




Review Article

Prevalence of stunting and obesity in Ecuador: a systematic review

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Submitted 25 March 2019: Final revision received 18 May 2020: Accepted 27 May 2020: First published online 29 July 2020

Abstract

Objective: In low- and middle-income countries, undernutrition remains a major risk factor for child growth retardation. In addition, the emergence of obesity in recent years is adding another public health concern in that both stunting and obesity are associated with serious adverse health consequences. This review was designed to evaluate the prevalence of stunting and obesity in Ecuador.

Design: Electronic databases were searched for articles published through February 2018 reporting the prevalence of stunting and/or obesity. Selected data were subjected to meta-analysis and pooled prevalence and their 95 percentiles (95% CI) were calculated.

Setting: Studies were identified in Medline, Web of Science, CINAHL, Cochrane Database and Ibero-America databases.

Participants: Population of Ecuador.

Results: Twenty-three articles were selected according to the inclusion/exclusion criteria of the study. The estimate of pooled prevalence of stunting was 23.2% (95% CI 23.3, 23.5) in preschoolers (age < 5 years), but was markedly higher in indigenous and rural communities. Pooled prevalence of obesity was 8.1% (95% CI 6.9, 9.3), 10.7% (95% CI 9.6, 11.7) and 10.5% (95% CI 9.2, 11.8) in preschoolers, school-age children (age: 5–11 years) and adolescent (age: 12–18 years), respectively. In adults (age ≥ 19 years), the rate of obesity was remarkably high as indicated by an overall estimate equal to 44.2% (95% CI 43.1, 45.4).

Conclusions: This study underlines high levels of stunting among children and obesity among adults in Ecuador, both of which are not equally distributed among the population. The magnitude of this double burden emphasises the need for sustained and targeted interventions.

Keywords
Stunting
Obesity
Double burden
Ecuador

In the last few decades, the prevalence of obesity has increased significantly throughout the world including low- and middle-income countries (LMIC), as well as high-income countries^(1,2). According to recent epidemiological data from the WHO, the prevalence of obesity in the world has nearly tripled since 1975^(1,2). In LMIC, although the rate of obesity is rising, nutritional deficiencies are still frequent^(3,4), increasing the risk of growth faltering and stunting in children^(4,5). Whilst nutritional deficiencies increase the risk of infection⁽⁶⁾, obesity is often associated with chronic metabolic diseases including diabetes and CVD^(7,8). Consequently, while LMIC continue to deal

with the problems of undernutrition and infectious diseases, they are also experiencing a rapid upsurge in obesity and chronic metabolic diseases⁽³⁾. This uncommon coexistence of undernutrition and obesity creates a 'double burden' situation that increases social and economic stress in countries with limited resources^(3,5).

Ecuador is a South American Andean middle-income country with about 16.5 million population, of which about 60% live in urban areas. Its population is heterogeneous with the majority (about 72%) is represented by the descendants of inter-ethnic unions (commonly called Mestizos). Minorities are represented mostly by Afro-Ecuadorians,

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the descendants of Black Africans (about 7.2 %); Native Ecuadorians, the descendants of native Indigenous inhabitants (about 7 %); and White Caucasians, the descendant of European immigrants (about 6.1 %). Geographically, Indigenous populations are located mostly in remote regions in the Amazon forest and highlands, which often have less access to healthcare facilities^(9,10). Because of the geographic and economic disparities, minorities are more vulnerable to nutritional deficiencies and diseases^(10–12). At the same time, rapid economic and demographic changes in Ecuador are altering the balance of dietary intake and promoting the replacement of low-energy plant-based diet with high-energy diet rich in fat predominantly from animal sources^(11,13). With this change, which is mostly located in urban areas, the occurrence of obesity and metabolic diseases is rapidly increasing. Independent studies were conducted to determine the importance of obesity and undernutrition in different locations in Ecuador, but the trend of occurrence and disparity in Ecuadorian population is still unclear. The objective of this study was to conduct a systematic literature review to evaluate the prevalence of stunting and obesity in Ecuador and assess the magnitude of these problems in relation to age, gender, ethnicity and geographical location. The findings of this search could provide valuable information needed to elaborate preventive interventions.

Methods

Search strategy and study eligibility

This systematic review was conducted in accordance with the Cochrane Collaboration's systematic review framework and Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) guidelines and reporting checklist⁽¹⁴⁾ (Table S1-Checklist). To identify all studies relevant to stunting and obesity in Ecuador, a comprehensive search of major electronic databases was conducted up to February 2018, with no start date restriction. The following databases were searched: Medline/PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>), Web of Science (<https://www.webofknowledge.com>), Cumulative Index of Nursing and Allied Health Literature (CINAHL) (<https://web.a.ebscohost.com>), Cochrane Database of Systematic Reviews (<http://www.thecochranelibrary.com>) and Ibero-America (Scielo and Redalyc) (<https://scielo.conicyt.cl>, <https://www.redalyc.org>). The search strategy was constructed using medical subject headings and the following keywords: 'obesity', 'overweight', 'stunting', 'underweight', 'growth retardation' or 'nutritional deficiency' and 'Ecuador'. All publication types were searched without language restriction or age limitation, and relevant studies were extracted and manually cross-referenced. In this selection, we included only records that involved human subjects of any age and presented anthropometric indices reflecting body weight

status according to standard definitions. We excluded studies that were based on animal models and/or *in vitro* experiments, or pertaining to patients diagnosed with a disease and undergoing treatments. Short communications, articles and meta-analysis reviews were included. Editorials, letters to the editor, meeting abstracts and literature reviews were excluded.

Anthropometric indices and definition of outcomes

Anthropometric indices used in selected studies were based on internationally known standards including WHO and International Diabetes Federation^(15,16). In preschoolers (age < 5 years), school-age children (5–11 years) and adolescents (age: 12–18 years), anthropometric indices used to assess physical growth and body weight were weight-for-age, length/height-for-age, weight-for-length/height and BMI-for-age. All of these indices were expressed as *z* scores calculated according to WHO standards^(15,17) and in comparison with international reference values that provide an assessment of optimal growth⁽¹⁷⁾. Preschoolers, school-age children and adolescents were classified as stunted if their length/height-for-age *z* scores were ≤ 2 SD, and underweight if their weight-for-age *z* score ≤ 2 SD. Overweight and obesity were determined for preschoolers as well as other children by *z* scores between >1 SD and ≤ 2 SD and >2 SD in BMI-for-age, respectively. Additionally, some studies classified preschoolers as overweight if their weight-for-height (WHZ) was >2 SD. For adults (age ≥ 19 years), BMI (kg/m^2) was used to classify overweight and obese according to the following cut-offs: ≥ 25 and <30 for overweight and ≥ 30 for obesity^(15,17). To assess abdominal obesity, some studies adopted the criteria of the International Diabetes Federation based on the measurements of waist circumference and define abdominal obesity when waist circumference (WC) is ≥ 94 cm for men and ≥ 88 cm for women⁽¹⁶⁾.

Study selection and data extraction

Using the inclusion and exclusion criteria, three authors (T.H., V.A.A. and L.C.) reviewed independently identified references in a two-phase process: based on reading of titles and abstracts, and then of full text. Data extraction from selected studies was reported independently by the authors using a pre-established data extraction and assessment template. The following information was independently extracted from each article by the investigators using a standardised form: study design, geographic location, years of survey, sample size, age, gender and ethnicity of participants, outcome definition (i.e. specific diagnostic criteria or cut-off of selected outcomes) and reported prevalence of stunting, underweight, overweight and/or obesity. Discrepancies in the evaluation of the studies were resolved through discussion and unanimous agreement.



Publication heterogeneity and data analysis

Statistical heterogeneity was assessed using the DerSimonian and Laird's Q and I^2 tests⁽¹⁸⁾. The Q test provides information about the presence or the absence of heterogeneity between studies, whereas the I^2 statistic quantifies the degree of heterogeneity^(19,20). Values of I^2 of 25, 50 and 75 % were considered low, medium and high heterogeneity, respectively⁽¹⁹⁾. To develop a summary of measures in the overall population, we plotted computed results for the prevalence of stunting and obesity in separate Forest plots according to the method of Neyloff *et al.*⁽²⁰⁾. Since there was heterogeneity among studies, the random effects model of DerSimonian-Laird was applied to compute pooled prevalence^(18,20). Random effects model is more conservative than fixed effects model and takes into account any heterogeneity inherent in the meta-analysis, in addition to the weight of each study in the analysis according to the sample size. Therefore, study variance impact on study weight is considerably diminished and so is the influence of individual studies' weights to the model as a whole. All point estimates of analyses and their 95 % CI, used in the forest plot, were calculated using the random effects models as reported by Neyloff *et al.*⁽²⁰⁾.

Quality assessment and risk of bias

The methodological quality of included studies was evaluated independently by two authors (V.A. and L.C.), using the Newcastle–Ottawa Scale⁽²¹⁾ modified by Nansseu *et al.*⁽²²⁾. The Newcastle–Ottawa Scale was designed to assess the quality of non-randomised studies in meta-analyses. This scale was formulated by a star distribution system, assigning a maximum of ten stars for the risk of bias in three areas: selection of study groups (4 stars), comparability of groups (2 stars) and ascertainment of the outcome of interest (3 stars). Total scale range was zero to ten, with higher score indicating better study quality. A score equal to or higher than seven was considered to indicate high study quality, a score between four to six was moderate quality, and a score equal to or under three was considered low quality. Discrepancies of quality assessment rating were resolved through discussion with the third member of the study (T.H.) and unanimous agreement.

Results

Search results and studies' characteristics

The screening process and results of database search are presented in the PRISMA flow diagram (Fig. 1). A total of 180 papers were initially retrieved using the search format described in the Methods section. Among this first selection, 131 studies were excluded because of duplication between databases and the remaining forty-nine studies were selected for initial identification. Of these, fourteen

studies were excluded because they were not related to Ecuador population or focused on obesity-related diseases which were clearly not relevant to the prevalence of stunting and/or obesity. The remaining thirty-five studies were further studied by careful reading of the full text. After the full review, twelve studies were excluded because they were (i) reviews, editorials or meeting abstracts (6); (ii) Non-human studies (4) and (iii) duplicates (2). Ultimately, twenty-three studies were included in the final selection and presented in this review. In general, these studies covered several regions in Ecuador, among which two studies were based on nationwide surveys^(3,23). Most studies were conducted in urban areas often in and around big cities such as Cuenca, Quito and Guayaquil. Only few studies took place in rural regions and in Amazon forest communities. While several studies examined the prevalence of stunting and/or obesity with age and gender, a limited number reported the distribution among ethnicities^(3,8,24) or between rural and urban regions^(23,25,26). The sample size of studies ranges from twenty subjects in a study conducted in Galapagos Islands⁽²⁷⁾ to a maximum of 1 294 372 subjects reported in a nationwide survey⁽²³⁾. The quality assessment indicated that all studies failed to provide the response rate and characterise the non-respondents in comparison with the respondents; likewise, reporting and/or controlling for important factors was unsatisfactory. In general, two studies were with high-quality evidence^(3,8) and the others were of moderate quality (Table S2). Because age could impact the prevalence of stunting and/or obesity, we subdivided the studies in four groups according to the age: preschoolers (age <5 years), school-age children ≥ 5 years and ≤ 11 years (5–11 years), adolescents ≥ 12 years and ≤ 18 years (12–18 years) and adults (≥ 19 years).

Prevalence of stunting and obesity in children and adolescents

The characteristics of the studies relevant to preschoolers, school-age children and adolescents are represented in Tables 1–3, respectively. According to these subdivisions, there were nine^(3,23,24,27–32), four^(3,9,33,34) and seven studies^(3,25,26,34–37), respectively. While the obesity rate was reported in most studies of these subdivisions, only few described the prevalence of stunting in school-age children and adolescents. Because of these differences, random effects model analysis of stunting data was performed only for preschoolers, while obesity data were computed for the three subdivisions. The resulting forest plots are presented in Figs. 2 and 3, respectively.

In preschoolers, the overall pooled estimate of stunting was 23.2% (95 % CI 23.3, 23.5) (Fig. 2). There was, however, a high level of heterogeneity among these studies ($I^2 = 97.9$) which could be related to variations of age, ethnicity and/or geographic location. Interestingly, a large

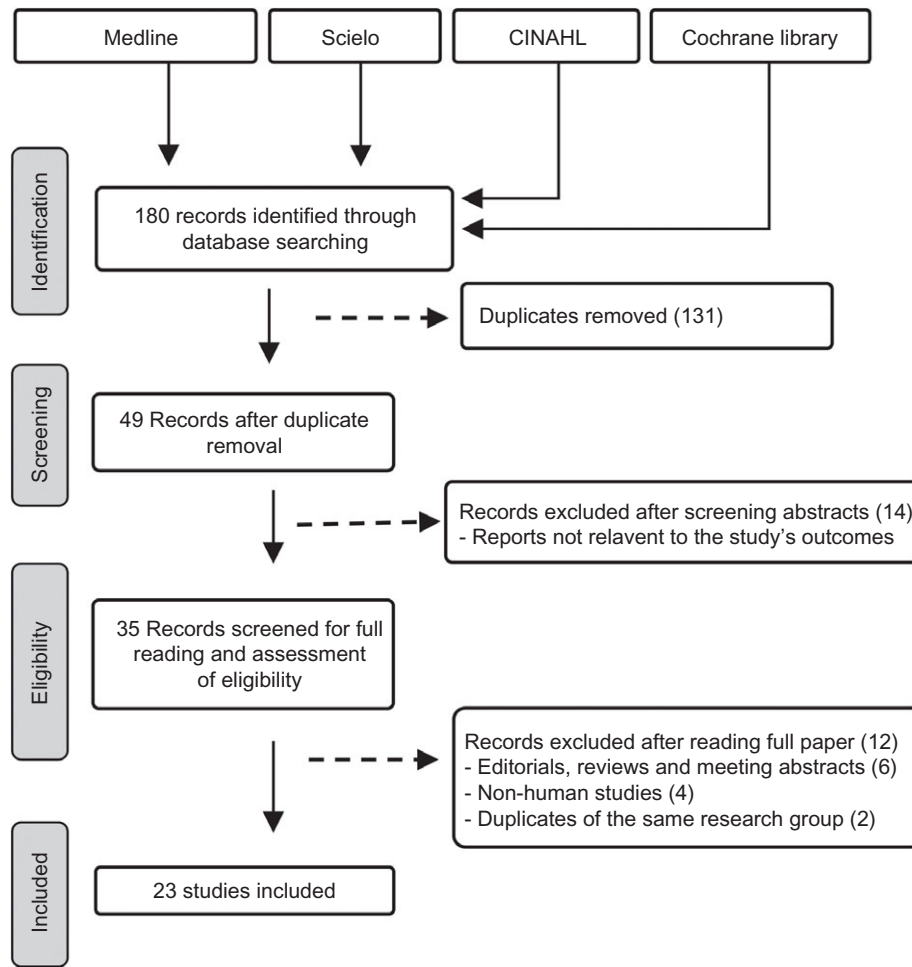


Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart illustrating the selection of the studies included in the systematic review

data collection from a nationwide survey⁽²³⁾ indicated that the prevalence of underweight and stunting was relatively low (0.8 and 3.3 %, respectively) in newborns (age: 0–5 months), but increased in the following months to reach markedly high proportions (7.1 and 34.1 %, respectively) at the age of 48–60 months. This progressive age-associated increase was also corroborated by the study of Freire *et al.*⁽³⁾ based on a later survey⁽³⁸⁾. Another important finding was the disparity of prevalence among ethnicities^(3,23). A study based on an early national survey (ENDEMAIN 2004) reported an alarming rate of stunting exceeding 46.6 % in Indigenous preschoolers, while this rate varied from 14.2 to 21.1 % in children of other ethnicities⁽²³⁾. The same study also reported a markedly higher occurrence of stunting in rural than urban areas⁽²³⁾. Similarly, another study conducted in low-income rural and peri-urban areas of Quito indicated that the rate of stunting was markedly higher than average pooled estimate, reaching 54.8 %⁽³²⁾.

Few investigations examined the rate of stunting in school-age children and adolescents as shown in Tables 2 and 3. While three studies^(3,9,33) reported a wide

range (14.9–44 %) of prevalence in school-age children, two other investigations^(3,26) indicated that the rate of stunting in adolescents varied between 19 and 24.8 %^(3,26). There was no clear difference between males and females in both age-school children and adolescents, but once again there was significant disparity among ethnicities with markedly high rates in Indigenous school-age children (36.5 %)⁽³⁾. Furthermore, a study conducted in the Paute region by Garrido *et al.*⁽²⁶⁾ indicated that stunting was clearly higher in rural (31.8 %) than urban areas (16.3 %) (Table 3).

The studies that examined the prevalence of obesity in preschoolers, school-age children and adolescents are listed in Tables 1–3, respectively. In general, the prevalence of obesity was relatively low in early childhood (preschoolers) and did not show a clear change in school-age children and adolescents; estimates of pooled prevalence were 8.1 % (95 % CI 6.9, 9.3), 10.7 % (95 % CI 9.6, 11.7) and 10.5 % (95 % CI 9.2, 11.8), respectively (Fig. 3). Although age subdivisions were created to narrow potential differences among studies, a high level of heterogeneity persisted in each of these subdivisions as indicated by an

Table 1 Characteristics of studies relevant to stunting and obesity in infants (age < 5 years)*

Reference no.	Location (s)	Study duration	Sample size	Gender (%) (female/ male)	Age (months)	Subject characteristics	Finding		
							Stunting	Underweight	Obese
León <i>et al.</i> ⁽²⁹⁾	Babahoyo	2007	140	50/50	3–60	Rural	18.6 %	8.6 %	5 %
Díaz <i>et al.</i> ⁽³¹⁾	Cuenca	2013	577	51/49	12–59	Urban	24.2 %	All ages: 7.9 % F: 6.6 %, M: 9.5 %	All: 4.70 % Age: 12–23 months: F: 0.9 %, M: 1 % 24–35 months: F: 1.2 %, M: 0.0 % 36–47 months: F: 0 %, M: 0 % 48–59 months: F: 0 %, M: 0 %
Ortiz <i>et al.</i> ⁽²⁴⁾	Cuenca Nabon	2008	703	Cuenca: 51/49 Nabon: 49/51	0–24	Rural and Urban highlands	All: 34.1 % Cuenca:17.7 % Nabon:37.4 %	Not reported	Cuenca: 5.7 % Nabon: 6.2 %
Freire <i>et al.</i> ⁽³⁾	Nationwide survey	2011–2013	8894	51/49	0–59	Rural and Urban	All: 25.3 %, F: 24.8 %, M: 25.3 % Age: 0–5 months: 16.8 % 6–11 months: 19.9 % 12–23 months: 32.6 % 24–35 months: 29.1 % 36–47 months: 27.2 % 48–59 months: 22.1 % Indigenous: 43.2 %	Not reported	Ow/Ob, All: 8.6 % Age: 0–5 months: 9.3 % 6–7 months: 9 % 12–23 months: 10.5 % 24–35 months: 6.4 % 36–47 months: 7.7 % 48–59 months: 10 %
World bank group ⁽²³⁾	Nationwide survey	2004	1 294 372	50/50	0–60	Urban and rural	All: 23.1 % F: 24.0 %, M: 22.1 % U: 16.9 %, R: 30.6 % Age: 0–5 months: 3.3 % 6–11 months: 12.4 % 12–23 months: 35.9 % 24–35 months: 31.1 % 36–47 months: 35.4 % 48–60 months: 34.1 % Ethnicity: Indigenous 46.6 % Mestizo 21.1 % White 18.6 % Black: 14.2 %	All: 9.3 % F: 9.8 %, M: 8.8 % U: 7.7 %, R: 11.3 % Age 0–5 months: 0.8 % 6–11 month: 8 % 12–23 month: 16 % 24–35 month: 14.3 % 36–47 month: 10.4 % 48–60 month: 7.1 % Ethnicity Indigenous:15.3 % Mestizo 8.7 % White 6.2 % Black: 11.4 %	Obese: Not recorded Overweight: All: 3.2 % F: 3.7 %, M: 2.7 % U: 3.5 %, R: 2.8 % Age 0–5 months: 5.3 % 6–11 months: 3.9 % 12–23 months: 4.1 % 24–35 months: 1.5 % 36–47 months: 2.8 % 48–60 months: 3.1 % Ethnicity Indigenous: 3.4 % Mestizo 3.0 % White 5.0 % Black: 3.0 %

Table 1 Continued

Reference no.	Location (s)	Study duration	Sample size	Gender (%) (female/ male)	Age (months)	Subject characteristics	Stunting	Finding		
								Underweight	Obese	Obese
Waldrop <i>et al.</i> ⁽²⁷⁾	Galapagos	2010	20	61/39	<6	Island residents	Not reported	Not reported	10 %	Not reported
Handal <i>et al.</i> ⁽³²⁾	Cayambe- Tabacundo	2003–2004	283		3–61		All: 53.4 %	Not reported	Not reported	Not reported
So <i>et al.</i> ⁽³⁰⁾	Amazon Region	2011–2013	1407	50/50	6–72	Indigenous community	All: 35.9 %	Not reported	Not reported	Not reported
Arsenal <i>et al.</i> ⁽²⁸⁾	Quito (2 sites)	2003–2005	564	51/49	6–35	Rural and peri-urban, low income	12–23 months: 54.8 % 24–35 months: 44.3 %	Not reported	Not reported	Not reported

F, female; M, male; U, urban; R, rural; Indigenous, native Ecuadorians; Mestizo, descendants of mixed marriage; Montubio, mestizo people living in countryside of coastal Ecuador; Ow, overweight; Ob, obesity.

*All studies adopted the WHO z scores.

$I^2 > 75\%$. While obesity rate was comparable between males and females in each subdivision, there were clear differences between ethnicities⁽³⁾, and between rural and urban locations^(25,26). As indicated above, while stunting was prevalent in Indigenous communities, the proportions of overweight/obese in school-age children and adolescent were also noticeably high in these communities reaching 24 and 48.8 %, respectively⁽³⁾. Taken together, these findings indicate that obesity and stunting co-exist in Indigenous communities, possibly affecting children at different age ranges.

Prevalence of obesity in adults

The prevalence of overweight and obesity in adults has been reported in eight studies^(3,8,27,39–43) (Table 4), six of which reported the distribution among genders^(3,8,40–43). While four studies examined the rate of abdominal obesity^(8,39,41,42), only one study compared the disparity between ethnicities, and between rural and urban areas⁽⁸⁾. In general, the results showed a markedly high prevalence of overweight and obese subjects reaching 45 and 25 %, respectively⁽²⁷⁾. Pooled estimate of the prevalence of obesity, analysed by the random effects model, was 44.2 % (95 % CI 43.1, 45.4) (Fig. 4). There was, however, high level of heterogeneity ($I^2 = 99.5\%$) which could be linked to multiple factors including age, ethnicity and geographic location. In line with this, several studies indicated that the prevalence of obesity (assessed by BMI) was higher in females (ranging from 13.7 to 28 %) than males (ranging from 3.3 to 18.4 %) ^(3,8,41). In addition, although two studies reported that abdominal obesity was higher in females than males^(8,41), two others reported comparable rates in both genders^(42,43). The impact of age was reported in the study of Campoverde *et al.*⁽³⁹⁾ showing that obesity increased progressively with age reaching almost 35 % in older subjects (age > 60 years). There was also clear disparity between rural and urban populations with markedly higher rates in urban locations⁽⁸⁾. Although comparative studies among ethnicities were sparse, one study reported that Afro-Ecuadorians had the highest prevalence of abdominal obesity (77.7 and 26.1 % for females and males, respectively)⁽⁸⁾.

Discussion

This review sought to assess the prevalence of stunting and obesity in Ecuador and to provide a summary of available evidence on this topic. Overall, this study reports several key observations. First, stunting is markedly high among children and adolescent nationwide, but is mostly prevalent in low-income population including Indigenous and rural communities. Second, stunting co-exists with excess weight and obesity mostly in Indigenous communities, suggesting a possible causal relationship. Third, the

**Table 2** Characteristics of studies relevant to school-age children (5–11 years)*

Reference no.	Location	Study duration	Sample size	Gender (%) (female/male)	Age (years)	Findings		
						Stunting	Underweight	Ow and Ob
Robalino <i>et al.</i> ⁽⁹⁾	Riobamba	2017	36	50/50	5–6	All: 44 % F: 38.89 %; M: 50 %	Not reported	Ow All: 5.56 %, F: 5.56 %, M: 5.56 % Ob All: 2.78 % F: 5.56 %, M: 0 %
Freire <i>et al.</i> ⁽³⁾	Nationwide survey	2011–2013	11 534	52/48	5–11	All: 14.9 % F: 14.8 %, M: 15 % Ethnicity: Indigenous: 36.5 % AfroEcuadorian: 7.7 % Montubio: 10.0 % Mestizo and White: 13.7 %	Not reported	Ow: F: 18.15 %, M: 19.80 % Ob: F: 6.95 %, M: 12.70 % Ow/Ob: Indigenous: 24.0 % Afro-Ecuadorian: 26.5 % Montubio: 16.9 % Mestizo and White: 30.7 %
Ramos <i>et al.</i> ⁽³⁴⁾	Riobamba	2013	1581	50/50	5–11	Not reported	Not reported	All Ow: 19.4 % Ob: 8.3 % Ow: F: 24.4 % M: 31.0
Oleas <i>et al.</i> ⁽³³⁾	Imbabura	2008–2009	450	42/56	6–12	All: 22 %	All: 7.3 %	Ow: 10 % Ob: 3.6 % AO: 6 %

F, female; M, male; Indigenous, native Ecuadorians; Mestizo, descendants of mixed marriage; Montubio, mestizo people living in countryside of coastal Ecuador; White, descendants of European Caucasians; Ow, overweight; Ob, obesity; AO, abdominal obesity.

*All studies adopted the WHO z scores.

prevalence of obesity is sensibly high in adults and is not equally distributed among ethnicities and rural–urban locations.

The present review emphasises the high prevalence of stunting in Ecuador and its heterogeneous distribution among ethnicities and geographical regions. In pre-schoolers, while average prevalence was about 23 %, it was markedly higher in Indigenous populations and rural regions reaching an alarming rate of 50 %. In comparison with surrounding countries, average estimate of stunting in Ecuador is relatively lower than Bolivia (41.6 %) and Guatemala (54.5 %), but remains relatively higher than Argentina (12.8 %) and Brazil (10.5 %)⁽⁴⁴⁾. Despite these variations, shared observation among these countries indicates that deprived subpopulations are the most affected by stunting^(24,38,45,46). In Ecuador, most Indigenous populations are dispersed in remote locations in the Amazon forest and highland regions with poor access to food sources and healthcare facilities⁽⁹⁾. The disparity of the occurrence of stunting is deeply rooted in differences of the socio-economic status with poverty and deprivation affecting mainly populations residing in rural remote areas such as Amazon forest and highlands of Andes Mountains^(9,12) or impoverished neighbourhoods surrounding major cities with high unemployment^(28,38,47).

Although several factors may contribute collectively to the manifestation of stunting, chronic undernutrition remains the most determinant cause of children development and health status^(10,44,45,48). In Ecuador, several studies have reported the existence of severe nutritional deficiencies which could explain the high occurrence of stunting^(3,32,41,47). In line with this, nutritional deficiencies, such as Fe and Zn deficiency, have been detected in stunted children as well as mothers^(3,44). Similarly, other nutritional deficiencies exemplified by vitamin D deficiency⁽⁹⁾ were also reported throughout the country but were mostly prevalent in rural and highland regions⁽⁹⁾. It is known that agricultures at high altitudes are often associated with poorer crop production⁽⁴⁵⁾, lower nutritional value of food^(46,49) and fewer income-generating options⁽⁴⁵⁾. As a result, children residing in these regions may experience inadequate essential nutrient intake^(46,49,50) and less access to good-quality complementary foods⁽⁴⁹⁾. The importance of growth-limiting nutrient deficiencies is highlighted by some studies showing that complementary foods significantly improved children growth in Indigenous and rural communities^(51,52).

In Ecuador, age distribution of stunting in preschoolers indicates that the rate of stunting increased rapidly from 5 to 6 months onwards until about 24 months, an age when the rate of stunting reached 35.9 %⁽²³⁾. Similar patterns of

Table 3 Characteristics of studies relevant to stunting and obesity in adolescents (12–18 years)*

Reference no.	Location	Study duration	Sample size	Gender (%) (female/ male)	Age (years)	Subjects characteristics	Findings		
							Stunting	Underweight	Ow, Ob, and AO
Casapulla <i>et al.</i> ⁽³⁷⁾	Quito	2015	433	Cariamanga: 69/31 Pomasqui: 68/32	13–18	Urban-Sierra region. Urban schools in Quito	Not reported	All:7.3 % Cariamanga: 6.5 % Pomasqui: 8.0 %	-Cariamanga: All: Ow: 10.3 %, Ob: 7.5 % -Pomasqui: All: Ow: 8.9 %, Ob: 5.2 % M, Ow: 6.6 %, Ob:3.7 %, AO:12 % F Ow:11.0 %, Ob:7.6 %, AO: 33 %
Freire <i>et al.</i> ⁽³⁾	Nationwide survey	2011–2013	8529	Not reported	12–19	All regions and ethnicities	All: 19 % F: 21.1 % M: 17.3 % Indigenous: 19.5 % Afroecuadorian: 13.4 % Montubio: 21.7 % Mestizo: 16.9 %	Not reported	Ow/Ob All: 26.0 %, F:28.8 % M: 23.3 % Indigenous: 48.8 % Afro Ecuadorian: 43.7 % Montubio : 17.8 % Mestizo: 26.1 %
Cambizaca <i>et al.</i> ⁽²⁵⁾	Loja	2013–2014	1337	61/40	11–17	Publics high schools	Not reported	F: 3.42 %, M: 2.83 % U: 3.0 %, R: 3.5 %	Ow, F: 20 %, M: 20.3 % U: 20.5, R:18.7 % Ob, F: 7.40 %, M:5.5 % U: 7.1 %, R: 3.1 %
Garrido <i>et al.</i> ⁽²⁶⁾	Paute	2014	314	57/43	12–19	Urban and Rural schools	All: 24.8 % Urban: 16.3 % Rural: 31.8 %	Not reporting	Ow, All:19.8 % U:24.1 %, R: 16.2 % Ob: All:2.95 U:4.3 %, R:1.7 % AO: All:1.6 % U:2.8 %, R:0.6 %, Ow:16.6 %, Ob: 4.9 %
Ramos <i>et al.</i> ⁽³⁴⁾ Yepez <i>et al.</i> ⁽³⁵⁾	Riobamba Esmeraldas Guayaquil Machala Manta Portoviejo Quevedo	2013 2006–2007	2099 2829	48/52 52/49	12–19 <19	Urban Urban	Not reported Not reported	UW: 2.0 % All: 16.8 % Age: 12–14 years: 16.8 % 15–16 years: 16.5 % 17–18 years: 16.4 %	Ow:13.7 %, Ob: 7.5 % Age: 12–14 years: Ow: 14.3 %, Ob: 7.8 % 15–16 years: Ow: 13.3 %, Ob: 7.8 % 17–18 years: Ow: 12.6 %, Ob: 5.5 %
Castro <i>et al.</i> ⁽³⁶⁾	Loja, Quito	2001	302	100	12–19	Semi urban	Not reported	All: 50 %	Ow: 8.3 %, Ob: 0.7 %

F, female; M, male; Ow, overweight; Ob, obesity; AO, abdominal obesity; U, urban; R, rural; Indigenous, native Ecuadorians; Mestizo, descendants of mixed marriage; Mulatto, descendants of mixed white and black ancestries; Montubio, mestizo people living in countryside of coastal Ecuador.

*All studies adopted the WHO z scores.

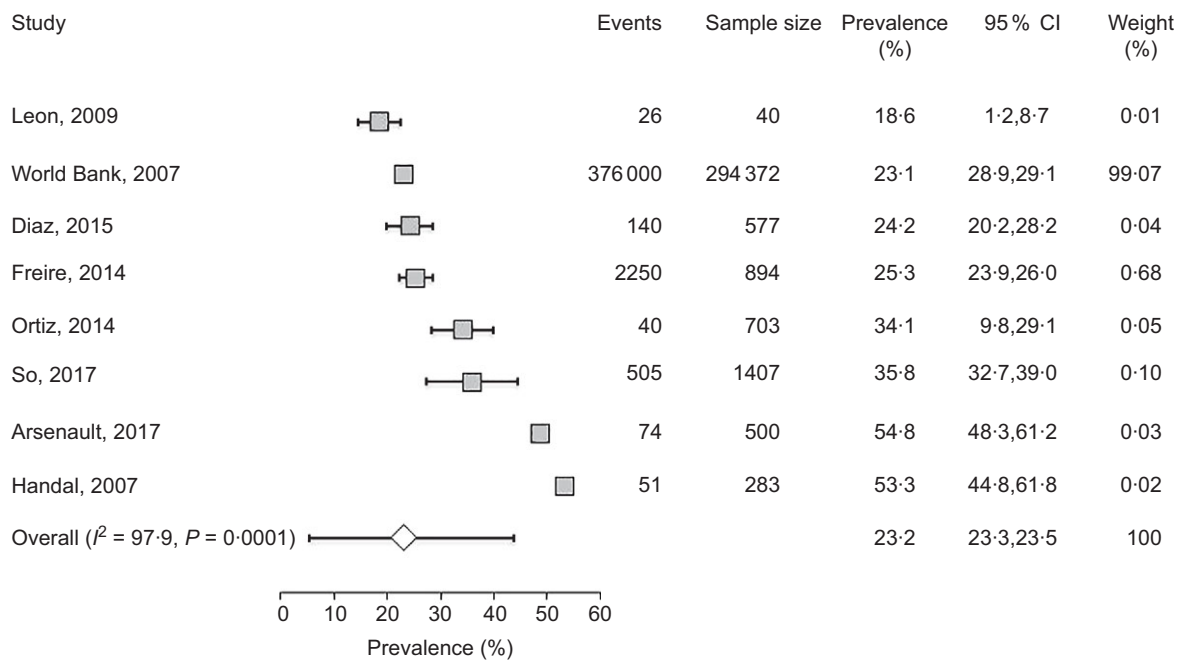


Fig. 2 Forest plot of a random effects meta-analysis of the prevalence of stunting in preschoolers (age <5 years). Values are standardised mean differences (95 % CI). The shaded squares represent the point estimate for each individual study, and the horizontal line extending from each square represents the upper and lower limits of 95 % CI. The characteristics of each study include number of events, sample size, prevalence, 95 % CI and study weight. The white diamonds represent the overall estimate of pooled prevalence

accelerated growth faltering during the 6–24-month period were also reported in other countries^(53–55). It is not clear why this growth faltering occurs mostly during the period 6–24 months. It is, however, noteworthy to indicate that this time coincides with a reduction or cessation of breast-feeding which may increase the risk of nutritional deficiencies, seriously compromising normal growth of children⁽²⁶⁾. This suggests that poor feeding practices might play an important role in influencing the growth of children, mostly after 6 months of age. In Ecuador, children in low-income families are given common adult foods often with low nutritive value and hard to digest given the fragile digestive system at this age. These findings highlight a time frame for the development of childhood nutritional defects and could help to elaborate preventive interventions to curb the development of stunting at its early stages.

The high prevalence of stunting represents an important challenge in a country with limited resources like Ecuador. Stunting in childhood has short-term and long-term negative repercussions on human health and economic development⁽⁵⁶⁾. In addition to reduced physical growth and increased risks of morbidity and mortality^(6,44,57), stunting is also associated with diminished cognitive and motor development^(58,59) which may lead to poor academic achievement and low economic productivity^(56,60). In relation to this, the evidence from Ecuador has been presented in a study of over 3000 preschool-age children, showing that stunting is associated with significant inferior language skills⁽⁶¹⁾. In light of the results of this study, and knowing

the lifetime cost of stunting, it is imperative that Ecuador elaborates and maintains a comprehensive strategy to address the root factors that lead to stunting. Such action is beneficial to human health as well as the country’s overall economic growth.

In addition to stunting, Ecuador is experiencing a high occurrence of obesity in adults. In general, the distribution of these conditions is defined mostly by economic inequality between communities, in that stunting is mostly affecting poor communities while obesity is encountered largely in economically advantaged urban residents^(8,35). This pattern of independent distribution does not, however, explain the fact that stunting and obesity co-exist within the same Indigenous communities in Ecuador⁽³⁾ and other countries^(59,62). While this coexistence is unexpected, since stunting is caused by undernutrition and obesity is the result of over-nutrition, previous studies indicated that early life stunting is a risk factor for the development of obesity at later age^(59,62,63) through a physiological adaptation mechanism referred to as ‘catch-up’ or ‘post-starvation obesity’^(64–67). Because stunting and obesity, considered separately, each presents an important risk factor for the development of diseases, the co-existence of both conditions represents a double burden that increases tremendously public health concerns.

Although most studies reported in this review are recent and do not allow the assessment of the occurrence of obesity over time, there is a strong evidence that current rate of obesity is high among adult Ecuadorians. Moreover, the rate of obesity increases with age and is more prevalent

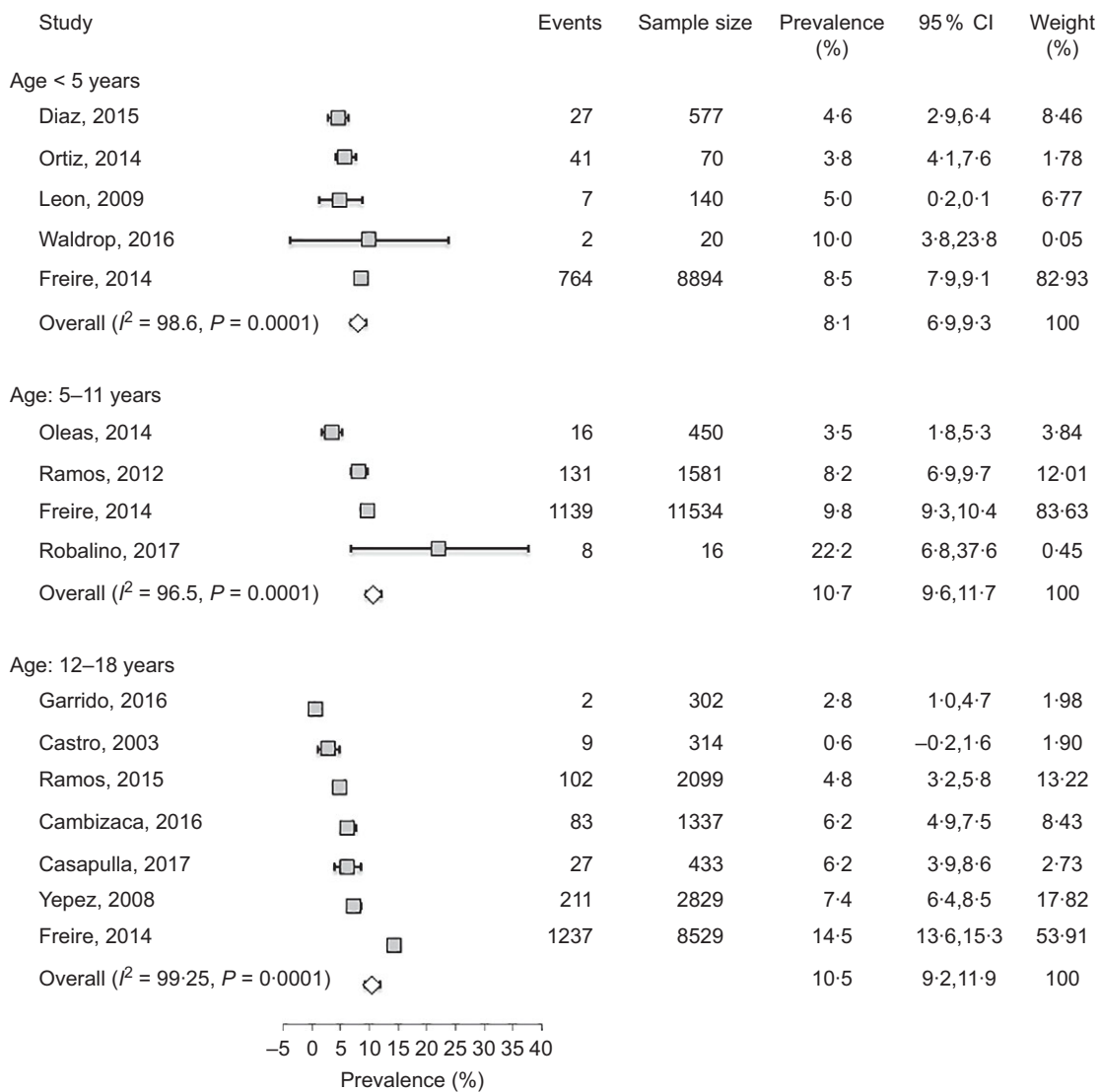


Fig. 3 Forest plot of a random effects meta-analysis of the prevalence of obesity in preschoolers (age < 5 years), school-age children (age: 5–11 years) and adolescents (age: 12–18 years). Values are standardised mean differences (95 % CI). The shaded squares represent the point estimate for each individual study, and the horizontal line extending from each square represents the upper and lower limits of the 95 % CI. The white diamonds represent the overall estimate of pooled prevalence in percent

in urban than rural regions. Similar heterogeneous trends were also reported in LMIC as well as high-income countries^(1,68) – an indication that obesity is a common problem worldwide. Several factors could contribute to rural–urban disparity of obesity prevalence including diet composition and physical activity. In Ecuador, as is the case for most LMIC, obesity is associated with a fast trend of mechanisation and urbanisation which is also accompanied with important shifts in diet composition and physical activity. In the urban areas, reduced physical activity and increased consumption of ultra-processed energy-dense foods, to the detriment of traditional plant-based foods, contribute substantially to the development of obesity^(3,11,13). Because obesity is often associated with diabetes and CVD^(7,69), it is possible that increased risks of CVD in Ecuador^(70–72) are linked to the rise of obesity⁽⁸⁾. Taken

together, these findings indicate that national effort towards the prevention and treatment of obesity, as well as undernutrition, should be a public health priority in Ecuador to limit the risk of co-morbidities.

Strengths and limitations of the study

The strengths of this review include a comprehensive and rigorous systematic search using well-established PRISMA guidelines. In addition, this search included multiple and widely known databases as well as uniform and reproducible data extraction using a preset checklist so as to minimise errors and bias⁽¹⁴⁾. This review also included studies from different regions of the country. Like any systematic review, mainly from observational studies, this study has limitations. First, we included only studies published

Table 4 Characteristics of studies relevant to adults (age ≥ 19 years)

Reference no.	Location	Study duration	Sample size	Gender (%) (female/ male)	Age (years)	Methods of measurements	Finding	
							Ow	Ob
Orces <i>et al.</i> ⁽⁸⁾	Andes and coastal	2010	2053	53/47	> 60	BMI according WHO criteria. AO according to IDF criteria	F: 43.0 %, M: 40.3 % Rural: 18.75 %, Urban: 20.54 %	Obesity: F: 22.6 %, M: 9.6 % Rural: 3.1, Urban: 7.03 Ethnicity: Indigenous: M: 7.5 %, F: 43.4 % White M: 20.5 %, F: 66.5 % Mulatto M: 29.1 %, F: 67.2 % Mestizo M: 15.5 %, F: 68.8 % Afro-Ecuadorians: M: 26.1 %, F: 77.7 % Abdominal obesity: F: 65.9 %, M:16.3 %
Sempertegui <i>et al.</i> ⁽⁴¹⁾	Quito	2003–2004	352	64/36	> 65	BMI according WHO criteria AO according to IDF criteria	F: 41.2 %, M: 29.5 %	Obesity F: 14.0 %, M:3.3 % Abdominal obesity: All: 61 %, F: 75 %, M: 37 %
Jairala <i>et al.</i> ⁽⁴⁰⁾	Guayaquil	2006–2011	441	37/63	21–85	BMI according WHO criteria	All: 43.31 % F: 23.9 %, M:48.8 %	Obesity: All: 27.21 %, F: 13.7 %, M:30.9 %
Torres <i>et al.</i> ⁽⁴³⁾	Cuenca	2013–2014	318	57/43		BMI according WHO criteria AO according to IDF criteria	All: 39.9 % F: 36.3 %, M: 44.9 %	Obesity: All: 23.6 %, F: 27.5 %, M: 18.4 % Abdominal obesity: All: 80.5 %, F: 84.6 %, M:75.0 %
Campoverde <i>et al.</i> ⁽³⁹⁾	Cuenca	2013–2014	318	57/43	>18	BMI according WHO criteria	All: 41.3 % Age: <40 years: 35.2 % 40–50 years:42.7 % > 60 years: 46.2 %	Obesity: All: 21.13 % <40 years: 4.8 % 40–59 years: 29.0 % > 60 years: 34.6 %
Freire <i>et al.</i> ⁽³⁾	Nationwide survey	2011–2013	87 280	50/50	19–60	BMI according WHO criteria	F: 38.3 %, M: 44.3 %	Obesity: F: 28.1 %, M: 17.0 % Ow/Ob All: 62.8 % F: 65.5 %, M:60 % Obesity: All: 25 %
Waldrop <i>et al.</i> ⁽²⁷⁾	Isabela Galapagos	2010	20	F: 100	Newborns	BMI according WHO criteria	All: 45 %	Obesity: All: 17.9 % Abdominal obesity: All:59 %, F:60.9 %, M: 57.5 %
Salazar <i>et al.</i> ⁽⁴²⁾	Imbabura	2014	297	46/54	33–53	BMI according WHO criteria AO according to IDF criteria	All 51.7 % F: 22 %, M:28.8 %	Obesity: All: 17.9 % Abdominal obesity: All:59 %, F:60.9 %, M: 57.5 %

IDF, International Diabetes Federation; F, female; M, male; Mestizo, descendants of mixed marriage; Mulatto, descendants of mixed white and black ancestries; Montubio, mestizo people living in countryside of coastal Ecuador; AO, abdominal obesity.

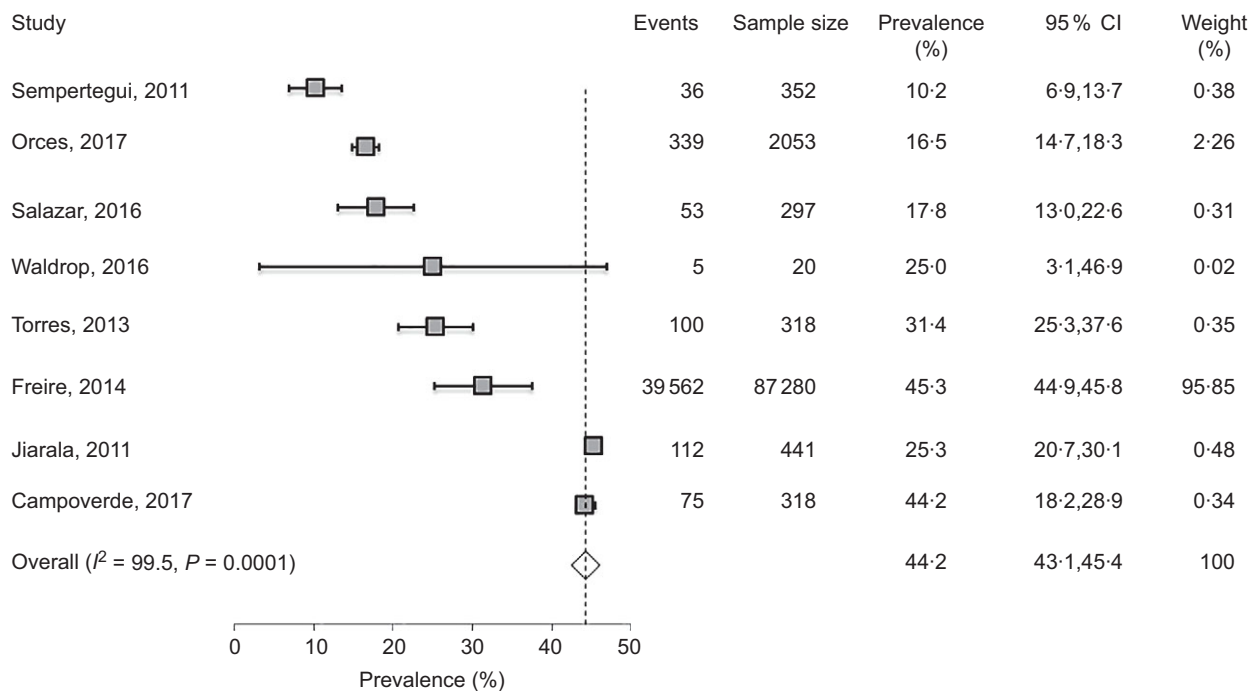


Fig. 4 Forest plot of a random effects meta-analysis of the prevalence of obesity in adults (age ≥ 19 years). Values are standardised mean differences (95 % CI). The shaded squares represent the point estimate for each individual study, and the horizontal line extending from each square represents the upper and lower limits of the 95 % CI. The white diamonds represent the overall estimate of pooled prevalence in percentage

in international and peer-reviewed journals and may have missed important unpublished data or local/internal reports which is a common practice in some countries. Second, there was some variation and heterogeneity of sample size among studies which may have introduced some weakness in the meta-analysis. It is, however, important to indicate that our results are in agreement with other studies in South America and in other parts of the world^(47,53,58). Third, this review did not calculate the effect of specific factors on the study outcomes, such as ethnicity, age and geographic location. This was due to the fact that the number of studies considering these factors was very limited and did not allow statistical analysis. Therefore, we included all studies to calculate overall pooled estimates and described the impact of these factors narratively in the results citing references when available. Finally, because most studies were relatively recent and did not allow an assessment over time, this review does not provide information on the longitudinal evolution of the study outcomes.

Conclusions

The prevalence of stunting is markedly high nationwide, but is mostly prevalent in low-income population including Indigenous and rural communities. In addition, the prevalence of obesity is strikingly elevated in adults and is not equally distributed among ethnicities and rural-urban

locations. The existence of this double burden – stunting and obesity – represents a major public health concern that requires further robust and sustained interventions.

Acknowledgements

Acknowledgements: The authors would like to thank Dr. Thomas Fungwe for helpful discussion. *Financial support:* This work was made possible by the generous support of Hackensack University Medical Center. *Conflicts of interest:* None. *Authorship:* The authors' contribution is as follows: V.A.A. and L.C. conducted the initial search. V.A.A., L.C. and T.H. analysed the data, designed and wrote the manuscript. All authors (T.H., V.A.A. and L.C.) read and approved the manuscript. *Ethics of human subject participation:* Not applicable.

Supplementary material

For supplementary material accompanying this paper visit <https://doi.org/10.1017/S1368980020002049>.

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