City features related to obesity in preschool children: a cross-sectional analysis of 159 cities in six Latin American countries

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Summary

Background Childhood obesity is a rising global health problem. The rapid urbanization experienced in Latin America might impact childhood obesity through different pathways involving urban built and social features of cities. We aimed to evaluate the association between built and social environment features of cities and childhood obesity across countries and cities in Latin America.

Methods Cross-sectional analysis of data from 20,040 children aged 1–5 years living in 159 large cities in six Latin American countries. We used individual-level anthropometric data for excess weight (overweight or obesity) from health surveys that could be linked to city-level data. City and sub-city level exposures included the social environment (living conditions, service provision and educational attainment) and the built environment (fragmentation, isolation, presence of mass transit, population density, intersection density and percent greenness). Multi-level logistic models were used to explore associations between city features and excess weight, adjusting for age, sex, and head of household education.

Findings The overall prevalence of excess weight among preschool children was 8% but varied substantially between and within countries, ranging from 4% to 25%. Our analysis showed that 97% of the variability was between individuals within sub-city units and around 3% of the variance in z-scores of weight for height was explained by the city and sub-city levels. At the city-level, a higher distance between urban patches (isolation, per 1 SD increase) was associated with lower odds of excess weight (OR 0.90, 95% CI 0.82–0.99). Higher sub-city education was also associated with lower odds of excess weight, but better sub-city living conditions were associated with higher odds of excess weight.

Interpretation Built and social environment features are related to excess weight in preschool children. Our evidence from a wide range of large Latin American cities suggests that urban health interventions may be suitable alternatives towards attaining the goal of reducing excess weight early in the life course.

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Keywords: Childhood obesity; Nutrition; Urban health; Residence characteristics

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Research in context

Evidence before this study
Several world regions are becoming more urbanized, a process which is occurring at a faster pace than the urbanization experienced by high-income settings. In addition, childhood and adolescent obesity is a well-recognized public health problem. The association between the built and social environment and health outcomes is well-established, particularly in adult populations, yet the evidence remains limited for the younger populations. Before commencing this study, in 2018, we searched PubMed and Google Scholar for studies published in English and Spanish and found that the relationship between some city features, such as walkability, and childhood or adolescent obesity had been evaluated in high-income settings, mainly in the US, Canada, and some European cities, but not thoroughly studied in Latin America.

Added value of this study
The Latin American region has experienced rapid urbanization and exhibits profound socioeconomic inequalities, and childhood and adolescent obesity is a public health concern. Using data derived from nationally representative surveys and combining it with unique city- and sub-city-level exposures, we were able to study excess weight in pre-school children benefiting from a wide range in the prevalence of this outcome across 159 cities from 6 different countries.
Most of the variability in individual-level weight z-scores was between individuals within sub-cities. However, approximately 3% of the variability observed in excess weight among preschool children was between sub-cities and cities. A key insight of these findings is not that one value is lower than the other but, rather, given the city-level analysis, the interpretation is also at the city-level, further indicating that features of the cities can be targeted to counter childhood obesity. Our analysis also found that both built and social environment features were associated with excess weight in children.

Implications of all the available evidence
We found that better living conditions and better population educational attainment were associated with higher and lower odds of excess weight, respectively, and independently from each other. These findings are helpful to capture the potential role different constructs of the urban environment may have in preventing or countering childhood obesity. Therefore, city-wide interventions oriented to prevent or revert excess weight in children may be useful to counter the burden of obesity, with practical implications for urban planning and public health prevention efforts.

Introduction
In 2016, almost 41 million preschool children worldwide were overweight[1]; of these approximately 3.8 million lived in Latin America. With an estimated global prevalence of 9.1% in 2020,[2] preschool overweight and obesity are considered global public health challenges[1,3,4] not only because of the negative consequences obesity has on children's wellbeing but also because of the increased risk of cardiovascular disease and predisposition to other non-communicable diseases over the life course.[4,5]

Preschool children are experiencing a rapid increase in obesity,[6] with prevalence reaching as high as 10% in some Latin American countries.[7] Tackling excess weight in the preschool stage is essential as young children develop habits, including lifestyle and dietary behaviours, which may perpetuate or worsen over their life course. Some factors such as insufficient sleep and inadequate monitoring and control of child weight by parents have been associated with a higher risk of preschool obesity.[8]

In addition to individual behaviours, the environment also plays a determinant role in the burden of childhood obesity, and some prevention strategies have focused on the food environment, most commonly targeting the reduction of junk food and sugar-sweetened items.[9,10] Yet, other aspects of the urban built and social environment also influence excess weight in children. Studies conducted mostly in the US suggest that city features that promote physical activity such as higher density of parks, increased vegetation, higher residential density, availability of walking and biking facilities, and low crime are associated with lower BMI in children ages 4–18 years.[11–13]

As for the social environment, obesity has a clear socioeconomic pattern,[14] and higher neighborhood deprivation has been associated with higher obesity prevalence in children in high income countries.[15–17] This could be explained by the interrelated and possibly synergistic effects of the social environment with individual-, household-, and area-level socioeconomic characteristics. For example, low household income may place families in areas where low levels of education are predominant and access to healthy foods and to facilities and venues that promote safe mobility and exercise activities are limited.[15]

The extent to which built and social environment variables are associated with overweight or obesity among preschool children has not been extensively studied, despite the potential that city-level interventions could offer to reduce the burden of obesity at a stage in life where behavioral habits relating to nutrition and mobility are constituted. This becomes particularly relevant in Latin America, where a nutritional transition has been occurring in cities, compounded by rapid urbanization and great socioeconomic inequalities, thus contributing to a double burden of obesity and malnutrition.

A recent systematic review assessing built environment as a determinant of childhood obesity, found that from 19 studies assessing walkability, only one was conducted in a LMIC and none in Latin America.[18] Context-specific studies are important to disentangle the complex relationship between city features and health outcomes. As an example, a study assessing the association of travel time by car and obesity in adults in Latin America found associations different than those expected based on work in high income settings. The authors suggested that the complexity of the setting, high inequality and rapid urbanization, can influence this association.[19] Although early childhood has been highlighted as the best opportunity for obesity prevention,[20,21] little information is available on city-level interventions,[21] which constitutes a missed opportunity to reduce obesity burden. Therefore, studies assessing the role of built and social environment in obesity in LMIC settings, specially of preschool children are needed.

In this study, we aim to examine the association of features of the built and social environment with excess weight in pre-school children by using city and sub-city level data from almost 160 cities in six Latin American countries. The availability of disaggregated data allows a deeper understanding of the childhood obesity burden by socioeconomic markers between and within cities which could be informative in the design of local strategies aimed at improving population health from a life course perspective. Latin America offers a unique context to study the links between the urban environment and its impact on children's health, including preschool age children. Latin America has rapidly become one of the most urbanized regions of the world,[22] with 81% of its population living in urban areas as of 2018, and is also experiencing a nutritional transition and now faces a double burden of malnutrition.[7,23,24] The socioeconomic inequities present in the Latin American region could provide more granular insights in terms of the childhood obesity burden by socioeconomic markers within cities.

Methods

Study design and participants

This is a cross-sectional multilevel analysis using individual- and contextual-level data. We used data from the SALURBAL project ("*Salud Urbana en America Latina*", Urban Health in Latin America), which has compiled and harmonized health, social, and built-environment data from 371 cities (population ≥100,000 in 2010) in eleven countries.[25] Each city is composed of one or more administrative sub-units (i.e., *municipios*, *comunas*, *distritos*, *partidos*, *delegaciones*, *cantones* or *corregimientos*) that we refer to as sub-cities. We included individual level data from national health surveys that had height and weight measures available for children between 1 and 5 years with the possibility to disaggregate data to be linked to SALURBAL city and sub-city units.[25] We included data from a total of 20,040 children aged 1–5 years from six countries (Chile, Colombia, Guatemala, El Salvador, Mexico, and Peru) who lived in 159 Latin American cities (6 in Chile, 35 in Colombia, 1 in Guatemala, 3 in El Salvador, 91 in Mexico and 23 in Peru) and 509 sub-cities (41 in Chile, 67 in Colombia, 1 in Guatemala, 21 in El Salvador, 243 in Mexico, and 136 in Peru) (Supplementary Table S1). The methods for the selection of surveys and its flowchart are described in the Appendixes (see Supplementary Fig. S1).

Outcome

Our primary outcome was excess weight (overweight and obesity) in children aged 1–5 years. To calculate weight for height z-scores (WHZ) for each child, we used measures of weight and length/height from national health surveys. These measures were collected following a standardized procedure. We used the WHO Child Growth Standards and categorized z-scores as follows: underweight (z-score < −2), normal (z-score between −2 and 2), and overweight and obesity were combined (z-score > 2).[26] Normal weight was used as the reference category and children with underweight were excluded from the analyses (n = 174).

The WHZ data used to create the obesity categories was obtained for children aged 1–5 and the data was harmonized using the World Health Organization (WHO) programs for child anthropometry (WHO Anthro). The program flags extreme values (in relation with the distribution of the data) based on extremely low or high value (<−5 or >5).[27]

Exposures

We characterized the urban environment in Latin American cities by including indicators of built and social environment at the city and sub-city levels. Supplementary Table S2 shows definitions and methodological approaches used to create these indicators, and below we describe how these variables were measured followed by our study hypotheses.

Built environment

Built environment refers to the constructed parts of the city including streets and buildings, many of them that become visible as aggregate units or urban patches. The built environment has different features that can be associated with mobilization through the city.

For the present study, we used characteristics of the built environment based on the distribution of urban patches. For SALURBAL, an urban patch is defined as a contiguous area of urban development, and they represent "pieces" of the sub-city and cities.

At the city-level, we explored three built environment features, i.e., fragmentation, isolation, and presence of a mass transit system. Fragmentation refers to the discontinuation of the urban tissue and it is measured by the number of urban patches per km^2. Higher fragmentation of the built-up area is associated with lower walking and higher obesity prevalence.[28] Isolation refers to distance between the urban patches is defined as the mean distance in meters to the nearest urban patch, and people living in less isolated areas are more prone to walking.[29,30] Presence of a mass transit system can facilitate the mobilization around the city.

We hypothesized that those children who live in cities whose urban patches are more fragmented and more isolated will have less access to mass transit and will have greater travel time to access to services, turning into barriers to access healthy food, healthcare, and education due to the need to either move longer distances or invest longer travel times. As an example, longer time to commute to healthcare might prevent families from regular attendance to appointments or doing so less frequently than those who live closer to healthcare services, which in turn can limit their access to opportunities for health promotion and prevention activities.

At the sub-city level, we considered different built environment features related to walkability,[28] including population density, intersection density, and area greenness, since walkability is a characteristic of the environment that can promote physical activity and reduce risk of excess weight.

Population density is measured as population per km^2 of all the built-up area inside the geographic boundary of the sub-city, and higher population density is associated with higher walkability.[30] Intersection density refers to the connectivity between the streets. It is measured as the number of intersections per km^2. Higher intersection density is associated with a higher likelihood of walking and physical activity.[29,30] Percent of greenness is defined as the zonal median of annual maximum Normalized Difference Vegetation Index (NDVI) of all land areas excluding water. This variable is related to the presence of green areas such as parks which represent opportunities for people to be active. This variable has been associated with lower excess weight and diabetes among adults in different countries.[31–33]

We hypothesized that higher population density, intersection density and green spaces, city features related to walkability, support physical activity, and will positively affect active transportation, e.g., walking of parents and children, as well as their opportunities to engage with recreational physical activity, leading to higher levels of physical activity which are in turn associated with lower excess weight.

Social environment

We characterized the social environment by including three scores: living conditions, service provision, and population educational attainment. We chose to use these scores at the sub-city level as they were associated with other infant health outcomes in previous work.[34] The scores are defined in Supplementary Table S2.

Briefly, living conditions is a score that includes the percentage of households with piped water inside the dwelling; the percentage of households with overcrowding (defined as more than 3 people per room, excluding kitchen and bathroom); and the percentage of population aged 15–17 attending school. The higher the score, the better living conditions there are in the city. Service provision is a score that considers the proportion of households with water from a public network (cube) and the proportion of households with sewage systems connected to a municipal public or private sewage network. The higher the score, the better service provision there is in the city. Population educational attainment is a score that includes the percentage of population age 25 or above that has completed high school level or above, and the percentage of population age 25 or above that completed university level or above. The higher the score, the better educational attainment at the city level.

We hypothesize that people who live in socioeconomically disadvantaged areas with lower socioeconomic position might have both lower household income and less (physical) access to healthy food options, constraining healthy food options in very early stages in life.[35] At the household level, poor water and sanitation conditions can impede safe food preparation. Additionally, limited access to household goods such as refrigerators prevent adequate fresh food storage, leading to greater reliance on shelf-stable packaged products and sugar sweetened beverages. In addition, families living in disadvantaged areas might experience barriers to accessing healthcare facilities, which could reduce the frequency of contact with health care providers to monitor child's growth, missing opportunities for health promotion and early detection of obesity risk. Moreover, socioeconomically disadvantaged areas may have limited access to safe environments for outdoor playing and physical activity. Finally, at the individual-level, inadequate eating behaviors related to deprivation have been proposed as other mechanism in childhood obesity,[16,36] and lower levels of maternal education might influence the dietary choices made for families and young children in particular, for whom food choices depend on adult decisions.[15]

Other variables

We included child individual-level characteristics, such as age and sex, and education of head of household as a proxy of household socioeconomic status. These variables were retrieved from the included surveys and harmonized as follows: age was converted to months and education level was harmonized using the Integrated Public Use Microdata Series (IPUMS) harmonization definitions representing the highest level of education completed (less than primary, primary, secondary, and university or higher).[37]

Statistical analysis

We used descriptive statistics to characterize the sample. We derived the prevalence of overweight and obesity for each city using a logistic model and presented the model-based prevalence among survey respondents living in SALURBAL cities.

To estimate the intra-class correlation coefficients, we first fitted a linear multilevel regression model with the outcome as continuous z-scores, adjusted for individual age, gender, and household education level and country fixed effects including city and sub-city random intercepts.

To assess the association between the different built and social environment features with the odds of overweight/obesity we fitted logistic multilevel regression models and incorporated city features in the following sequence: *model 1*: all built environment variables, *model 2*: social environment variables, and *model 3*: both built and social environment variables.

All the analyses were conducted using Stata Version 16 (Stata Corp, College Station, TX, USA).

Role of the funding source

The funder had no role in study design, data collection, data analysis, interpretation, writing of the report.

Results

Overweight and obesity in urban Latin American preschool children

Table 1 describes the individual and city level characteristics of participants by weight for height categories excluding underweight. The number of children varied per country, ranging from 256 in Guatemala to 6814 in Peru, and the median number of children per city was 110, interquartile range (IQR): 39–230. Overall, 49.1% (9842/20040) were male, and 17.5% (3474/20040) lived in a household where the head had less than primary education level. The median z-score for WHZ was 0.4 (IQR: −0.2 to 1.1) and most of the children (92.1%, 18450/20040) were within the normal z-score range.

The model-based prevalence of overweight and obesity among survey respondents living in SALURBAL cities and countries ranged from 4% to 25%. Cities with the highest prevalence of childhood excess weight were found in Chile and the lowest in some cities in Colombia and Peru (Fig. 1). When partitioning variance in the continuous Z scores we found that most of the variance (97%) was found between individuals within sub-city areas. However, city and sub-city levels explained 1.1% and 1.8% of the variance, respectively.

Associations between the built and social environment with excess weight in urban Latin American preschool children

When compared to normal weight children in a bivariate analysis, children with excess weight were more frequently found in cities with higher fragmentation and lower isolation, and in sub-cities characterized by lower population educational attainment, lower population density, higher intersection density and lower percent of greenness (Table 1). However, to assess these associations properly, we present the regression models.

For the urban built environment, we found that a 1-SD higher isolation at city-level was significantly associated with 10% lower odds of excess weight (OR 0.90, 95% CI 0.82, 0.99) after accounting for individual and country level variables (Table 2, *model 1*). This association did not change when additional features of the built and social environment were included (*model 3*). The association with fragmentation was in the expected direction (higher fragmentation, higher odds of excess weight) but confidence intervals were wide. Other characteristics of the built environment including presence of mass transit, population density, intersection density and percent of greenness were not substantially associated with the odds of excess weight in preschool children.

With regards to the social environment, we found that 1-SD higher scores of living conditions and educational attainment at the sub-city level were associated with 16% higher and 16% lower odds of excess weight, respectively, after accounting for individual and country level variables (*model 2*). The associations remained similar; 15% higher and 14% lower odds when characteristics of the built environment were considered (*model 3*). Better service provision was also associated with lower odds of overweight/obesity although the association did not reach statistical significance at the 0.05 levels (OR 0.91, 95% CI 0.81, 1.01). Similarly, there was no evidence of an association between the education level of the head of household and childhood excess weight (Table 2).

Discussion

In this study we described the prevalence of overweight and obesity across cities and across countries in Latin America and examined city features associated with this variability. We found that prevalence of excess weight varies substantially across cities and countries, with the highest prevalence among Chilean cities and the lowest in some cities in Colombia and Peru, and the differences between countries were much larger than within countries. The prevalence estimates of childhood overweight and obesity in some cities in Mexico and Peru were higher than 10%, and all Chilean cities were above 15%, placing them as a significant public health issue.[38] Although most of the variability in individual-level weight Z scores was between individuals within sub-cities, approximately 3% of the variability in excess weight among preschool children was between sub-cities and cities. Higher levels of urban isolation at the city-level and higher levels of population educational

	Normal	Overweight/obesity	Overall
	n = 18,450	n = 1590	N = 20,040
Individual characteristics			
Boys, n (%)	9116 (49.4)	726 (45.7)	9842 (49.1)
Age in months, median (IQR)	37 (24, 48)	38 (24, 49)	37 (24, 48)
Head of household education level, n (%)			
Less than primary	3224 (17.6)	250 (15.8)	3474 (17.5)
Primary	6654 (35.5)	562 (35.5)	7216 (36.3)
Secondary	6719 (36.8)	616 (38.9)	7335 (36.9)
University or more	1687 (9.2)	156 (9.9)	1843 (9.3)
Weight for height z-scores (median, IQR)	0.3 (−0.3, 0.9)	2.5 (2.2, 3.0)	0.4 (−0.2, 1.1)
City level variables (median, IQR)			
Fragmentation [Patch density (n/100 ha)]	0.3 (0.1, 0.6)	0.4 (0.1, 0.5)	0.3 (0.1, 0.6)
Isolation [mean distance [m] to the nearest urban patch]	72.1 (64.7, 91.6)	70.6 (63.4, 89.5)	72.1 (64.7, 91.6)
Mass transit availability [n of cities (%)]	19 (12.0)	19 (12.6)	19 (12.0)
Sub-city level variables (median, IQR)			
Built environment			
Population density [n/km^2]/1000	9.9 (6.3, 133.0)	8.7 (5.5, 124.4)	9.7 (6.3, 133.0)
Intersection density [n/km^2]	15.3 (3.8, 49.4)	19.6 (4.0, 73.3)	15.6 (3.8, 52.4)
Percent greenness [%]	83.4 (43.9, 95.5)	76.6 (38.6, 94.3)	83.3 (43.9, 95.4)
Social environment			
Living conditions score	0.3 (−1.0, 1.1)	0.5 (−0.6, 1.3)	0.3 (−1.0, 1.1)
Service provision score	1.3 (0.1, 1.8)	1.4 (0.3, 1.9)	1.3 (0.1, 1.8)
Educational attainment score	0.3 (−0.7, 1.5)	0.1 (−1.0, 1.2)	0.3 (−0.7, 1.5)
Respondents per country, n (%)			
Chile	1072 (5.8)	346 (21.8)	1418 (7.1)
Colombia	5468 (29.6)	285 (17.9)	5753 (28.7)
Guatemala	247 (1.3)	9 (0.1)	256 (1.3)
El Salvador	958 (5.2)	61 (3.8)	1019 (5.1)
Mexico	4330 (23.5)	450 (28.3)	4780 (23.9)
Peru	6375 (35.6)	439 (27.6)	6814 (34.0)

n = number of children living with normal, overweight/obesity in our study. N = total number of children included in the study.

Table 1: **Distribution of individual, and urban environment characteristics where children live by children's weight for height categories in 159 Latin American cities in the SALURBAL study (n = 20,040).**

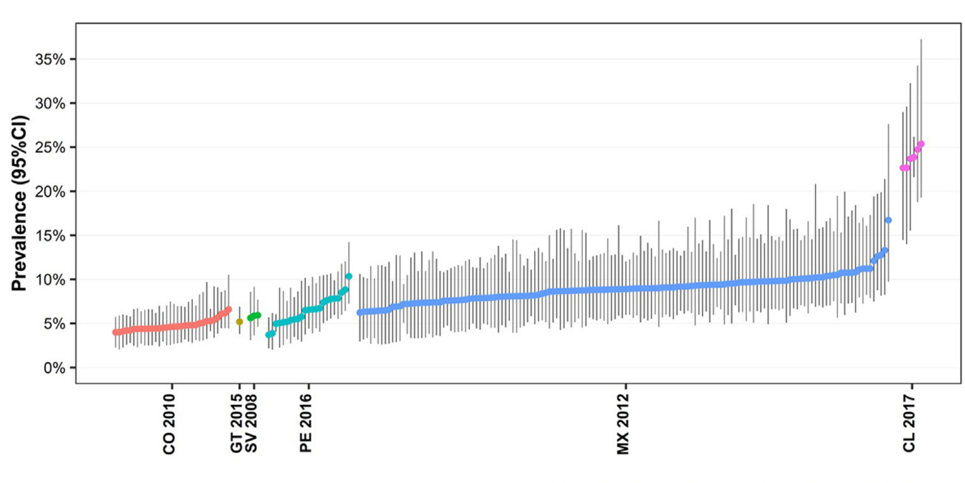

Fig. 1: Prevalence of overweight and obesity in children aged 1–5 in Latin American cities.

	Contrast (SD)	Model 1	Model 2	Model 3
		OR (95% CI)	OR (95% CI)	OR (95% CI)
City level variables				
Fragmentation [Patch density (n/100 ha)]	0.28	1.09 (0.94, 1.25)		1.09 (0.94, 1.26)
Isolation [mean distance [m] to the nearest urban patch]	40.21	**0.90 (0.82, 0.99)**		**0.90 (0.82, 0.99)**
Mass transit presence	No	1.07 (0.79, 1.46)		1.05 (0.77, 1.44)
Sub-city level variables				
Built environment				
Population density [n/km^2]	5202.36	0.97 (0.86, 1.09)		0.99 (0.88, 1.11)
Intersection density [n/km^2]	45.44	1.05 (0.95, 1.16)		1.07 (0.96, 1.19)
Percent of greenness [%]	33.05	0.98 (0.87, 1.10)		0.99 (0.88, 1.12)
Social environment				
Living conditions score	1.78		**1.16 (1.02, 1.32)**	**1.15 (1.00, 1.31)**
Service provision score	1.35		0.93 (0.84, 1.03)	0.91 (0.81, 1.01)
Education attainment score	1.66		**0.84 (0.74, 0.95)**	**0.86 (0.76, 0.97)**
Random effects				
City level variance (SD)		**0.0416 (0.0265)**	**0.0675 (0.0270)**	**0.0500 (0.0272)**
Sub-city level variance (SD)		**0.0502 (0.02970)**	**0.0321 (0.0263)**	**0.0373 (0.0283)**

The odds of childhood overweight and obesity were estimated using multivariable multilevel logistic models. *Model 1* includes built environment variables. *Model 2* includes social environment variables. *Model 3* includes both built and social environment variables. All models are adjusted for individual variables: age in months, sex, and head of household education, and country fixed effects. Bold values are those found to be statistically significant.

Table 2: **Association between the built and social environment with excess weight in preschool children in 159 Latin American cities.**

attainment at the sub-city level were associated with lower odds of excess weight while better living conditions at the sub-city level was linked to higher odds.

The literature on urban environments and childhood obesity has mostly focused on older children, particularly from high-income settings. As an example, one study conducted in children between 4 and 18 years found that living in neighborhoods with less residential density, traffic density, sidewalk completeness, and intersection density were associated with higher BMI z-scores.[12] Other studies conducted in the USA in older children, with ages ranging from 7 to 17 years, found a negative association between walkability and child obesity or BMI z-scores.[13,39]

In our study, we found no relationship between childhood excess weight and variables such as fragmentation, population density, intersection density and percent of greenness. This is important as the urban features linked with a relationship in childhood obesity appear to be specific to a given target group, even within children. For example, our study focused only on children aged 1–5 years, whose mobility patterns within and around the city are different from those of older children.

In our study across 159 Latin American cities, we found that higher levels of urban isolation at the city level were associated with lower odds of excess weight. Isolation was defined as the distance to the nearest urban patch within the geographic boundary and may affect how much people need to travel to get to other places in the city. From an adult and older children standpoint, neighborhood isolation has been posed to reduce active transportation including walkability and more isolated areas have been linked to higher rates of obesity,[40,41] yet this observation merits further scrutiny, particularly for younger and preschool children as the 1–5 years old population in our study. The protective effect of isolation on pre-school overweight and obesity observed in our study allows us to hypothesize that additional features related to increased mobility and active behaviors, such as the perception of safety as enabling factors in the use of available public spaces, may be more common in more isolated areas. This observation is compounded with the finding that higher area-level education scores were also associated with lower odds of excess weight.

The association between use of public transportation and obesity among children aged 2–18 years was explored in a systematic review, without clear associations described.[42] Similarly, we did not find an association between the availability of mass rapid transit and the risk of childhood excess weight, possibly because the use of public transport among Latin American children aged 1–5 years is not common. This observation calls for further studies to clarify the potential role of public transportation on children's nutritional status with an emphasis on context.

As for the social environment at the sub-city level, we found that better living conditions and better population educational attainment were associated with higher and lower odds of excess weight, respectively, and independently from each other. Higher service provision was also associated with lower odds although confidence intervals overlapped. These findings are helpful to capture the potential role different constructs of the urban environment may have in preventing or countering childhood obesity.[35] Better living conditions may be accompanied by greater integration to the urban way of living with greater access to ultra-processed products and obesogenic environments whereas better population-level education attainment could be linked to favoring peer and community health-promoting behaviors as well as greater access to healthier decisions with respect to food choices that reduce the odds of childhood excess weight. This protective relationship observed with area-level educational attainment provides re-assurance that it is an amenable area to target interventions to reduce childhood obesity.

The findings from our study of excess weight in preschool children in Latin American cities are relevant to inform policies in different fields. We report that socioeconomic factors matter at the area-level, different metrics of socioeconomic position yield different relationships with excess weight, and childhood overweight is not a mere consequence of higher income. Given that adult obesity has a clear inverse socioeconomic patterning, and that the transition towards a higher burden of obesity among the most socioeconomic deprived groups is not yet complete in the Latin American region,[14] our findings are uniquely positioned to inform policies to prevent and counter the socioeconomic transition of obesity. On another front, we also report that urban features explain a proportion of excess weight in preschool children, and the implementation of population-level interventions aimed to change urban environments could also impact childhood overweight.

In this study we examined urban determinants of preschool obesity in a vast number of cities across the Latin American region. The focus on cities with ≥100,000 inhabitants afforded a high degree of contextual heterogeneity as urbanicity varied across the cities studied, spanning from small urban settings to major metropolitan areas. Also, we used multilevel models that allowed us to explore associations at different levels regardless of the number of individuals in each city or sub-city by introducing random effects to the models. However, some limitations merit attention. We were unable to include surveys from all countries in Latin America, as some of them do not conduct population level surveys to collect weight and height data in preschool children. We did not study other variables such as food environments or access to parks, which are well-studied drivers of childhood obesity. However, these variables are likely to be mediators, rather than confounders, of the effects we studied. Also, the sub-city areas that we studied are very large and likely very heterogeneous. Studies using measures for smaller neighborhoods are needed to properly characterize environmental impacts. Other variables such as access to health care and individual diet or activity patterns, including screen time, are also important but they may lie on the causal pathways of the associations of interest. Additionally, given the significant variability of excess weight prevalence within cities, we require further exploration of the role of family and neighborhood factors in excess weight prevalence. It is important to acknowledge that we are exploring the association between city features and childhood overweight/obesity and not aiming to assess causality.

Population-wide prevention approaches appear to have small and modest effect, but this perception is outweighed given their sustained reach to many individuals.[43,44] In this regard, urban health interventions could have an impact in reducing excess weight in children alongside the economic and societal benefits that would accrue by avoiding excess weight, including obesity, early in the life course.

Contributors

J.H.Z.-T., A.B., C.A.-R., A.O., M.L. and J.J.M. participated in the conception of the idea. J.H.Z.-T., A.B., M.L. conducted the analysis. J.H.Z.-T. and A.B. drafted the first version of the manuscript. All the authors (J.H.Z.-T., A.B., C.A.-R., A.O., M.L., J.J.M., T.D., L.R.-O., G.S.L., M.M., O.S., C.P.F.) participated in the interpretation of the results and revision of the manuscript. J.H.Z.-T., A.B. and M.L. had access to and verified the data.

Data sharing statement

The SALURBAL study obtained health survey data from health and/or statistical agencies within each country. Data from Chile (http://observatorio.ministeriodesarrollosocial.gob.cl/elpi/elpi_bd.php), Mexico (https://ensanut.insp.mx/), Peru (http://webinei.inei.gob.pe/anda_inei/index.php/catalog/563), and El Salvador (http://ghdx.healthdata.org/record/el-salvador-reproductive-health-survey-2008) are publicly available at the links provided. Data from Colombia and Guatemala are available under restricted access due to data use agreements between the SALURBAL Study and statistical agencies within the country. Requests for the harmonized data set can be obtained by contacting the SALURBAL project salurbal.data@drexel.edu and after completing a data use agreement. Requests are reviewed by the Data Methods Core and Publications & Presentations Committee monthly. To learn more about SALURBAL's data set, visit https://drexel.edu/lac/ or contact the project at salurbal@drexel.edu.

Declaration of interests

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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.2023.100458.

References
1 World Health Organization (WHO). Noncommunicable diseases: childhood overweight and obesity. https://www.who.int/dietphysicalactivity/childhood/en/. Accessed August 14, 2021.
2 de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr*. 2010;92(5):1257–1264.
3 United Nations (UN) Department of Economic and Social Affairs Sustainable Development. *The 17 goals*; 2020. https://sdgs.un.org/goals. Accessed August 14, 2021.
4 World Health Organization (WHO). *Taking action on childhood obesity*. World Health Organization; 2018.
5 Abarca-Gómez L, Abdeen ZA, Hamid ZA, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet*. 2017;390(10113):2627–2642.
6 Di Cesare M, Sorić M, Bovet P, et al. The epidemiological burden of obesity in childhood: a worldwide epidemic requiring urgent action. *BMC Med*. 2019;17(1):1–20.
7 Shimabuku RL, Delgado CA, Nakachi G, Teruya AA, Velasquez PM. Double burden of excess weight and anemia in Latin American children up to 2019. *Tohoku J Exp Med*. 2020;252(2):159–168.
8 Dev DA, McBride BA, Fiese BH, Jones BL, Cho H, Behalf Of The Strong Kids Research Team. Risk factors for overweight/obesity in preschool children: an ecological approach. *Child Obes*. 2013;9(5):399–408.
9 Taillie LS, Bercholz M, Popkin B, Reyes M, Colchero MA, Corvalán C. Changes in food purchases after the Chilean policies on food labelling, marketing, and sales in schools: a before and after study. *Lancet Planet Health*. 2021;5(8):e526–e533.
10 Von Philipsborn P, Stratil JM, Burns J, et al. Environmental interventions to reduce the consumption of sugar-sweetened beverages: abridged Cochrane systematic review. *Obes Facts*. 2020;13(4):397–417.
11 Ding D, Sallis JF, Kerr J, Lee S, Rosenberg DE. Neighborhood environment and physical activity among youth: a review. *Am J Prev Med*. 2011;41(4):442–455.
12 Duncan DT, Sharifi M, Melly SJ, et al. Characteristics of walkable built environments and BMI z-scores in children: evidence from a large electronic health record database. *Environ Health Perspect*. 2014;122(12):1359–1365.
13 Jia P, Xue H, Cheng X, Wang Y, Wang Y. Association of neighborhood built environments with childhood obesity: evidence from a 9-year longitudinal, nationally representative survey in the US. *Environ Int*. 2019;128:158–164.
14 Jiwani SS, Carrillo-Larco RM, Hernández-Vásquez A, et al. The shift of obesity burden by socioeconomic status between 1998 and 2017 in Latin America and the Caribbean: a cross-sectional series study. *Lancet Glob Health*. 2019;7(12):e1644–e1654.
15 Li X, Memarian E, Sundquist J, Zöller B, Sundquist K. Neighbourhood deprivation, individual-level familial and socio-demographic factors and diagnosed childhood obesity: a nationwide multilevel study from Sweden. *Obes Facts*. 2014;7(4):253–263.
16 Navalpotro L, Regidor E, Ortega P, Martínez D, Villanueva R, Astasio P. Area-based socioeconomic environment, obesity risk behaviours, area facilities and childhood overweight and obesity: socioeconomic environment and childhood overweight. *Prev Med*. 2012;55(2):102–107.
17 Nobari TZ, Whaley SE, Prelip ML, Crespi CM, Wang MC. Trends in socioeconomic disparities in obesity prevalence among low-income children aged 2–4 years in Los Angeles county, 2003–2014. *Child Obes*. 2018;14(4):248–258.
18 Malacarne D, Handakas E, Robinson O, et al. The built environment as determinant of childhood obesity: a systematic literature review. *Obes Rev*. 2022;23:e13385.
19 Delclòs-Alió X, Rodríguez DA, Olmedo NL, et al. Is city-level travel time by car associated with individual obesity or diabetes in Latin American cities? Evidence from 178 cities in the SALURBAL project. *Cities*. 2022;131:103899.
20 Natale R, Scott SH, Messiah SE, Schrack MM, Uhlhorn SB, Delamater A. Design and methods for evaluating an early childhood obesity prevention program in the childcare center setting. *BMC Public Health*. 2013;13(1):1–10.
21 Volger S, Rigassio Radler D, Rothpletz-Puglia P. Early childhood obesity prevention efforts through a life course health development perspective: a scoping review. *PLoS One*. 2018;13(12):e0209787.
22 United Nations (UN) Department of Economic and Social Affairs. *2018 Revision of world urbanization prospects*; 2018. https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html. Accessed January 13, 2022.
23 Corvalán C, Garmendia M, Jones-Smith J, et al. Nutrition status of children in Latin America. *Obes Rev*. 2017;18:7–18.
24 Irache A, Gill P, Caleyachetty R. The co-occurrence of overweight/obesity and anaemia among adult women, adolescent girls and children living in fifty-two low-and middle-income countries. *Public Health Nutr*. 2022;25(6):1595–1606.
25 Quistberg DA, Roux AVD, Bilal U, et al. Building a data platform for cross-country urban health studies: the SALURBAL study. *J Urban Health*. 2019;96(2):311–337.
26 World Health Organization (WHO). *WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development*. World Health Organization; 2006.
27 World Health Organization (WHO). *WHO anthro survey analyser and other tools*; 2020. https://www.who.int/toolkits/child-growth-standards/software. Accessed August 14, 2021.
28 Yang S, Chen X, Wang L, et al. Walkability indices and childhood obesity: a review of epidemiologic evidence. *Obes Rev*. 2021;22 Suppl 1(Suppl 1):e13096.
29 Koohsari MJ, Sugiyama T, Shibata A, et al. Associations of street layout with walking and sedentary behaviors in an urban and a rural area of Japan. *Health Place*. 2017;45:64–69.
30 Cerin E, Conway TL, Adams MA, et al. Objectively-assessed neighbourhood destination accessibility and physical activity in adults from 10 countries: an analysis of moderators and perceptions as mediators. *Soc Sci Med*. 2018;211:282–293.
31 Huang WZ, Yang BY, Yu HY, et al. Association between community greenness and obesity in urban-dwelling Chinese adults. *Sci Total Environ*. 2020;702:135040.
32 Sarkar C. Residential greenness and adiposity: findings from the UK biobank. *Environ Int*. 2017;106:1–10.
33 Fan S, Xue Z, Yuan J, et al. Associations of residential greenness with diabetes mellitus in Chinese Uyghur adults. *Int J Environ Res Public Health*. 2019;16(24):5131.
34 Ortigoza AF, Granados JAT, Miranda JJ, et al. Characterising variability and predictors of infant mortality in urban settings: findings from 286 Latin American cities. *J Epidemiol Community Health*. 2021;75(3):264–270.
35 Howe LD, Galobardes B, Matijasevich A, et al. Measuring socio-economic position for epidemiological studies in low- and middle-income countries: a methods of measurement in epidemiology paper. *Int J Epidemiol*. 2012;41(3):871–886.

36 Centro de Investigación en Evaluación y Encuestas. *Encuesta nacional de Salud y nutrición - 2012*; 2016. https://ensanut.insp.mx/encuestas/ensanut2012/index.php. Accessed August 14, 2021.
37 The World Bank. *Integrated public use Microdata series (IPUMS)*; 2020. https://microdata.worldbank.org/index.php/catalog/ipums/about. Accessed August 14, 2021.
38 de Onis M, Borghi E, Arimond M, et al. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. *Public Health Nutr*. 2019;22(1):175–179.
39 Xue H, Cheng X, Jia P, Wang Y. Road network intersection density and childhood obesity risk in the US: a national longitudinal study. *Public Health*. 2020;178:31–37.
40 Ewing R, Schmid T, Killingsworth R, Zlot A, Raudenbush S. Relationship between urban sprawl and physical activity, obesity, and morbidity. *Am J Health Promot*. 2003;18(1):47–57.
41 Sallis JF, Floyd MF, Rodríguez DA, Saelens BE. Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation*. 2012;125(5):729–737.
42 Xu F, Jin L, Qin Z, et al. Access to public transport and childhood obesity: a systematic review. *Obes Rev*. 2021;22:e12987.
43 Miranda JJ, Barrientos-Gutiérrez T, Corvalan C, et al. Understanding the rise of cardiometabolic diseases in low- and middle-income countries. *Nat Med*. 2019;25(11):1667–1679.
44 Rose G. Sick individuals and sick populations. *Int J Epidemiol*. 1985;14(1):32–38.