REVIEW ARTICLE

Describing studies on childhood obesity determinants by Socio-Ecological Model level: a scoping review to identify gaps and provide guidance for future research

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Abstract

Childhood obesity is increasing worldwide and is a major public health concern once children with obesity are at higher risk for several diseases and are often stigmatized. Children with obesity are more likely to become adults with obesity with greater needs of healthcare. Determinants of childhood obesity might be grouped in five levels according to the Socio-Ecological Model (SEM): individual, interpersonal, institutional, community and policies. This scoping review emerged from the need to identify which determinants of childhood obesity have been more frequently studied (and how) and which require more investigation. The main objectives were to quantify studies on the determinants of childhood obesity by SEM level addressed, to identify gaps in the literature regarding the studied SEM level(s), to describe the studies' characteristics and to provide guidance for SEM levels that need further investigation. This scoping review follows the five-stage protocol methodology proposed by Arksey and O'Malley in 2005. PubMed database was systematically searched, and hand-searches also took place. The search yielded 975 results from which 552 were excluded after title and abstract reading. The remaining 423 results were fully read and information about methodologic aspects, namely study design, sample size, sample constitution (children, dyads or/and parents) and children's age as well as the SEM level determinants addressed was retrieved. Despite the consensus about the appropriateness of SEM as a framework to comprehensively examine childhood obesity determinants, studies addressing all SEM levels determinants jointly or the policies level determinants alone were not found. Other gaps shown were: the small number of studies that included the policies level determinants alongside determinants from other levels ($N = 10$) and studies using cohorts study design (ranging from 2 to 28 per SEM level). These gaps should be considered when planning future research.

Introduction

Obesity overall and childhood obesity specifically, has been increasing worldwide for the last few decades and is considered a major public health concern in many countries [1–4]. Obesity is a preventable, non-communicable disease and a risk factor for the development of other diseases in

children namely asthma, non-alcoholic fatty liver, type 2 diabetes mellitus, hypertension, obstructive sleep apnea, some type of cancers and dyslipidemia among others [3–6]. Besides, children with overweight and obesity are often stigmatized, both by their peers and by the society overall [7]. In short, children with obesity have poorer health status when compared with children with normal weight and are more likely to become adults with obesity and several comorbidities [2, 3, 8]. Individuals with obesity have lower quality of life and represent a burden for national health care systems due to the high need to use these services [3, 9]. Recent efforts have been made by some governments to tackle childhood obesity, but have not accomplished significant results, so far [10].

Childhood obesity results from the complex relation between aspects of different nature namely genetic, environmental and community, for example [3, 6]. These aspects are

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systematized by the Socio-Ecological Model (SEM), a theoretic framework that aims to better understand the factors that impact individual's health [11]. SEM is an adaptation of the Ecological Systems Theory proposed by Urie Bronfenbrenner in 1977. The Brofenbrenner theory states that, to comprehend the individual and his behaviour it is necessary to consider not only his immediate context but also the environmental aspects beyond its sphere of proximity [12]. Centers for Disease Control and Prevention (CDC [13]) groups childhood obesity determinants into the following five SEM levels: the individual (knowledge, attitudes, beliefs and behaviours), the interpersonal (family, peers, social networks and associations), the institutional (rules, regulations, policies and informal structures), the community (social networks, norms and standards) and the policies level (local, state, federal policies and laws to regulate/support healthy actions). Studies have mostly focused in certain SEM level aspects such as, the individual or the interpersonal, but evidence about the combined impact of factors from different levels in childhood obesity is scarce [11].

Recent systematic reviews and meta-analyses on childhood obesity focus in specific issues, namely the impact of the built environment characteristics [14, 15] or the socioeconomic status [16, 17] in children's weight. Other reviews screen the literature that describes interventions and programs aimed at tackling childhood obesity to identify the reasons that lead to the success or to the lack of significant results of such programs and interventions [18, 19]. Unlike the latter reviews, it was not this study aim to identify factors that are consistently associated (or not) with childhood obesity nor to provide insight about what are the most successful interventions to tackle childhood obesity. Such interventions might be designed using SEM as framework, but they do not identify childhood obesity determinants [20].

This scoping review emerged from the need to identify which SEM levels of determinants of childhood obesity have been more frequently addressed (and how), and which still require further investigation. It was hypothesized that few studies address all SEM level determinants jointly and that there is a disproportionality between the number of studies per level of SEM. Thus, this review main objectives were to quantify the studies on the determinants of childhood obesity per level of SEM and to identify gaps in the literature on this subject which, to the best of our knowledge, has not been done yet. Furthermore, it was also intended to describe the studies' methodologic characteristics and to provide guidance for future research.

Methods

This scoping review follows the five-stage protocol methodology proposed by Arksey and O'Malley [21] and later updated by Levac et al. [22]. According to the latter authors, scoping reviews have been given little attention when compared with other types of reviews, such as the systematics. Nevertheless, scoping reviews might be more appropriate when the research question is broader, and the goal does not comprise the evidence systematizing nor the studies quality assessment, such as in this study. Furthermore, scoping reviews allow the incorporation of different study designs which enhances the findings without compromising its reliability [21, 22].

In this scoping review, one can identify two out of the four reasons that Arksey and O'Malley [21] lists as the most common, to undertake such study: the first, which is to map a large amount of literature available on a subject by assessing its extent, range and nature without describing its findings; and the second that encompasses the identification of gaps in the literature, but not gaps in the research.

Stage 1: identifying the research question

This study research question arose from the need to identify which SEM level of childhood obesity determinants have been more frequently studied, and whether there are gaps in this literature. Furthermore, it was intended to verify if the study design, sample size and constitution, among other characteristics, differ according to the SEM level of determinants under study. Thus, this study research question was: *which SEM level of determinants of childhood obesity have been more studied (and how), and what are these studies main characteristics?*

Stage 2: identifying relevant studies

The identification of the relevant studies was performed through a systematic search in PubMed using the following search expression: *("Pediatric Obesity" OR "Childhood Obesity") AND ("Risk factors" OR "Social Determinants of Health" OR "Socioeconomic Factors" OR "Built Environment" OR "Residence Characteristics" OR "Social Support" OR "State Government") NOT ("early intervention" OR "program" OR "prevention" OR "adolescents" OR "adults")*, and with the following filters activated: Journal Article, Humans, English, French, Portuguese, Spanish, Child: Preschool Child: 2–5 years, 6–12 years. In order to achieve this search expression, several attempts were done using different combination of Medical Subject Headings (MeSH) terms. The MeSH terms used were selected after searching for each term definition in the MeSH database from PubMed. In addition to the terms related to childhood obesity, the other included terms intended to represent each of the SEM level determinants. Excluded terms are mostly related with interventions and programs as this type of studies were out of the scope of this

review. The search was conducted in July 25 of 2018 and the number of papers retrieved from PubMed were 970. Hand searches were also performed, and five pertinent studies were found and included in this review.

Stage 3: study selection

Stage 3 was subdivided in two steps: in the first step all 975 papers were screened (by reading the title and abstract) to include only the relevant papers and, in the second step the previously included 423 papers were fully read to assure their relevance to the present scoping review and to retrieve relevant information (Fig. 1).

Stage 4: charting the data

A database in SPSS (v.20) format was created and the following information was retrieved from the 423 papers included in this scoping review: year of publication, title, abstract, country of origin (where the study was conducted), study design, sample size, sample constitution (children, dyads or/and parents) and children's age.

Studies were also screened to identify which SEM level of childhood obesity determinants were addressed. The SEM levels of the variables analyzed in each study were identified taking into account the description of each SEM level presented as follows, and not according to the conceptualization of such aspects made by each study. The SEM levels used in this scoping review were based in the model proposed by CDC [13]: (1) the individual level that includes all factors intrinsically related with the child such as age, gender, biological and anthropometric information as well as personal beliefs and behaviours; (2) the interpersonal level that comprises the characteristics of parents, close relatives and peers such as, educational level, socioeconomic status among others; (3) the community level which is mostly associated with the social associations,

religious groups or others that the child is integrated in; (4) the environment level of factors concerns the social and the built environment features, i.e., the neighbourhood socioeconomic status and urban design, for example; and (5) the policies level, that comprises factors of a broader dimension such as legislation and policies documentation. The main differences between CDC's levels and the ones used in this review are: the inclusion of the institutional aspects in the policies level and the creation of an independent level regarding the environmental factors.

Some studies addressing parents' sociodemographic or psychological characteristics, considered these aspects as environmental [23, 24]. However, for this review purpose, these studies were classified as addressing interpersonal SEM level determinants and not environmental, according to the conceptualization of SEM level framework previously described.

Stage 5: collating, summarizing and reporting the results

The results are presented in graphic and table format.

Results

From the 423 studies included in this scoping review, 385 studies (91.02%) addressed individual SEM level determinants, 254 (60.05%) the interpersonal level, 78 (18.44%) the community level, 89 (21.04%) the environment level and only 10 (2.36%) studies addressed aspects from the policies level (Fig. 2).

A total of 43.30% ($N = 181$) addressed factors from two SEM levels, 34.21% ($N = 143$) focused in determinants of a single SEM level and 23.35% ($N = 99$) included factors from three or more SEM levels (Fig. 3). No study assessed all five SEM levels of determinants jointly.

In Fig. 4, a Diagram of Venn is presented to illustrate the relation between and among the studies included in this scoping review. This diagram shows the overlapping of the studies according to the five SEM levels, in which the intersection relation was defined as "AND" meaning that a study can only be included in the intersection areas if it
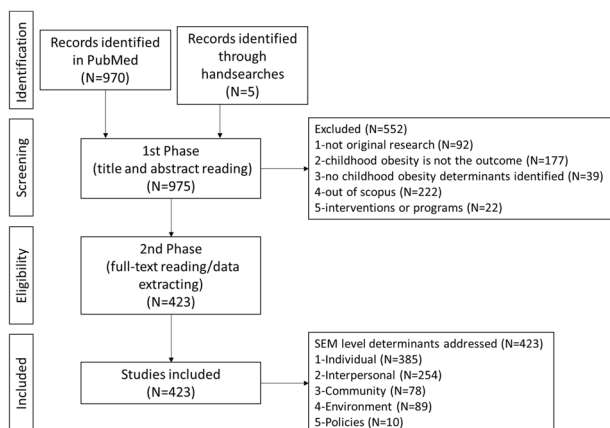

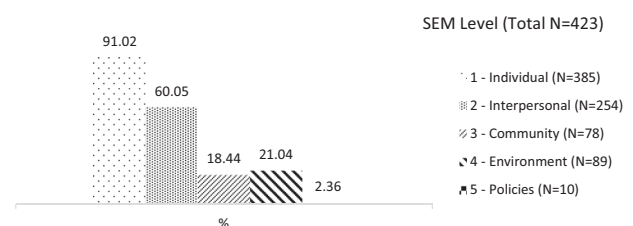Fig. 1 Flow diagram of studies included in the scoping review

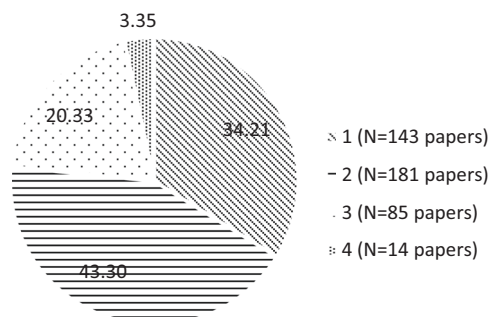Fig. 2 Proportion of papers per SEM Level determinants addressed

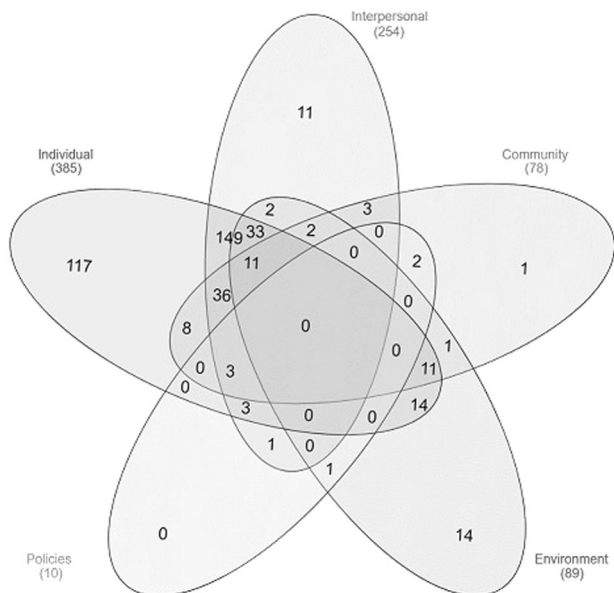**Fig. 3** Proportion of papers per number of SEM Level addressed

Fig. 4 Diagram of Venn of the number of papers by SEM Level(s) addressed (created using http://www.interactivenn.net/index2.html)

addresses the determinants of the different levels in such intersection.

In the centre of the diagram there is a "0" which means that none of the studies encompasses the five level determinants. Also, despite the existence of studies addressing the policies level determinants none focused exclusively in this level. One hundred and forty-nine studies addressed both individual and interpersonal SEM level determinants and 117 addressed only individual aspects. Thirty-six studies included individual, interpersonal and community aspects and 33 included environmental determinants as well as the individual and interpersonal variables. Fourteen studies focused in both individual and environmental levels simultaneously and another 14 addressed the environmental features exclusively. Eleven studies comprised the individual, interpersonal, community and environmental level and three studies included the individual, interpersonal, community and policies levels (Fig. 4).

Table 1 summarizes the main characteristics of the studies included in this scoping review. Overall, studies were very identical once they were mostly published in the last 5 years and a half, come from USA, UK or China, use cross-sectional study designs, with sample sizes of 1000 or less participants, mostly children with a combination of different ages. Studies assessing the environmental determinants used slightly larger samples than the other studies once this type of studies usually resort to secondary data, such as census data or another institutional source.

Discussion

This scoping review results show the following gaps in the literature: studies addressing all SEM levels determinants jointly or the policies level determinants alone were not found. Other gaps shown by the results were: the small number of studies that included the policies level determinants alongside determinants from other levels ($N = 10$) and studies using cohorts study design (ranging from 2 to 28 per SEM level). Despite it, there is a consensus about the appropriateness of SEM as a theoretical framework to comprehensively examine childhood obesity determinants, that involves individual, interpersonal, community, environmental and policies level factors [20].

Above all, the gaps in the literature identified in this study reveal that there is a large disproportionality between the number of studies per SEM level of determinants addressed. The amount of evidence about the individual level of determinants, which were addressed by 285 (91.02%) studies, allows us to state that these determinants are almost undeniably associated with childhood weight status [15] whereas more evidence is needed about the role of the community, environmental and policies levels determinants, that altogether were addressed only by 177 (41.84%) studies. So far, the latter levels of determinants remains understudied [25].

Governments are responsible for providing healthy environments for populations to live in [26] namely by the implementation of policies through legislation. Determinants from the policies SEM level are considered as a group of broader and modifiable factors with a potentially high impact on individuals health due to its capacity of embracing large layers of the population [13, 26]. Furthermore, policies are sustainable and cost-effective tools to tackle obesity [26]. For example, in the USA, counties that have stronger nutritional laws concerning school lunches, nutrition education curriculum requirements or food and beverages advertisements at schools, among others, have lower childhood obesity prevalence when compared with counties with no legislation in such matter [27].

Table 1 Studies characteristics according to Socio-Ecological Model (SEM) level of determinants addressed

	Total (N = 423)	Level of SEM addressed				
		Individual (N = 385)	Interpersonal (N = 254)	Community (N = 78)	Environment (N = 89)	Policies (N = 10)
	N (%)					
Year of publication						
1984–2000	18 (4.3)	17 (4.4)	10 (3.9)	2 (2.6)	4 (4.5)	0 (0.0)
2001–2006	19 (4.5)	18 (4.7)	12 (4.7)	2 (2.6)	2 (2.2)	0 (0.0)
2007–2012	116 (27.4)	108 (28.1)	76 (29.9)	28 (35.9)	25 (28.1)	5 (50.0)
2013–2018 (Jul)	270 (63.8)	242 (62.9)	156 (61.4)	46 (59.0)	58 (65.2)	5 (50.0)
Country of origin						
USA	131 (31.0)	113 (29.4)	82 (32.3)	30 (38.5)	28 (31.5)	7 (70.0)
UK	29 (6.9)	28 (7.3)	14 (5.5)	9 (11.5)	12 (13.5)	0 (0.0)
China	26 (6.1)	24 (6.2)	14 (5.5)	0 (0.0)	4 (4.5)	0 (0.0)
Canada	20 (4.7)	17 (4.4)	12 (4.7)	5 (6.4)	5 (5.6)	0 (0.0)
Germany	14 (3.3)	14 (3.6)	10 (3.9)	2 (2.6)	3 (3.4)	0 (0.0)
Brazil	11 (2.6)	11 (2.9)	7 (2.8)	4 (5.1)	3 (3.4)	0 (0.0)
Greece	11 (2.6)	11 (2.9)	6 (2.4)	1 (1.3)	0 (0.0)	0 (0.0)
Mexico	11 (2.6)	10 (2.6)	7 (2.8)	1 (1.3)	2 (2.2)	0 (0.0)
Australia	10 (2.4)	9 (2.3)	5 (2.0)	1 (1.3)	1 (1.1)	0 (0.0)
Portugal	10 (2.4)	10 (2.6)	9 (3.5)	0 (0.0)	3 (3.4)	0 (0.0)
Others	150 (35.5)	138 (35.8)	88 (34.6)	25 (32.1)	28 (31.5)	3 (30.0)
Study design						
Cross-sectional	266 (62.9)	242 (62.9)	159 (62.6)	61 (78.2)	72 (80.9)	6 (60.0)
Cross sectional using cohort/longitudinal data	83 (19.6)	72 (18.7)	55 (21.7)	8 (10.3)	11 (12.4)	3 (30.0)
Cohort (birth, prospective, retrospective...)	28 (6.6)	27 (7.0)	16 (6.3)	2 (2.6)	3 (3.4)	0 (0.0)
Other (qualitative, case-control, observational...)	46 (10.9)	44 (11.4)	24 (9.4)	7 (9.0)	3 (3.4)	1 (10.0)
Sample size						
1000 or less	167 (39.5)	161 (42.1)	95 (37.7)	24 (32.0)	19 (22.1)	0 (0.0)
1001–4000	111 (26.2)	102 (26.7)	66 (26.2)	16 (21.3)	26 (30.2)	3 (33.3)
4001–8000	59 (13.9)	53 (13.9)	40 (15.9)	12 (16.0)	13 (15.1)	2 (22.2)
8001 or more	79 (18.7)	66 (17.3)	51 (20.2)	23 (30.0)	28 (32.6)	4 (44.4)
Missing	7 (1.7)	x	x	x	x	x
Sample constitution						
Children	343 (81.1)	316 (82.1)	182 (71.7)	65 (87.2)	83 (93.3)	9 (90.0)
Dyads (children and mother or father)	70 (16.5)	63 (16.4)	64 (25.2)	8 (10.3)	4 (4.5)	0 (0.0)
Parents (mothers and/or parents)	6 (1.4)	3 (0.8)	6 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)
Other (households, schools, neighbourhoods…)	4 (0.9)	3 (0.8)	2 (0.8)	2 (2.6)	2 (2.2)	1 (10.0)
Children age						
Up to 5 years	38 (9.0)	34 (9.0)	28 (11.0)	3 (3.9)	3 (3.4)	1 (10.0)
From 6 to 8 years	45 (10.6)	41 (10.8)	26 (10.2)	6 (7.8)	8 (9.1)	0 (0.0)
Other ages or mix of different ages	334 (79.0)	304 (80.2)	200 (78.7)	68 (88.3)	77 (87.5)	9 (90.0)
Missing	6 (1.4)	x	x	x	x	x

x Not applicable

Although late, governments worldwide are starting to pay more attention to the obesity epidemic, but few are implementing public health measures to decrease obesity prevalence [10, 26]. In Portugal, the government has recently approved overtaxing beverages that exceed a defined amount of added sugar thus, inhibiting the

consumption of large amounts of sugar of the entire population [28]. So far, there are no epidemiological studies about the impact of such legislation [26] in the Portuguese's health. However, some of the Portuguese beverage industry claims to have decreased the amount of sugar in their products. This governmental decision was partially based on the resulting Consensus on the use of Low- and No-Calorie Sweeteners (LNCS) from the International scientific experts in food, nutrition, dietetics, endocrinology, physical activity, paediatrics, nursing, toxicology and public health met in Lisbon on July 2017 [29]. Similar policies were implemented by some governments of MERCOSUR countries, namely Argentina, Brazil, Paraguay, Uruguay, Chile, Equator and Peru as well as by the Mexican and Canadian governments, for example. In these countries the food items' labelling was regulated to become clearer and more precise regarding LNCS addition [29] and in some cases there was also a tax increase of sweetened beverages. A study conducted in Chile, aimed to assess the potential impact of increasing taxes of sugar sweetened beverages on consumption trends, concluded that taxation of soft drinks might reduce its consumption and consequently decrease the overweight/obesity epidemic in this country [30]. Regardless, Vallgarda [31] sees these type of actions as minimal considering the dimension of the problem and affirms that despite the political discourses emphasizing the magnitude of the problem, politicians propose few and weak measures, perhaps due to the importance of the food and drink industry freedom.

Measures to tackle childhood obesity focused in a single level of determinants, as the ones previously mentioned, might not be the more appropriate nor have the most significant results once childhood obesity is the product of a complex interaction between different nature aspects. Instead, the delineation of interventions and programs to tackle childhood obesity should use SEM as framework and have in consideration the interaction between aspects either from the same level or from different levels [20]. Such approach was taken in consideration in the delineation of programs implemented in four cities from USA. In these cities, directives from national level policies were integrated in community level programs, which in turn were materialized in specific actions in school settings, local associations or in entire communities, to promote healthier lifestyles in families, thus in children. In all four cities there was a statistically significant decrease in childhood obesity which suggests that the conjugation of efforts from different level institutions might be the most successful strategy [20].

Obesity only caught the governments attention when it was considered an epidemic [10]. The delayed awareness of governments for this matter might be related with the lack of monitoring of obesity prevalence evolution throughout time. This could have been prevented if individuals' weight

and overall health was systematically assessed and disseminated, namely resorting to research projects using cohorts study designs. Longitudinal cohort designs enable the assessment of the determinants and aetiology of [childhood] obesity. The 1958 British birth cohort, that used data from two generations, showed that not only the prevalence of childhood obesity increased substantially since the early 1980's, but also that the direction of some risk factors shifted throughout time [32]. It was found that before 1984, having a low socioeconomic status was protective for childhood obesity but afterwards it became a well-known childhood obesity risk factor. Authors suggest that this shift might be due to the difficulty in acquiring healthy foods once they have become more expensive [32]. Policies need this type of evidence—from longitudinal studies—in order to successfully tackle childhood obesity [33]. However, the results from this review showed that only a few of the analyzed studies used cohort data or performed longitudinal analysis.

Evidence from longitudinal cohort studies are especially useful in the identification of the diseases or ill health causes. For example, longitudinal evidence showed that mother depressive symptomology in early childhood causes a suboptimal child development or that the use of paracetamol while pregnant or during infancy causes wheezing [34]. Regardless, there is lack of longitudinal research projects, mostly because it requires great efforts to have a continuous source of funding. Like most research projects, longitudinal projects have a maximum of 3 or 4 years of funding at a time. This is not in line with the nature of a longitudinal study design [35]. Most of the funders are not willing to wait long for results and evidence from longitudinal studies takes time to achieve, even though longitudinal studies are more cost-effective when compared with cross-sectional studies [34].

Another result of this review highlights the large amount of studies that address the individual SEM level determinants, either by itself or in conjunction with determinants from other SEM levels (385 of the 423 studies). Once again time and costs issues are probable barriers to the design of projects that include more SEM level determinants, which should be mitigated in future studies. The individual determinants include psychological, biological and genetic factors that are intrinsic of the child. Both the psychological and biological aspects have been consistently associated with children's weight status [36]. In fact, several genes have been identified as obesity risk genes and evidence suggests that the predisposition for obesity might be inherited [3, 37]. According to Llewellyn et al. [38] such predisposition enhances the risk of obesity but only when combined with obesogenic environments and through a low satiety responsiveness mechanism. Physiologic and biochemical mechanisms are responsible for the regulation of

children's body weight but these are influenced by behaviours and environmental factors [37]. Endocrine changes or specific genetic syndromes alone are the causes for obesity of a small proportion of children with such condition [3]. Besides, humans are genetically stable for a long time now, i.e., no significant genetic changes in humans have been documented recently [32]. Thus, the increase of childhood obesity over the last thirty years has little to do with genetic factors [39]. Groups of individuals with similar genetic background, but living in different biosocial and cultural environments, have different rates of obesity [40]. Nevertheless, there are still few researchers stating that genetics might explain up to 70–90% of the variation in BMI [36]. Further and more systematic research is needed about this specific topic that it is still not consensual.

Nowadays the environmental factors are considered one of the main drivers of the obesity epidemic [39] but, as one can observe, not all individuals living in the same environment develop obesity [41]. This means that the interaction between environment and genetics have different results in different individuals regarding obesity. For example, the risk of a child developing obesity is enhanced when he/she has a genetic predisposition to become overweight, inherited from the parents, and is surrounded by an obesogenic environment [37]. Hence, if couples are joined based in similarities, individuals with overweight will contribute to an increased rate of children with overweight, as Bouchard [42] concludes.

Several theories attempt to explain the drivers of obesity, but none is flawless due to the inherent complexity of this condition [26, 41] which is determined by numerous factors from different natures that interrelate through distinct mechanisms. This poses as obstacles when attempting to define obesity aetiologically [41] and when identifying childhood obesity risk factors or protective aspects. It also represents a methodological challenge regarding data analysis. For example, environment features such as the presence of parks in the neighbourhoods and legislation about the quality of food available at school are both important aspects and might impact children's weight but its joint analysis is a complex task. So, even though research about childhood obesity should be more holistic, such obstacles and challenges might be the reasons for the lack of studies addressing all levels of determinants jointly or the high number of studies focusing only in one or two SEM levels of determinants.

Strengths and limitations

To the best of our knowledge this is the only scoping review that aimed to describe studies about childhood obesity determinants regarding the nature of the assessed factors. The use of SEM categorization of childhood obesity determinants, based in the CDC proposal, proved to be a useful tool to achieve this review goal, more specifically the identification of gaps in the literature on the determinants of childhood obesity. Thus, the results from this review are unique and provide a broader understanding of the existing literature and its gaps which is useful when delineating future researches.

This review does not provide a summary of the evidence on the magnitude of associations between the determinants of different SEM levels and children weight status, which might be considered as a limitation. However, the goal of this review was to quantify and describe studies according to the SEM level addressed and not to identify new childhood obesity risk factors nor to compare studies' results. Thus, the studies were included regardless of the study designs, statistical analyses and definitions of overweight and childhood obesity used.

Conclusion

Individual level determinants of childhood obesity are the most studied but, it is important to acknowledge that they cannot solely explain children's weight status. Childhood obesity is determined by aspects of different nature so, studies should be based in a more holistic perspective, i.e., address aspects from different SEM levels simultaneously. This requires new analytical methods and more suitable quantitative analysis, such as multilevel modelling techniques to encompass all relevant childhood obesity determinants in future research.

Also, more research is needed on policy-level determinants alongside other childhood obesity determinants. It is crucial to deepen the knowledge about the real impact of legislation focused on the promotion of healthy lifestyles, in the population weight status.

Finally, populations' weight status should be systematically monitored, and its determinants assessed, using longitudinal cohort designs to enable the development of informed and evidence-based interventions in the future.

Compliance with ethical standards

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