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A systems thinking framework for understanding rising childhood obesity in the Caribbean

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Abstract

Objective The aim of this study is to develop a systems thinking framework to describe the common complexities of childhood obesity in the Caribbean region and identify potential areas of intervention.

Methods Group model building (GMB) is a form of systems science. Trained GMB facilitators in Puerto Rico, the US Virgin Islands, Barbados, and Trinidad and Tobago convened a group of multi-disciplinary stakeholders in a series of virtual meetings in 2021 to elaborate a hypothesis of the system driving childhood obesity represented by causal loop diagrams (CLD). Commonalities and differences between the CLDs from each island were identified and reconciled to create a synthesized CLD.

Results A single explanatory CLD across the islands was developed and includes nine reinforcing loops. These loops addressed the interconnected role of schools, policy, commercial determinants, community and the personal experience of the child in rising childhood obesity rates.

Conclusions Despite differences across settings, there is a core system driving childhood obesity in the Caribbean, as described by stakeholders in GMB workshops. Policy solutions to the problem must be multi-faceted and multi-level to address the interlinked reinforcing loops of the complex system and reduce rates of childhood obesity.

Keywords Childhood obesity, Caribbean, Group model building, Systems science

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Introduction

Childhood obesity is on the rise globally [1–3]. Obesity has traditionally been characterized as a disease of lifestyle, with a presupposed bias that individuals' choices are at the root of its cause. However, a growing body of literature points to drivers embedded in the structure of society as significant contributors of childhood obesity. These include access to healthy foods [1, 4], the built environment[5], and, for children, the school and home environments [6], all of which interact in complex ways [7]. The Innocenti Framework proposed by Raza et al. [8] shows the cyclical nature of food systems that determine dietary patterns for children, setting eating habits that may persist throughout the lifecourse and heavily influence the future risk for NCDs. This

framework recognizes the complex factors influencing the food system for children but does not include physical activity, arguably one of the most significant primary modifiable behavioural risk factors for obesity. Indeed, physical inactivity among youth in the Caribbean is high [9], with its own set of complex drivers and determinants. Frameworks exist for improving physical activity in children, but they centre mostly around the school environment [10], which is only a part of the environment in which children live. Given the complexity of the problem of childhood obesity, there is growing evidence that, for sustainable effect, multicomponent, multi-disciplinary and multi-environment interventions are needed.

The Caribbean region, a diverse mix of countries and territories comprised mostly of islands, with many small island developing states [11], shares a common rising and high burden of childhood obesity. The region has established reducing the burden of obesity and related noncommunicable diseases (NCDs) as a political priority [12]. However, despite this political momentum, enacted policies have failed to reduce the rising prevalence of obesity [12].

Systems thinking provides an approach to understand and address complex problems, such as childhood obesity [13, 14]. Indeed, systems thinking has been embedded in the development of and frameworks related to obesity and its determinants [15]. Some of these have been derived using participatory approaches with key stakeholders and others solely through reviews of the literature or from the perspective of the authors. Adding stakeholder input can bring broad and "real world" perspectives to building conceptual models, leading to joint learning and the development of dynamic hypotheses [16].

We present a framework causal loop diagram for the Caribbean that links the complex modifiable determinants of childhood obesity (social, economic and environmental) using a stakeholder-driven systems approach. The framework recognizes the common drivers of the rising obesity epidemic, some unique to the Caribbean and some with considerable overlap with other parts of the world. Finally, together with stakeholders, it explores potential areas of intervention to change the trajectory of childhood obesity.

Methods

This framework was devised as part of a larger study: the paediatric cohort of the Eastern Caribbean Health Outcomes Research Network (P-ECHORN) study. P-ECHORN seeks to characterize intergenerational factors that contribute to paediatric cardiovascular risk. Understanding the determinants of the high and rising burden of childhood obesity in the Caribbean is a key component to developing successful interventions [17].

The participatory group model building process

The established methods of participatory group model building (GMB) were used to engage stakeholders in constructing the framework presented here [18, 19]. Between two and four group model building sessions were held with key stakeholders in each of the study settings: the United States Virgin Islands (USVI), Puerto Rico, Trinidad and Tobago and Barbados. Stakeholders included a mix of health professionals, civil society members, public health planners and researchers with perspectives on childhood obesity, education, nutrition and physical activity (Appendix A). Stakeholders were purposively recruited to ensure diverse perspectives that spanned the education, healthcare and policy systems. Eligibility included the ability to speak English or Spanish (Puerto Rico) and availability for the scheduled GMB sessions.

The GMB sessions are facilitated by persons trained in the methods of GMB. Facilitators follow a set of clear "scripts" to guide stakeholders though the process of developing a causal loop diagram and identifying feedback loops [19]. The process uses iterative steps where stakeholders define the problem and how it is changing over time, prioritize the factors contributing to the problem, identify the consequences of the problem and then illustrate how they are related in feedback loops. The group then discusses the feedback loops to identify potential points for intervention. Due to the coronavirus disease 2019 (COVID-19) pandemic, the sessions were conducted virtually [20].

Using this approach, each site developed a causal loop diagram to explain the rising burden of childhood obesity in the study settings and identify points of intervention. Individual diagrams were then combined and synthesized by the researchers into a framework causal loop diagram that included the major pathways and feedback loops common to all the settings. The composition of the stakeholders attending each virtual workshop can be found in Appendix A. The causal loop diagrams resulting from these sessions are presented in Appendix B.

Once the causal loop diagrams for each island were finalized, the research team reviewed them to identify commonalities. The shared themes contributed to the overarching causal loop diagram described in this paper.

The diagrams are drawn using conventions typical to system dynamics causal loop diagrams [21]. Briefly, the arrows in the diagram show a causal relationship between two variables. A plus sign next to an arrow indicates that a change in one variable leads to a change in the connected variable in the same direction. For example, a rise in policies supporting health will lead to a rise in healthy

communities (denoted by the + symbol), and similarly a decrease in policies would lead to a decrease in health in communities. A negative symbol indicates an opposite relationship. For instance, increasing physical education in schools will reduce physical inactivity. Similarly, a decrease in healthy communities would lead to a greater acceptance of childhood obesity. Loops are indicated by a circular arrow symbol with a label in the centre. The "R" indicates a reinforcing loop that leads to growth or decay for the variables connected. Balancing loops are labelled with a "B", indicating goal-seeking or stabilizing behaviour. Over time, balancing loops lead to an equilibrium in a system and can often explain a lack of increase or decrease in an outcome. There are no balancing loops identified by stakeholders in this framework. However, a simple example of a balancing loop could be: a person is hungry, which means they eat more food, and eating more food then makes the person less hungry.

Results

Causal loop diagram

Figure 1 presents the framework CLD derived from the multi-island stakeholder group model building sessions in the Caribbean. The CLD shows multiple interacting and connected reinforcing loops that are nested within each other, each contributing to a high and rising burden of childhood obesity. We divided the diagram into three thematic areas to describe these pathways, understanding

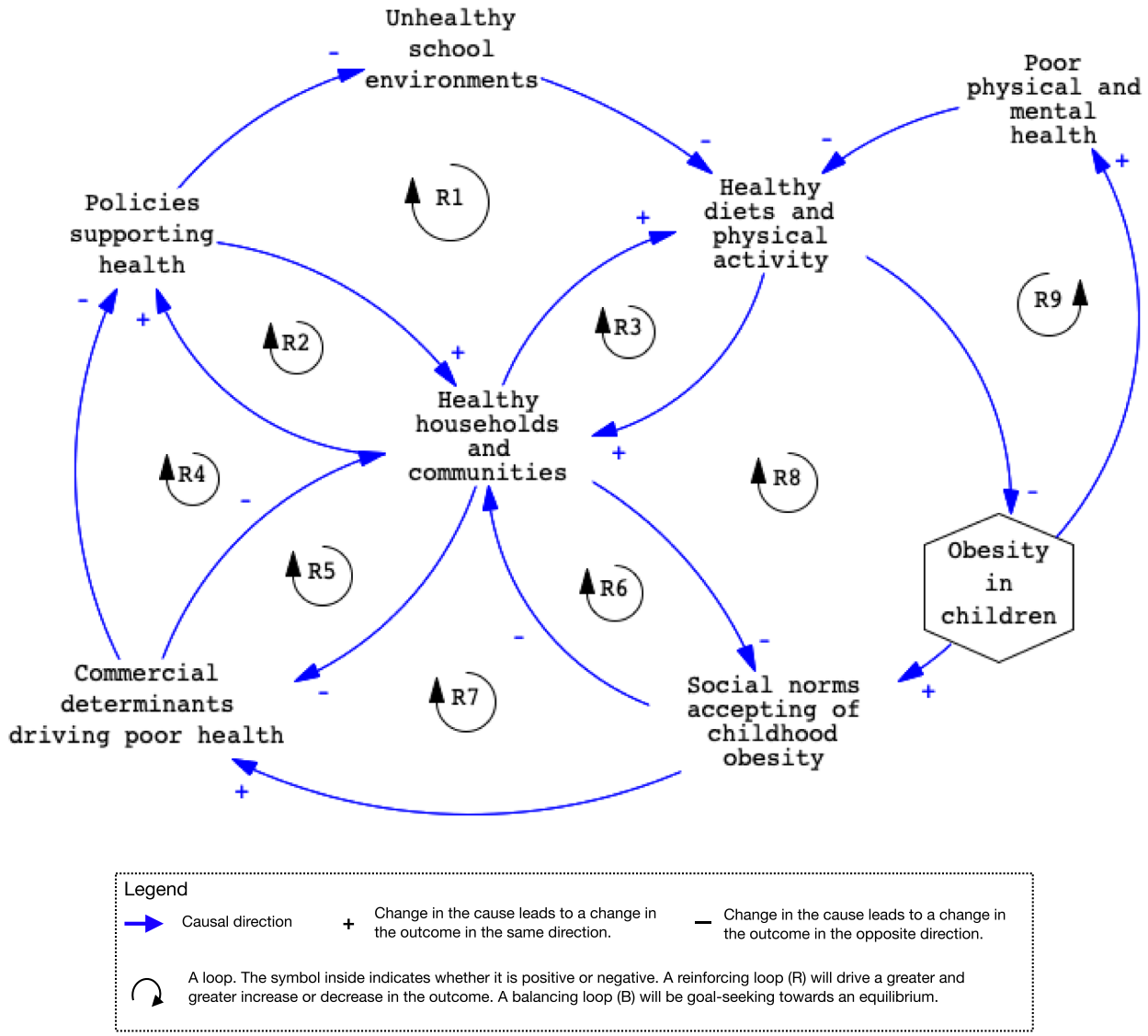

Fig. 1 School, household, and community environments

that these domains overlap and interact, and are not distinct in their relationship to childhood obesity and the environments driving it. The three areas are school and community environments, policy and commercial determinants and the experience of the child. Each is described in turn with the corresponding loops and pathways.

School, Household, and Community Determinants

School, household and community environments represent the world in which children live, learn and develop health-related behaviours. Stakeholders across all study settings described current environments that did not put an emphasis on physical activity or healthy diets for children. When parents try to improve their children's health, their efforts are undermined by the ubiquitous presence of unhealthy foods in and around schools and physical spaces that are not conducive to engaging in physical activity or active transportation. This partly explains the generally low level of physical activity among children in the Caribbean [2] and the high consumption of unhealthy foods such as sugar-sweetened beverages [22]. Unhealthy school environments have a direct impact on decreasing healthy living practices for children, undermining health in the community and, over time, weakening community support for policies supportive of health [1]. This sets up a feedback loop whereby communities are less connected to, and less supportive of, policies that are designed to strengthen healthy environments. The nature of the feedback loop means that an absence of health-promoting policies can lead to communities over time becoming less accepting of those policies. Stakeholders described school environments that favoured academic learning over physical activity and often sacrificed recreational time or physical education for more study time for students. In addition, they also described school environments being surrounded by unhealthy food either being sold directly within the school, sometimes at the demand of parents, or by vendors positioned near schools. The unhealthy school environments described by several stakeholders are a direct result of the lack of government-led regulation of these drivers of poor health.

Stakeholders posited that a community that experiences the health benefits of health-supporting policies would be empowered to support and vote for those policies [4]. Currently, communities were described by stakeholders as being generally unhealthy, which is reflected by high levels of obesity and NCDs in the region [23], and this is driving a shift in social and cultural norms that make childhood obesity more acceptable and normalized [8]. Social norms undermine the health of communities through the normalization of childhood obesity and are reinforced by the structural determinants of poor diet, including a lack of access to healthy foods, low health literacy and the historical and cultural practices that can include unhealthy dietary components [24]. However, stakeholders across all islands remarked on the strong influence of fast foods, ultra-processed foods and foods prepared outside the home as drivers of an unhealthy dietary pattern [25]. This further drives the commercial market, which then reinforces an obesogenic environment [9]. A more detailed discussion on policy and commercial determinants is presented below.

The household environment plays a critical role in the development of food and physical activity habits for the child. Some of the determinants of household food consumption were described by stakeholders as being driven by social norms and acceptability of unhealthy foods. Other determinants, however, were external, such as the affordability and accessibility of healthy foods relative to unhealthy ones as a consistent problem across the Caribbean. Stakeholders reported an increasing number of households with working caregivers or parents, and more single-parent households which limit the time for food preparation or for engaging in leisure or physical activity. Many meals are consumed or bought pre-made outside the household where the nutritional content depends on preparation outside the home.

Policy and commercial determinants

One of the major barriers to enacting effective policies is, according to stakeholders, the influence of commercial interests on policy and communities. These interests include the producers and sellers of unhealthy foods (both multinational and local) and urban and rural development that depends on car use. The many complex factors driving these determinants are shown in the island-specific CLDs in the appendix. Direct marketing and lobbying of policy-makers for commercial interests undermine policies supportive of health [26, 27]. Examples of this include the attempts of the ultra-processed food industry to influence World Health Organization policies related to non-communicable diseases [28]. This leads to unhealthier communities that are dependent on and supportive of those interests (in part through marketing and its effects in changing social norms) [29], and finally, reinforces the power of those commercial interests to drive policy [6]. The impact of commercial interests could be reduced by the actions of communities to drive policy [4], but stakeholders at the time felt that the community action loop did not dominate over commercial interests.

Experience of the child

The establishment of environments and social norms that are obesogenic have a direct impact on the likelihood of

a child developing obesity. The child has a limited impact on these external factors. Nevertheless, obesity can have serious negative effects on the physical and mental health of the child, which may, in turn, hamper their ability to engage in healthy behaviours, further exacerbating obesity [10]. The external factors of structural determinants of health are often overlooked by public health policy. Rather, public health initiatives tend to focus on individual behaviour change. For example, public health messaging directed at adults, recommending a healthy diet and increased exercise, has had limited impact. Similarly, initiatives focused on child individual-behaviour change are unlikely to succeed, according to stakeholders. This is largely because the child's behaviour is influenced by external factors shaped by caregivers, community, schools and policy. Examples mentioned by stakeholders include the discouragement of recreational play in schools and unsafe neighbourhoods limiting physical activity. These cultural and structural barriers play an outsized role in limiting the region's ability to reduce childhood obesity. Specific policies and supportive environments that address these external determinants are critical.

Identifying interventions

Intervening for childhood obesity

Upon reviewing the CLD, stakeholders emphasized the need for a coordinated, all-of-society approach to changing the trajectories of childhood obesity in the region. They emphasized the limited benefits of engaging only in schools [1] or through policies focused only on diets [4, 6] and favoured a global and all-encompassing intervention that worked with policy-makers, communities, parents and the children themselves for a healthier environment. They described the need for skills building (for example, health literacy, food literacy, physical activity techniques and options, etc.) through education for both children and their parents. This would address reinforcing loops [8, 10, 30] – education would improve healthy eating, address social norms of obesity and reduce the mental and physical health impact of obesity. Interventions discussed also included significant infrastructure overhauls to make physical activity more accessible and safer for children, including safe and protected pavements for walking and spaces for recreation [4, 5]. In addition, mandating the refocusing of school curricula to include physical education and healthy eating (currently lacking in the Caribbean) would recognize and enshrine the impact of schools on child health. Currently, the physical environment is centred around the use of cars for transportation, and leisure time is spent mostly on sedentary activities. Safe infrastructure for active transport and physical activity beyond just engaging in competitive sports were priorities for stakeholders. Stakeholders also saw a role for greater regulation of commercial interests [6, 9, 29], but felt that this should not be the only avenue for improving healthy environments in schools. Stakeholders called for public health actions such as the adoption and enforcement of regional standards for school food environments, the adoption of consistent food labelling for the region, and enshrining childhood obesity in the public health policy agenda.

Unique experiences of Caribbean islands and countries

The framework presented above is meant to be used to understand the common drivers of childhood obesity across the Caribbean. However, for each study site, unique drivers and outcomes emerged in the group model building process. Stakeholders in Barbados were especially focused on the school environment, emphasizing the damaging effects of unhealthy food both within and just outside of schools. They described how schools use the sale of unhealthy foods in fundraisers because they appeal to the children, and parents are accepting of this practice. This example shows how it may not be enough to mandate healthy foods in lunch menus; rather, focus must be placed on a healthy food environment for the whole school and surrounding areas. Stakeholders in Barbados also discussed the lack of physical activity in schools, where competitive sports are often encouraged, but not physical education for all students. They described how transportation to and from school is often motorized either due to preferences by the parents or because of safety concerns with roads that lack maintained pavements.

Stakeholders in USVI described specific concerns in communities where they felt a lack of parental guidance and supervision around food choices was a problem. They also felt that, in their communities, there was a general perception that children were unsafe outside due to high rates of crime and lack of safe places for recreation. This perception is not unique to USVI and has been found in other studies in the Caribbean [31].

Stakeholders from both Trinidad and Tobago and Barbados felt that there was a lack of investment in schools and national public health campaigns focused on childhood obesity. This was contributing to childhood obesity not being seen as a problem or a public health priority, supporting harmful social norms.

Finally, stakeholders in Puerto Rico added a dimension not discussed in other groups: the clinical environment. They stated that childhood obesity is regarded as a serious concern for health professionals; yet, there was no interprofessional education throughout the academic preparation of healthcare professionals that was focused on the integration of obesity prevention. They noted a

lack of integrated clinical services and the available time for healthcare providers to provide counselling to families regarding weight management could be exacerbating the problem.

Discussion

This framework, which is derived from multiple, diverse stakeholders across several islands in the Caribbean, explains the rise in childhood obesity across the region. It depicts three key interconnected domains: the school and community environment (including structural components of the built environment), policy, and child experience. While these domains have been described previously by others, they have not been interlinked using a participatory systems approach. This framework allows us to examine how the school, built and policy environments collectively affect obesity, and how adverse physical and mental health consequences experienced by the child as a result of obesity, in turn, drive further obesity. One of the pillars of systems thinking is that intervening at any point in a feedback system can affect change. Thus, a causal loop diagram can present a roadmap for identifying key points of entry for change. In this CLD, proposed interventions included recommendations found in the WHO Global Action Plan for Physical Activity, which also discusses the importance of the school environment [32]. In addition, the CLD demonstrates the importance of addressing wider societal drivers, including commercial determinants of health, the impact of government policies and the central role that these have on households and communities.

These complex interactions must be considered when designing interventions for effectiveness and sustainability. Policies for childhood obesity may fail if they focus on just one aspect of the system. The recommendation to consider and intervene in the system as a whole aligns well with the conceptual framework put forth by the Lancet Commission Global Obesity Syndemic [3], which also took a systems approach to the determinants of obesity. This paper demonstrates how areas of high leverage may be explored using causal loop diagrams, which are useful for generating dynamic hypotheses [33].

While other frameworks exist for reducing childhood obesity, these were developed in large, high-income countries and may not translate to the particular needs of the Caribbean [34]. The areas of intervention discussed by stakeholders in this study align well with global recommendations [23, 35, 36], but unique Caribbean cultural drivers and norms that have deep historical roots must be considered and included in the design and implementation of policies for obesity. Much of the Caribbean shares a history of slavery or colonization which influenced the way people view food, the act of eating and engaging in physical activity [37, 38]. Food is also a powerful cultural unifier among Caribbean populations [39]. Participants in this study were aware of these perspectives and reiterated the importance of engaging directly with Caribbean decision-makers and stakeholders to create interventions that are not in conflict with this context.

In addition, this framework highlights the Caribbean region's focus on the commercial determinants of health and their role in sustaining the obesogenic environment. Commercial determinants of health are not explicitly recognized in prevention strategies and are very present in the Caribbean through high levels of food importation and influences from outside markets such as the United States, Canada and the United Kingdom, over which the region has no jurisdiction [40]. The Caribbean itself has relatively little power in shaping the regulation of multinational commercial actors, being a region with a comparatively low population and where the importation of foods plays an outsized role. Nevertheless, there are examples of efforts to counteract these commercial determinants of health: the Healthy Caribbean Coalition has called for the adoption of food labels, which have been shown to be effective, and several islands have implemented sugar-sweetened beverage taxes [41, 42]. These measures are part of a larger effort to implement policies and regulation in the region to curb the obesity epidemic and are actively being attacked by industry actors [43]. This framework highlights the importance of intervening not just in the food environment but also to provide more structural support for an environment enabling physical activity. This finding has been found elsewhere in similar studies in the Caribbean and would support a coordinated effort such as the one initiated for the regulation of unhealthy foods [44]. To date, most interventions at the Caribbean level, including the Caribbean Moves initiative, centre on engaging in exercise and ad hoc physical activity events which do not support the long-term structural changes called for by this framework [45]. Indeed, the types of policies that could be developed using this framework extend beyond the traditional realm of "health" and concern many social determinants as well, including housing and safe neighbourhoods, income and employment stability for households and accessibility across all communities to healthful environments.

Reducing obesity in children is important not just for their own health but for the health of entire communities. The behaviours learned in adolescence can have a long-term impact on behaviours in adulthood and shift the outcomes related to these behaviours including obesity and NCDs [10]. Furthermore, the behaviours and norms established in childhood can be passed on to the next generation, setting up an intergenerational impact on obesity. The Caribbean region is adopting a number of

policies that have the potential to shift this trend, including healthy school standards, limitations on the marketing of unhealthy foods to kids and public health physical activity initiatives targeting children [22, 35]. Civil society advocacy groups such as the Healthy Caribbean Coalition have provided a framework for civil society action in support of national efforts to prevent and control childhood obesity. While these initiatives are encouraging, the lack of a coherent and coordinated plan leaves these interventions vulnerable to failure. Using a framework such as the one presented here can help organize and coordinate those efforts if all areas are considered and mitigation plans are put in place. They can also aid in evaluating progress across the whole system.

In addition, the influence of factors such as tourism and the diaspora on the behaviours and beliefs of the community is unique to the Caribbean. Stakeholders described how tourism shapes the way in which foods are brought in from other parts of the world, and this influences local populations. Studies have shown shifting dietary patterns towards more unhealthy foods in the Caribbean diaspora which is always in contact with people in the region [46]. The social aspirations linked with living a lifestyle closer to those of US or UK populations has been documented elsewhere in Caribbean studies [47]. While these aspects may not directly affect children, they are present in communities and households, where children experience their impact.

This framework uses a systems approach to connect the different domains of the obesogenic environment for children into a dynamic single hypothesis about childhood obesity in the Caribbean. The framework from Garcia et al. [48] (for Latinx and Latin American populations), developed using a systems approach, shares many of the same concepts as the one described here. Our paper adds to this existing literature by operationalizing the general action framework of Garcia et al. through the engagement of key stakeholders to develop a detailed and culturally relevant childhood obesity framework specific to the Caribbean context.

This framework is sensitive to the realities of the Caribbean, which is made up mostly of small island developing states (SIDS) that share common features: small geographic territories, developing economies, high levels of within-island inequalities, a high level of food importation (which is often ultra-processed) and a unique vulnerability to climate change [3]. These features should be considered when designing and implementing interventions for the region, and recommendations from other parts of the world may not fit entirely within this context. There is a high promise of life-long gains in health when reducing childhood obesity; however, changes must be systemic and sustained over decades [49]. For example, childhood obesity in the United States seems to have plateaued and may be falling as a result of recent policy initiatives [50].

Strengths and limitations

This is the first multi-Caribbean Island stakeholder-driven framework on childhood obesity from a developing region. The insights derived here align well with other frameworks from high-income countries [51] and may provide knowledge for the SIDS and developing country regions facing the same rise in childhood obesity. However, important limitations exist. Group model building is sensitive to stakeholders selected for participation. While this framework used key stakeholders who are experts in public health, no community members were explicitly included, although the stakeholders themselves are members of their communities. Nevertheless, this may be a limitation in terms of key insights that could inform the framework. Many of the key stakeholders themselves are parents in the Caribbean and could speak to their experiences in that capacity; however, including the children themselves would strengthen this framework. Furthermore, because the stakeholders were participating in a professional capacity, there is a strong likelihood that vulnerable and low socioeconomic status populations were under-represented. Stakeholders were asked to consider their perspectives with regards to their own experience, but having representation from these communities would have given a more complete view of some of the inequalities which may be present within communities. This was not done because of ethical considerations and due to issues in implementing the group model building workshops virtually because of the COVID-19 pandemic.

Conclusion

The drivers of childhood obesity in the Caribbean are complex and embedded in societies. Changing the trajectory of rising childhood obesity in the region will require a coordinated, all-of-society approach and commitment that works with policy, community, schools and children together.

Abbreviations

CLD	Causal loop diagram
GMB	Group model building
NCD	Non-communicable diseases
P-ECHORN	Paediatric cohort of the Eastern Caribbean Health Outcomes Research Network
USVI	US Virgin Islands

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Author contributions
L.G., S.H. and B.R. conceptualized the study. The facilitator for the CLD was A.B. in the USVI; H.H., W.J. and N.G. in Barbados; R.K. in Trinidad and Tobago; and R.V.R. in Puerto Rico. L.G. wrote the first draft of the manuscript with extensive revisions by S.H. All authors reviewed and provided edits and comments to the manuscript.

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Availability of data and materials
All study data are available from authors upon reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained in all jurisdictions by the appropriate review body: University of the West Indies, University of Puerto Rico, University of the Virgin Islands and Yale University. All participants provided consent prior to participating in sessions.

Consent for publication
Consent discussed the possibility of publication without identification.

Competing interests
The authors declare no competing interests.

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