cross-sectional study

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Summary

Background Malnutrition and food insecurity might be driven not only by individual factors but also by contextual conditions, such as area-level deprivation or vulnerability. This study aimed to analyze the association between area-level vulnerability and *i*) household food insecurity and *ii*) malnutrition in children in Medellin, Colombia, during the years 2017 and 2018.

Methods We obtained data from two different sources: the Living Standards Measurement Survey (LSMS) and the nutrition surveillance system of Medellin. The main outcomes were food insecurity in households with children and anthropometric indicators for children under five. The main predictor was area-level vulnerability. Mixed effects Poisson regression with robust standard errors models were conducted to test the association of quintiles of deprivation with each outcome.

Findings Households with children living in areas with the highest deprivation had 1.9 times the prevalence of food insecurity as compared to those living in areas with the lowest deprivation (PR 1.91, 95% CI 1.42–2.57). Similar results were observed for underweight/risk of underweight (PR 1.26, 95% CI 1.11–1.42), stunting/risk of stunting (PR 1.36, 95% CI 1.22–1.53) and stunting (PR 1.93 95% CI 1.55–2.39) among children under five. We found no consistent associations with wasting/risk of wasting or excess weight/risk of overweight across quintiles of deprivation.

Interpretation This study sheds light on the role of area-level vulnerability on malnutrition in children in Medellin, Colombia, showing a pattern of increasing prevalence of food insecurity, underweight and stunting by quintile of deprivation.

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Keywords: Food insecurity; Malnutrition; Children; Small-area vulnerability; Deprivation; Modes of living

Introduction

Malnutrition, encompassing both under and over-nutrition, impacts more than 1 billion people worldwide.[1] Children under five are vulnerable to its effects, including higher mortality and risk of long-term non-communicable diseases.[2] Malnutrition is driven by

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Research in context

Evidence before this study

We searched PubMed, Scielo, and LILACS for studies examining the association between area-level socio-economic conditions and food insecurity and malnutrition. There are known area-level inequalities in malnutrition in children. However, there are no studies examining these inequalities in food insecurity and malnutrition in large Colombian cities such as Medellin, and very little research examining small-area inequalities in Latin America and the Caribbean. The studies conducted in Colombia have found consistent associations of small-area vulnerability with stunting. Nonetheless, they have used data older than 10 years ago and with limited area-level measures. No study has assessed the association of vulnerability or deprivation with food insecurity at the small area level in Colombia. From the search of similar articles in Latin America, a study focused on intraurban disparities in a Brazilian city showed stronger associations of food insecurity in households living in areas considered at more disadvantage but did not assess vulnerability using a specific area-level measure.

Added value of this study

Using cross-sectional data from administrative records, we investigated the association of small-area vulnerability with food insecurity and malnutrition in children in Medellin, finding a higher prevalence of both types of outcomes in areas with the highest deprivation. Our report is one of the first attempts to analyze this association within a major city in Colombia using a comprehensive area-level measure of vulnerability, adding to the body of knowledge on the role of the small area on nutrition inequalities in Colombia and Latin America and the Caribbean. Our results could be informative for cities with similar characteristics in the region and in other countries in the Global South.

Implications of all the available evidence

Our findings support the existing evidence on the existence of small-area inequalities in malnutrition and highlight the importance of addressing structural contextual factors to reduce inequalities between areas. It also highlights the crucial role of accessing multilevel data at the individual and contextual socio-economic conditions, to achieve a better understanding of the nutritional status of children and for prioritizing public policies that allow achieving health and nutrition equity.

socio-economic conditions,[3] including food systems, family factors, and household and contextual conditions.[4] Households with children exhibit a higher prevalence of food insecurity[5]—defined as lack of adequate physical, social, or economic access to sufficient and nutritious food—which has been associated with under and over-nutrition.[6]

Most studies analyzing the association of socio-economic conditions with food insecurity and malnutrition have been conducted at national, regional, or city levels using individual-level approaches. However, more evidence is cumulating on the potential role of contextual factors.[7] One of the contextual determinants of food insecurity and malnutrition is hypothesized to be area-level deprivation or vulnerability,[8] a raising concern in low- and middle-income countries (LMICs).[9] Increasing urbanization and high levels of inequality in LMICs' cities have created an unequal geographic distribution of food environments, regarding access to food in general and healthy food options in particular, thereby promoting geographical differences in nutritional outcomes.[7]

Medellin, the second largest city in Colombia, exhibits marked differences in living conditions between its administrative subdivisions,[10] which could translate into nutrition inequalities.[11] Associations of parental education and household unsatisfied basic needs with malnutrition in children have been reported in the province of Antioquia[12] (of which Medellin is the capital city), but the role of area-level vulnerability has yet to be explored in the city. Some studies have reported contextual nutritional inequalities at the municipal and regional levels in Colombia, also accounting for household and maternal determinants,[13,14] however, the impact of small area level conditions has not been investigated so far within cities. A few studies have shown small area contextual inequalities in malnutrition, but have used mainly data prior to 2010 and limited area-level measures.[15,16] Even more, to our knowledge, no study has assessed the role of small area contextual conditions on food insecurity in Colombia as for yet and while the association of regional and rural/urban disparities has been documented broadly,[17] few studies have analyzed these associations within cities in Latin America and the Caribbean at the small area level.

Understanding the role of socio-economic conditions on food insecurity and malnutrition at more detailed scales within cities, particularly the role of area vulnerability with a comprehensive area-level measure, is important as it could allow devising targeted interventions in areas with higher needs. We hypothesize that there are spatial differences in malnutrition across administrative units in Medellin, where people living in areas with higher deprivation or vulnerability within the city experience both food insecurity and malnutrition in a higher extent than those living in less deprived areas. Thus, we aimed to analyze the association of area-level vulnerability with food insecurity among households with children and with malnutrition in children under

the age of five, using data from surveys and official registries from Medellin, Colombia, during the years 2017 and 2018.

Methods

Study setting and data sources

We obtained data from two different population sources: the Living Standards Measurement Survey (LSMS) (Encuesta de Calidad de Vida) and the nutrition surveillance system (Sistema de Vigilancia al Estado Nutricional Infantil), both from Medellin. The LSMS is an annual representative survey developed by the planning department of the local administration aiming to assess the different dimensions of welfare and living conditions of the households and individuals of the city through a diverse set of subjects. It has representativeness and geographical coverage for the overall city and for its 21 higher administrative subdivisions (neighborhoods conjunctions for planning purposes, with budget allocation) in both the urban and rural areas. Additional information about the survey may be found in the Supplementary Material (Appendix A). We used the 2017 and 2018 LSMS data for the analyses focusing on food insecurity, and we selected households with children (age < 18) that had complete information on food insecurity, according to the responses of the head of the household.

The nutrition surveillance system is a notification system comprising public and private healthcare centers that follow up the growth and development of children under six years of age in Medellin. Institutions report the nutritional status of children under their jurisdiction resulting from child well-being check-up visits. For the analyses on malnutrition, we included all children aged 0–59 months with complete information on the variables under study, reported by the system for the years 2017 and 2018. The registry had a coverage rate of approximately 70% for 2017 and 2018, based on the number of children of that age in Medellin, as projected by the 2018 census.

The Living Standards Measurement Survey (LSMS) surveyed 9145 and 9240 households in 2017 and 2018, respectively. Our final sample included a total of 7962 households when we only included households with children. There were no households with missing food insecurity data. The Nutrition Surveillance registry gathered data on 98,029 and 103,742 children aged 0–59 months in 2017 and 2018, respectively. Following the exclusion of children who lacked information on the administrative subdivision of residence (2018 (2%) for 2017 and 1703 (1.64%) for 2018), our final sample comprised 96,011 and 102,039 children in 2017 and 2018, respectively.

Outcome measures

Household food insecurity

Household food insecurity was assessed by adapting the Food Insecurity Experience Scale (FIES) proposed by the Food and Agriculture Organization (FAO) Voices of the Hungry project (VoH)[18] from the available food security questions in the LSMS. The questions included in this survey belong to a former version of the Latin American and Caribbean Food Security Scale (ELCSA-2009), which contains 15 questions addressed to households with adults and children (see Table SB1 in the supplementary material). The FIES is a shorter experienced-based psychometric scale that reflects the first questions addressed to adults in the ELCSA, both having almost the same content with the following differences: a shorter time frame (last 30 days in ELCSA-2009), level of analysis (questions framed for the household in ELCSA-2009) and wording (adapted to the local context in ELCSA-2009). The FIES contains 8 dichotomous questions, with a positive answer contributing one point towards a score ranging from 0 to 8 points used to classify the food security status of respondents. Only the first 8 questions from ELCSA-2009 were used for the analysis of food insecurity in the frame of the FIES (see Table SB1 in the supplementary material). The thresholds were defined according to the global standards proposed by the VoH.

Households were classified as being food secure (score of 0), with mild food insecurity (1–4), moderate food insecurity (5–6), and severe food insecurity (7–8). For multivariable analyses, food security was dichotomized as being food secure (score of 0) or experiencing any type of food insecurity (score of 1 or above). Several sensitivity analyses were conducted to assess different thresholds for defining food security. These included assessing moderate or severe food insecurity vs. food security or mild food insecurity based on the above thresholds, as well as using the individual probabilities obtained from Rasch modeling implemented to verify the validity of the scale and to calculate the proportion of moderate and severe food insecurity according to the FIES global standards considering the survey weighting scheme.[19,20] Additional sensitivity analyses were conducted using the ELCSA-2009 with the entire set of questions reported in the survey (see Table SB1 in the supplementary material), including those for households with children and its corresponding thresholds (see Table SB2 in the supplementary material).

Malnutrition in children

Over and undernutrition were assessed through anthropometric indicators categorized using z-scores (see Table SC1 in the supplementary material). Underweight/risk of underweight (weight for age z-score < 1sd), stunting/risk of stunting (height for age z-score < 1sd), wasting/risk of wasting (weight for height z-score < 2sd), and excess weight/risk of overweight (weight for height z-score > 1sd) were classified using the WHO standard reference population and cut off points for children under 60 months (UNICEF/WHO updated recommendations).[21] Children with biologically implausible (extreme values

that could represent errors) z-scores for each outcome were excluded from the respective analysis. Additional analyses were conducted for stunting alone (height for age z-score < 2sd) due to the relatively higher proportion of the outcome overall and by administrative subdivision.

Exposure measures

Social vulnerability index

We developed a comprehensive area-level measure of vulnerability based on the theoretical category of the modes of living from the Latin-American social determination of health perspective. The modes of living—representing the different constitutive dimensions of life—and social vulnerability, are understood as collective patterns shared by groups of people that are driven by power relations and that influence individual lifestyles. Five interrelated dimensions having a reciprocal influence on health and nutrition are proposed.[22]

Data for the index of vulnerability in the modes of living at the higher administrative subdivision level were retrieved from the 2017 LSMS. We selected indicators that were representative of the five dimensions of the modes of living as well as of power relations (axes of inequality) and other vulnerability-related demographics based on a literature review, expert advice, and discussions within the team. As the area-level conditions are not expected to change drastically from one year to the other, only the vulnerability index for the first year (2017) was developed and used for analyses. Principal component analysis (PCA) was selected for index development to include a data-driven approach. Sequential PCAs were carried out until a final set of indicators was selected and the index was constructed following the statistical procedures suggested elsewhere.[23,24] A summary of the index development can be found in the supplementary material (Appendix A).

The final index of vulnerability in the modes of living included 24 indicators based on the first component retrieved from the final PCA, which accounted for 61% of the total variance of the data (Table 1 and Supplementary Table SA1). The initial set of indicators considered in preliminary analysis included, among others, being a victim of a robbery or another violent act, neighborhood safety, self-perception of discrimination against women and community participation, but were excluded after executing the sequential PCA, as they did not contribute meaningfully in relation to other indicators. We extracted index scores for each administrative unit and standardized the index to have a mean of 0 and a standard deviation of 1. Administrative units were then further classified into quintiles of deprivation, with the first and fifth quintiles representing the least and the most deprived, respectively. We conducted exploratory data analysis for the index to explore face validity and found a spatial distribution consistent with the expected socio-economic vulnerability of the city (Supplementary Figure SA1). In order to conduct the analyses with the individual level data, we assigned the corresponding vulnerability index quintile classification of the administrative unit as a new variable in each dataset according to the administrative unit ID where participants lived.

Statistical analysis

To assess the association between area-level vulnerability quintiles and household food insecurity and malnutrition in children, we pooled the information from 2017 to 2018 per type of outcome and used mixed effects Poisson regression models with robust standard errors, with households or children as the first level, and administrative subdivisions as the second level. Three types of models were developed for each case: 1) a model with the vulnerability index as the only predictor, 2) a model further adjusted for age and sex, and 3) a model additionally adjusted for the area of residence (urban vs. rural). Time-varying age was categorized into five periods of 12 months for the analyses of malnutrition in children and three categories for those of food insecurity (<25, 25–59, >60 years). A fourth model additionally adjusted for individual-level socio-economic position was developed only for food insecurity, considering two variables: education (higher education, secondary education, and primary education or less) and occupational class of the head of the household (director–qualified formal worker, independent worker, lower occupational class workers and without occupation), as the data from the nutritional surveillance system did not contain such information (Supplementary Tables SB5–SB7). Models for children also included the year as a fixed effect variable due to a lack of unique identifiers in the data and children being likely to be the same across the years. Additional analyses for food insecurity including the predicted probabilities from Rasch modeling were conducted using multilevel Tobit models following the same strategy as the data presented left censoring. Analyses were carried out using R version 4.0.3 and STATA version 14.0 (StataCorp, College Station, TX, USA).

Role of the funding source

The funders had no role in the study design, analysis, decision to publish, or preparation of this manuscript.

Results

In our pooled sample, 63% of households with children had any indication of food insecurity (Supplementary Table SB4). The proportion of nutritional outcomes in children under five ranged from 10% (wasting/risk of wasting) to 32% (stunting/risk of stunting) depending on the outcome (Supplementary Table SC3). Demographic characteristics and a summary of the outcomes per data source are reported in the supplementary material (Tables SB3 and SB4 and SC2 and SC3).

Theoretical dimension	Indicator[h]
Axes of Inequality	Working class in precariousness[a]
	Ethnic communities (Afro-Colombian, Indigenous, and Rom communities)
Ecosystem relations[i]	Negative perception of the quality of streets and sidewalks
	Overcrowding
	Cooking with potentially dangerous sources
	Dwelling affected by environmental phenomena[b]
	Lack of adequate sewage
	Long commute to work
Organization and supports	Low trust in organizations and public institutions
	Problems of neighborhood coexistence
	Low community participation
	Negative perception of freedom of expression
Culture and spiritual means	Low participation in cultural activities
Consumption	Lack of basic supplies[c]
	Digital divide[d]
	School lag (backwardness)[e]
	Illiteracy[e]
	House beneficial owner or de facto occupant
	Lack of car or motorcycle ownership
Work	Lack of social security[f]
	Unemployed in the labor force
	Underemployment[g]
Vulnerability related demographics	Population younger than 18 years
	Population older than 65 years

[a]Non-qualified workers, workers without remuneration, and people recognized as informal workers. [b]Any of the following: floods, avalanches, landslide, land subsidence, faults or fires. Self-reported by household informant. [c]Defined as lacking at least one of the following: fridge, stove, or washing machine. [d]Defined as households without internet connection, or with internet connection but without computer/mobile phone. [e]Calculated for the household (at least one member of the household with the deprivation measure, for school lag at least one school-age child). [f]Defined as lacking pension scheme and occupational risk insurance. [g]Invisible underemployment, defined as the desire to change the current job. [h]Indicators refer to the proportion of the population at the administrative unit level. [i]The original framework refers to this dimension as "Metabolic relations (ecosystem)" and was adapted here for clarity purposes.

Table 1: **Dimensions of the index of vulnerability in the modes of living and its constitutive indicators.**

Association between area vulnerability and food insecurity and malnutrition

In the age and sex-adjusted model, households classified in the highest quintile of deprivation had 1.9 times the prevalence of food insecurity compared to those in the least deprived quintile (PR 1.91, 95% CI 1.42–2.57) (Fig. 1 and Supplementary Table SB5). The link between deprivation and food insecurity was stronger when comparing moderate and severe food insecurity to food security or mild food insecurity (PR 3.18, 95% CI 1.71–5.94)—(Fig. 1 and Supplementary Table SB5). Similar results were also observed in sensitivity analyses using the food insecurity thresholds of the Latin American and Caribbean Food Security Scale (ELCSA-2009), as well as when modelling the individual probabilities of moderate or severe food insecurity with Tobit models (Supplementary Tables SB6 and SB7).

We found associations of area-level vulnerability with underweight/risk of underweight after adjusting for age and sex, with children living in areas within the most deprived quintile having 1.3 times the prevalence of underweight compared to those living in the least deprived quintile (PR 1.26, 95% CI 1.11–1.42). When looking at wasting and excess weight the association was less clear, with those children belonging to the most deprived quintile being less likely to be in excess weight/risk of overweight (PR 0.92, 95% CI 0.88–0.97) and we found no association for wasting/risk of wasting (PR 1.06, 95% CI 0.97–1.16). When looking at stunting/risk of stunting, there was also an association with area-level vulnerability, with those in the most deprived quintile having 1.4 times the prevalence of stunting/risk of stunting compared to those in the least deprived quintile (PR 1.36, 95% CI 1.22–1.53). When analyzing data for stunting alone, a similar gradient but a relatively stronger association was observed (PR 1.93 95% CI 1.55–2.39) (Fig. 2 and Supplementary Table SC4).

Discussion

In this study exploring the association between small area vulnerability and food insecurity and malnutrition in children in Medellin, Colombia, we showed, first, that households with children living in areas with the highest deprivation had almost two times the prevalence of food insecurity as compared to those living in areas with

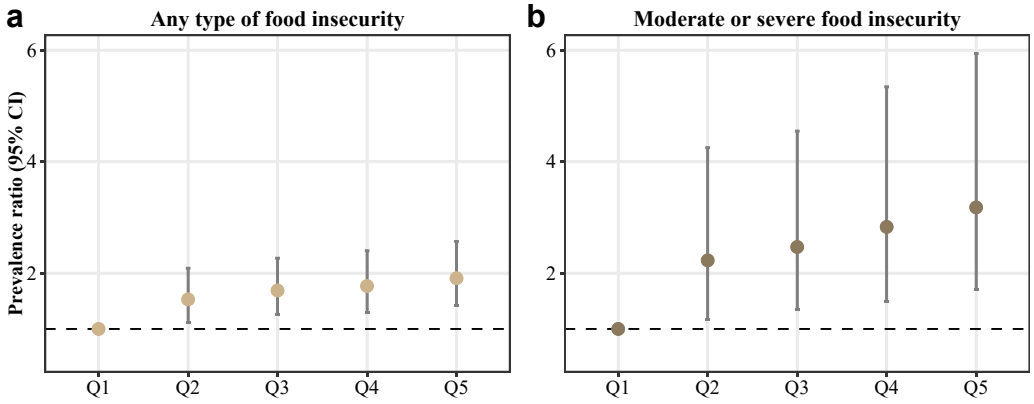

Fig. 1: **Prevalence ratios (95% CI) for (a) Any type of food insecurity and (b) Moderate or severe food insecurity, associated with area level quintile of deprivation in households with children, according to the Food Insecurity Experience Scale (FIES).** Results obtained from the age and sex-adjusted Poisson regression model. The dashed line represents no association.

the lowest deprivation. This association was robust to the selection of food insecurity scales and thresholds. Second, we observed that children living in areas with the highest level of deprivation had 1.3–1.9 times the prevalence of underweight/risk of underweight, or stunting, respectively, as compared to those living in the areas with the lowest levels of deprivation. We found no consistent associations between area vulnerability and wasting/risk of wasting or excess weight/risk of overweight.

When looking at food insecurity in households with children, we found a dose-response pattern, with a

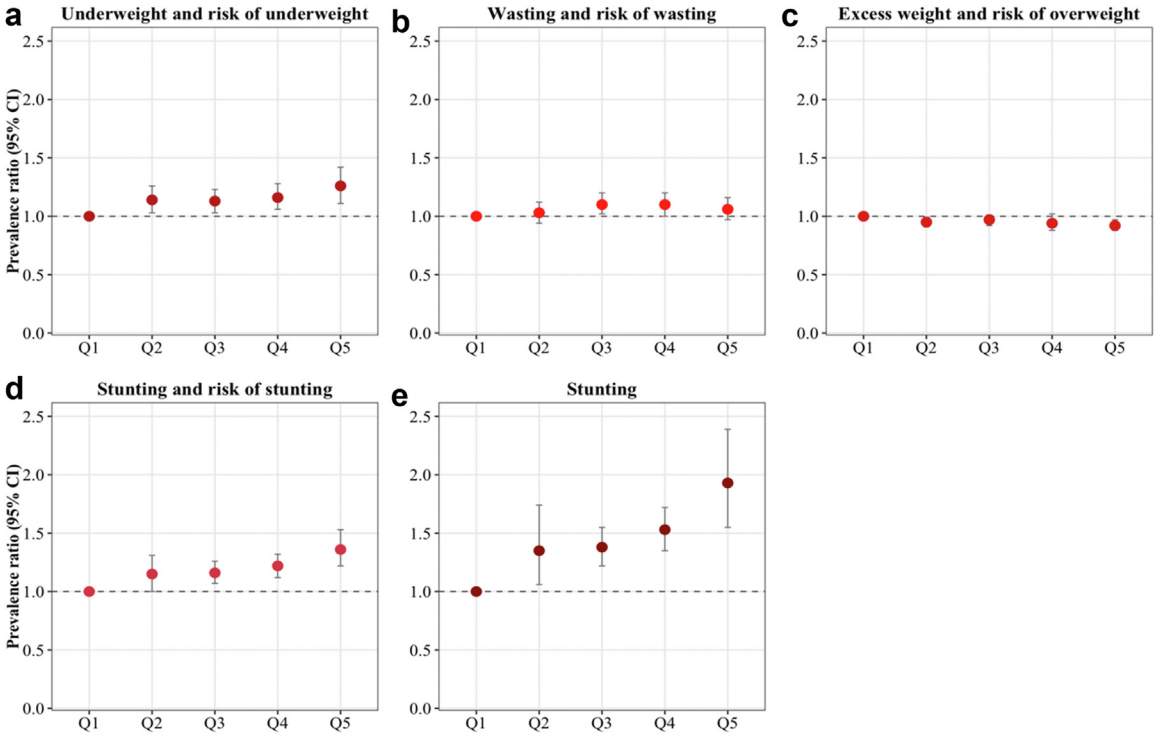

Fig. 2: **Prevalence ratios (95% CI) of (a) Underweight and risk of underweight, (b) Wasting and risk of wasting, (c) Excess weight and risk of overweight, (d) Stunting and risk of stunting, and (e) Stunting (without risk), associated with area level quintile of deprivation.** Results obtained from the age and sex-adjusted Poisson regression model. The dashed line represents no association. In some cases, the confidence intervals may not be visible because they are too narrow (e.g., Excess weight).

stronger association as the level of vulnerability increased, with our study being the first to report this association at the small area level in Colombia. These results are in line with a study conducted in the city of Salvador, Brazil, that found stronger associations of food insecurity in households living in areas with more disadvantaged conditions,[25] and reports from North America finding similar results.[8,26] Households with children have been shown to have a higher prevalence of food insecurity[5,27] which might make them more vulnerable to their contextual conditions and calls for attention for a closer assessment of this association.

When looking at malnutrition in children under five years of age, a higher prevalence of undernutrition was observed in areas classified as the most deprived. Although we did not find a clear association with wasting, which could be related to improved surveillance and political commitment to reduce this outcome at the national and local levels, we found a strong association of area-level vulnerability with stunting. A more evident pattern of area-level vulnerability with stunting rather than with underweight or wasting in children under five could be explained by the chronicity characterizing this status, which may have been more difficult to reverse by recent policies, also because of its origins in early life/pre-conception.[28] Additional analyses considering other age groups, especially school age children and adolescents, as well as disaggregated analysis by sex, would be necessary to have a complete picture of the spatial distribution of nutrition inequalities in children within the city.

We found a similar pattern of area-level vulnerability with food insecurity in households with children and with stunting in children under five, suggesting that those children that live in more vulnerable areas have higher chances of experiencing food insecurity and having poorer childhood development as well. Although we did not study this association directly, other studies have found such a link in preschool children.[29,30] Stunted children are prone to grow into adults with lower chances to thrive in education and work,[31] therefore, they have less chance to get out of the vicious cycle of inequity. This should emphasize the importance of addressing food insecurity through policies in Colombian and Latin American cities, as it represents an opportunity to achieve health equity. Further research measuring the effect of area-level vulnerability on stunting is warranted, especially where the role of the intermediate pathways of food insecurity, and individual-level socio-economic conditions can be assessed.

Our results are also in line with the few studies focusing on the effect of small area contextual vulnerability on nutritional outcomes in Colombia, with findings showing a consistent pattern concerning stunting in children under five. Osorio et al. found that the average level of wealth had a negative association with stunting after adjusting for other individual and household characteristics.[15] Likewise, García et al. found a negative association of access to sanitation with stunting in children under five.[16] Osorio et al. also found a positive significant influence of the mean years of mother's education at the community level with the height for age z-score, after adjusting for other characteristics.[32]

The relationship between area vulnerability and food insecurity and malnutrition is complex and requires further investigations. Housing costs, a lack of resources and food, lower levels of health literacy and nutritional information, and barriers to accessing healthcare and healthy food options may lead to food insecurity, while the environmental conditions in which people live may also expose children to health hazards, altogether leading to constant malnutrition.[7,26,33] Conversely, people experiencing food insecurity, poor health and nutrition might face barriers in access to education and job opportunities, in turn increasing their need to live in more deprived but more affordable areas. Access to food and food choices at the local level are also heavily conditioned by economic and trade policies[34] that influence food sovereignty,[35] leaving the most vulnerable in society having to adapt to the most deprived food environments. Further research aiming to disentangle macroeconomic and structural mechanisms is needed to better identify potential interventions at the public policy level.

We also found that those children living in the most deprived areas were less likely to be in excess weight which is also in line with other studies showing a higher prevalence of child overweight among those with better socio-economic conditions.[36] This might be related to the current stage of the nutritional transition in Colombia,[13,37] being experienced differently across socio-economic groups, as suggested by system dynamic models.[38] Further analyses are needed to elucidate this relationship in Medellin and other cities at the sub-city level.

Strengths of our study include the large sample size using official registries and representative surveys of the city, the use of more recent data compared to previous studies in Colombia, and the development of analyses at the sub-city level. Another important strength of our research is the use of a comprehensive measure for assessing area vulnerability. Our index is one of the few attempts to consider area-level vulnerability from alternative theoretical perspectives in Colombia. It highlights the importance of considering the different constitutive dimensions of life as an interrelated continuum and brings into the discussion the importance of assessing indicators that have not been traditionally considered and that provide a more comprehensive picture of the vulnerability, as experienced at the local level.

Our study also has some limitations. First, the scale at which analyses were developed is large and might

hide a high heterogeneity of subunits (neighborhoods). Nonetheless this is the level at which the planning processes are currently done in the city and results are relevant for policy planning and intervention at this level. Second, as we have developed a new measure of vulnerability, some issues of comparability with other studies may arise. Nevertheless, to the best of our knowledge, no other study published in indexed journals has looked at health or nutrition inequalities using any of these measures within the city. Additionally, as stated previously, our index is one of the few attempts to try to approach vulnerability from alternative theoretical perspectives highlighting the importance of the specific context,[39] that we consider necessary in order to better explain and study nutrition and health inequalities in the country and the region. However, several domains and/or indicators that could influence area level vulnerability might not be captured entirely with the data used, such as the case of violence and conflict, and further analyses with more objective data could be required to have a more complete picture of the situation. Nevertheless, this data has been the one extensively used to report the living conditions in the city and may approximate, at least partly, several of the phenomena that encompass vulnerability.

Third, specific limitations arise when using secondary data. For the analysis of malnutrition, the nutrition surveillance system of the city does not make public other individual data related to the health status or socioeconomic conditions of children, including among others information about maternal nutrition, weight at birth and ethnicity, limiting our ability to develop more complex models that could have helped to understand mechanisms at different levels as well as the independent effects of area-level factors. We also relied on the anthropometric data reported into the system, that is often done by qualified nurses or medical doctors, but not by trained nutrition professionals and with the same calibration of instruments, which could have led to measurement error, especially considering the biologically implausible values. Nevertheless, the proportion of children with implausible values was small (<0.5%) and we excluded them from the analyses as it seemed unlikely to have biased the estimates (Supplementary Table SC3).

Additionally, even though this is a population-based registry with a fair coverage rate, not all the children are reported within the system, as some children may go to private practitioners that are not obliged to issue a report. This is particularly the case for the most affluent administrative unit of the city, possibly leading to some bias in the reporting process and representativeness of the data. Nonetheless, we partly overcome this issue when pooling together several administrative units into the same quintile category. Also, some children had missing data about their administrative unit of residence, limiting our ability to include them in the analyses. Those children might belong to vulnerable population groups, such as migrant or homeless populations, possibly underestimating the prevalence of outcomes, although reporting error might not be excluded. Due to the restricted information available in the dataset we did not consider it appropriate to impute this data. Nevertheless, the proportion of missing values was relatively small (≤2%), and might have not significantly affected our results.

For the analysis of food insecurity, we used data from the local LSMS that is not explicitly intended for measuring food security and much of its information is self-reported, which could have led to social desirability bias. Also, the original questions to measure food security in the survey belong to the ELCSA-2009, which was later revised and adapted for further use in 2012. As the questions of the FIES are equivalent to this scale, we used the FIES approach allowing us to have comparable results with other studies. We found similar results when using the ELCSA-2009. Although this survey is representative of dwellings across administrative units of the city, the sampling procedure does not consider the type of household, and the households with children selected might not necessarily represent all households in the city. Nonetheless, the sampling procedure is random and the proportion of households with and without children has been constant throughout the years (results not shown), which could be a good reflection of the household composition in the city. Also, most of the studies analyzing food insecurity have used data from surveys representative of the general population, such as in our case. Developing specific studies considering households with children are encouraged for a better representation of the situation, as stated previously. Finally, although controlling for individual level socioeconomic factors is not always advisable or appropriate,[40] we conducted sensitivity analyses adjusting by individual level socio-economic position and found similar results to those presented in the main analyses (Supplementary Tables SB5–SB7). Further analyses exploring the possible intermediate effect of individual level socio-economic conditions on food insecurity might be needed for a better understanding of the mechanisms behind this association.

Malnutrition has a negative impact on human capital,[41] food insecurity, and socio-economic conditions have been repeatedly shown as major contributors of malnutrition. In turn, children are more vulnerable to its effects, with increasing evidence pointing to the role of contextual mechanisms on food-related outcomes.[42,43] Although we cannot make a causal claim due to the cross-sectional nature of our data, our study sheds light on the role of small-area vulnerability in influencing food insecurity and malnutrition in children in Medellin, with our findings showing a pattern by quintile of deprivation with those in the most deprived quintile exhibiting the strongest association on the assessed

outcomes. Our results could be informative to several cities in Latin America and the Caribbean with similar characteristics to those of Medellin, a large metropolitan area with more than 2 million inhabitants and a mixed urban and rural composition.

National, provincial and municipal level differences in nutritional outcomes have been shown within Colombia,[13,14,16] with our study exhibiting similar differences within one of its largest cities. We urge policy planners and researchers to look further into the distribution of nutritional inequalities within cities, where actionable strategies can be implemented. This could be even crucial in a historical moment where the COVID-19 pandemic and the global economic situation might have worsened the living conditions and food insecurity for those most in need.

Although we used more recent data and singularly complement previous studies in Colombia, it may not be reflective of the current situation. We encourage the public administration to update and enrich publicly available data, within data protection limits, in an effort to allow more accurate representations of the current situation. This may include, among others, reporting disaggregated data by year and information about ethnicity, weight at birth, overall health status of the child and maternal nutrition, as well as some other basic information about socio-economic conditions such as the level of education of the parent or guardian. Collecting and reporting data at more granular levels, such as the neighborhood or census sector, would also be important to have a better picture of the situation and promote possible targeted interventions. Additionally, more concrete information about the data available in the public repository website, including the explanation of the sampling procedure or details about the development of the LSMS (Encuesta de Calidad de Vida) for each year, as well as further details about the Nutrition surveillance system would be of great interest to better plan and conduct future research.

Improving the environment in which children grow up in Medellin is essential for tackling long-lasting inequalities between areas. Policymakers should pay close attention and act upon the modes of living and the structural determinants of nutrition. Complete and accessible reporting, including data on the individual and contextual socio-economic conditions, is also crucial for having a better picture of the nutritional status of children and prioritizing public policies that allow for achieving health and nutrition equity.

Contributors

H-AS-R, SS, UB and G-JO-C conceived the study. H-AS-R and G-JO-C checked and requested data when necessary. H-AS-R conducted statistical analyses and drafted the first version of the manuscript with support from UB and SS. HMQ, GJ-O-C and SJ contributed to the interpretation of findings. All authors reviewed and approved the final manuscript.

Data sharing statement

For this study, we accessed public databases from the open data portal of the city of Medellin (MEDATA), which are available on the municipality website. The scripts used to perform the analysis will be available upon reasonable request to the corresponding author.

Editor's note

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Declaration of interests

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2023.100521.

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