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Systematic Review
Sustainability of Childhood Obesity Interventions: A Systematic Review

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Abstract

Background and Objective: Childhood obesity is a global epidemic. While childhood obesity intervention programmes have been developed and implemented, few studies have investigated the sustainability of these programmes. This systematic review explored the sustainability of childhood obesity interventions at the individual, interpersonal, organizational, community and public policy levels of the Socio-ecological Model (SEM). **Materials and Methods:** A keyword search was conducted using the online databases EBSCO, PubMed and Science Direct. The inclusion criteria were primary research, long-term childhood obesity interventions (at least 12 months) with a follow-up of at least 6 months after the end of the intervention, overweight or obesity interventions implemented from 2007 until June 2018 and English as the reporting language. **Results:** These systematic searches found 1953 studies but only eight met the inclusion criteria. Factors such as programme champion, system/policy, workforce, community capacity, engagement/relationship building, adaptation/adoption, evaluation and feedback, training and education, collaboration and partnership as well as ongoing support contributed to the sustainability of the programme. **Conclusion:** It is important that future research assesses the sustainability of childhood obesity interventions, particularly at the public policy level. Attention should be given to enhancing sustainability in future intervention studies.

Key words: Childhood obesity, childhood overweight, health behavior, pediatric obesity, program sustainability, socio-ecological model

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

According to a World Health Organization report[1] published in 2016, the number of obese children and adolescents has increased tenfold globally in the past 40 years. A study published in the Lancet found that from 1980-2013, the worldwide prevalence of childhood overweight and obesity increased by 47%[2]. In Malaysia, the South East Asian Nutrition Surveys (SEANUTS), conducted from 2010-2011, reported that among urban children aged 7-12 years[3], 14.4% were overweight and 20.1% were obese. Overweight and obesity were estimated to cause 3.4 million deaths, 4% of disability-adjusted life-years (DALYs) and 4% of years of life lost worldwide in 2010[4]. In addition, overweight and obesity during childhood are known to have implications for both physical and psychosocial health. Moreover, it has been reported that the risk of persistence of overweight and obesity from childhood to adulthood was high and that obesity increases the burden of cardiovascular disease[5].

While many public health studies have focused on determining the factors that are critical for successful implementation[6], little attention has been paid to the aspects that impact the sustainability of these programmes. Furthermore, many health intervention programmes have not been studied in terms of their sustainability. As reported by Gruen *et al.*[7], sustainability issues in health intervention programmes are becoming increasingly important to funders, programme managers and decision and policy makers who often face challenges in sustaining health intervention programmes and are concerned about the long-term impact of their investments. While numerous factors contribute to the successful implementation of these intervention programmes, the effects of these programmes may diminish over time[8-10]. After an initial period of support, many intervention programmes are terminated because of financial limitations and a lack of human resources. If more attention was paid to sustainability issues, such unfortunate results could be avoided.

After examining different definitions of sustainability, Shediac-Rizkallah and Bone[11] proposed three indicators of sustainability: (1) Continued health benefits for participants after the termination of programme funding, (2) Continuation of programmes within an organization, often referred to as 'institutionalization' or 'routinization' and (3) Continuation of community capacity by developing processes to deliver programmes in a community. Sustainability can also be defined as the ability of a programme or intervention to be institutionalized within an existing government or community setting[12].

While systematic reviews of many aspects of childhood obesity are now available for example, the two landmark reviews in the Cochrane Library, namely, Interventions for Preventing Obesity in Children[13] and Interventions for Treating Obesity in Children[14], there are, to date, no systematic reviews on the sustainability of childhood obesity interventions according to the Socio-ecological Model (SEM).

Understanding the factors that impact the sustainability of childhood obesity intervention programmes is vital to the durability of these programmes[15]. Even if the implementation of an intervention is successful, it may not necessarily develop as intended[16]. Interventions conducted over one school year or longer appear to be more sustainable[17,18]. Hence, to better understand the sustainability of childhood obesity intervention programmes, this systematic review considered data from interventions that lasted 12 months or longer. This duration was chosen because, as shown by Ickes *et al.*[19], interventions of more than one year correlate with positive BMI improvements and are more likely to be sustainable at different levels of the SEM.

This systematic review focused on the SEM developed by McLeroy *et al.*[20]. There are five levels of influence for health-related behaviour: (1) Individual factors such as the continuation of health benefits, beliefs, attitudes and knowledge, (2) Interpersonal factors (family, peers and friends), (3) Organizational or institutional factors for social institutions, such as schools and health care organizations, (4) Community factors for relationships among organizations, neighbourhoods and parks and (5) Public policy factors for local and state policies [20].

This systematic review aimed to investigate the level of sustainability of childhood obesity interventions and to identify the factors that influenced the sustainability of the intervention programmes.

MATERIALS AND METHODS

Data sources: A comprehensive literature search was performed using three electronic databases PubMed, Science Direct and EBSCO (Medline Complete) for the period from 2007-2018. The following keywords and their variations were used as search terms: 'sustainability', 'institutionalization', 'children', 'adolescent', 'youth', 'intervention', 'programme', 'program', 'project', 'overweight' and 'obese'.

The search strategy was based on the following components of 'population, intervention, comparison and outcome' (PICO): population (0-18 years old, children, youth or adolescents); intervention (obesity/overweight interventions published between 2007 and June 2018, non-pharmaceutical-

based interventions, intervention of at least 12 months); comparisons (with or without control group); outcomes (more than 6 months of follow-up after the end of the intervention, reporting sustainability outcomes). PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[21] were used for the reporting procedures.

Study selection: The inclusion criteria were developed and applied by two researchers separately for study selection. Two researchers independently conducted the search and a third researcher helped to resolve any disagreements concerning the inclusion and exclusion criteria. To be eligible for inclusion in the review, studies had to consist of primary research published in the English language between January 2007 and June 2018. We reviewed studies that examined sustainability outcomes, such as the continuation of some components of programmes or the desired outcomes that were sustained after the initial implementation. Studies were excluded if they (I) Included a pharmaceutical-based intervention, (ii) Involved interventions of less than 12 months in duration and (iii) Did not report sustainability outcomes.

Data extraction: A standard data extraction form was used to populate the evidence tables and to cross check for agreement and accuracy. A priori coding was created beforehand and applied to the text during data analysis. The extracted items for the evidence tables were programme champion, system/policy, workforce, community capacity, engagement/relationship building, adaptation, evaluation and feedback, training and education, collaboration and partnership and ongoing support.

RESULTS

Our systematic search found 1953 studies (Fig. 1) after a comprehensive literature search. After screening the titles and abstracts, 40 potential papers were retrieved. Of these, seven papers were eligible for inclusion. Forward and backward citation searches were applied to all eligible studies and an eighth eligible paper was identified from this forward and backward citation searching process. The reasons for exclusion and the study flow are reported in Fig. 1. Disagreements were resolved through discussion and, when required, referred to a third researcher. Table 1 summarizes the study characteristics and main findings of the eight selected interventions. Table 2 provides an overview of the sustainability variables and the SEM level targeted by interventions in the eligible studies. Table 3 shows a summary of the sustainability outcomes.

Sustainability at the individual level and intrapersonal level: The continued health benefits, such as anthropometric outcomes, were assessed in the eligible studies. All of the interventions that were conducted ranged from one year and six months to four years and four months in duration. The involvement of individuals, specifically children, in

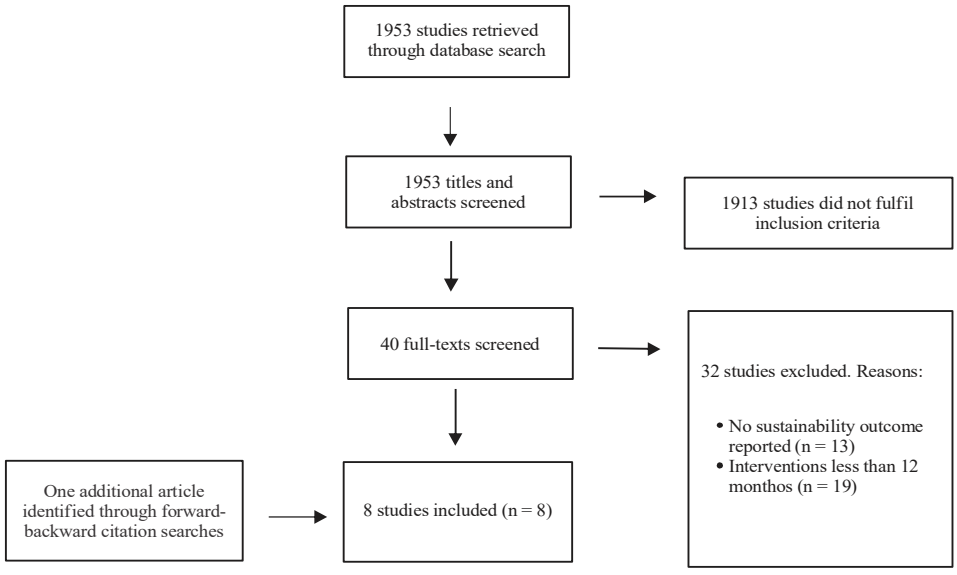

Fig. 1: PRISMA (reference) study flow diagram

Table 1: Summary of study characteristics and main findings of the eight selected interventions

Author, year and country	Sample size and age (years or grades)	Study design and duration (years)	Description of the intervention	Intervention outcome(s)	Sustainability outcome(s)
Sanigorski *et al.*[22] Australia	Baseline: Intervention (n = 1001), Comparison (n = 1183) Follow-up: Intervention (n = 839), Comparison (n = 979) Aged 4-12	Quasi-experimental and longitudinal design 4 years	Be Active Eat Well intervention programme aimed to build community's capacity to promote healthy eating and physical activity by reducing screen time, sweetened beverages, energy-dense snacks and increasing fruit consumption, active play and active transport to school	Lower increases in body weight, waist and body mass index z-score. Significance gained in anthropometry of children from the low socioeconomic at 3 years followed-up	Community capacity building through networks and partnerships
Donnelly *et al.*[23] United States	Baseline: Intervention (n = 814), Control (n = 713) Follow-up: Intervention (n = 792), Comparison (n = 698) Grades two and three	Cluster randomized controlled trial 3 years	In Physical Activity Across the Curriculum study, 90 minutes per week of moderate-to-vigorous physically active academic lessons	Schools with more than 75 min of physical activity per week showed significantly less increases in BMI, greater changes in daily physical activity and academic achievement	The adoption of the programme in the curriculum. Teachers as programme champion
Schetzina *et al.*[28] United States	114 students Aged 7-10	Pre and post programme evaluation 1 year and 6 months	A comprehensive programme included nutrition services, health education, physical education, school health services, counselling and psychological services, healthy school environment, health promotion for staff and family and community involvement	Healthier foods and drinks consumption by students, teachers as programme champion	The adoption of the programmes for classroom teaching Teachers as programme champion
Benjamin and Whitman[24] Chicago	581 students, Grade 1-8	Pre and post-intervention survey. 2 years	Wellness council was formed in school Policy changes were implemented in 5 target areas (health education, physical education, school environment, family involvement and staff wellness)	Significant increases in student knowledge and physical activities	Institutionalization the initiatives within school system. Received ongoing funding support from parents
Chomitz *et al.*[27] United States	1858 children Grade 5 children	Longitudinal study 3 years	Healthy Living Cambridge Kids developed in four phases: formative, developmental, implementation and sustainability. Areas: city wide policies, advocacy, stakeholder training, public health outreach, school policies and systems changes (physical, nutrition and gardens)	Decreases in BMI z-score and proportion obese, increases in mean number of fitness tests	Multidisciplinary coalition and support of educators, healthcare professionals, parents. Incorporated local priorities that leveraged resources and developed community support.

Table 1: Continue

Author, year and country	Sample size and age (years or grades)	Study design and duration (years)	Description of the intervention	Intervention outcome (s)	Sustainability outcome (s)
London and Gurantz[26] United States	Baseline: Not reported, 2 years follow-up = 1105 students (Grades 5 and 7, n = 566 and Grades 7 and 9, n = 539) Grade 5- 7 and Grade 7-9 children	Longitudinal study 2 years	California Physical Fitness Test was used to measure aerobic capacity, body composition, abdominal strength and endurance, trunk extensor strength and endurance, upper body strength and endurance and flexibility	10% increase of probability being physically fit. 14.7% increased likelihood of subsequent fitness compared to 8.8% for 1 year of participation	Community partnership at all levels pooled resources and mobilized organizations that involved city departments school districts and nonprofit organizations
Po'e *et al.*[29] United States	Intervention (N = 300 dyads), Control (N = 300 dyads)	Randomized controlled trial 3-5 years old 3 years (Ongoing study)	Growing Right Onto Wellness (GROW) consists of 3 phases: Intensive, Maintenance and Sustainability to test the efficacy of a family-centred, community-based, behavioural intervention for childhood obesity prevention **Intensive:** Goal check-in with problem solving, interactive didactic, small group/individual discussion **Maintenance:** Monthly coaching calls that reinforce the core messages **Sustainability:** Continuous participation in monthly GROW activities that reinforce key messages from intensive phase and utilizing the existing infrastructure	BMI, weight and height, waist circumference, triceps skinfolds, physical and dietary assessment, social network, genetic data and cognitive assessment measurement	Involvement and partnership with private and public organizations that utilized social media to sustain positive healthy behaviour
Polacsek *et al.*[25] United States	Baseline: n = 600. Before Intervention (N = 341), During Intervention (N = 378). Intervention Sites (N = 235), Control Sites (N = 304) 2-18 years old	Quasi-experimental 4 years and 4 months	In Maine Youth Overweight Collaborative 1.5 day learning session every 6 months, 4-6 min to deliver the 5210 healthy habits message, 5 min each well-child visit, two 30-minute meetings per month, one to two 1 h conference calls per month and a 1 h site visit every few months	Significant increase in the tracking of BMI percentile Significant decrease in having heard messages about nutrition through parent surveys	Nationwide adoption of the programme through community partnership.

Table 2: Variables related to sustainability with Socio-ecological Model (SEM) levels targeted by interventions in the eligible studies

Variables (number of references)	Levels in SEM	References
Programme champion (n = 2)	1,2,3	23,28
System/policy (n = 3)	3	24,25,28
Workforce (n = 5)	1,2,3,4	23,24,25,26,28
Community capacity (n = 5)	4	22,24,26,27,28
Engagement/relationship building (n = 7)	1,2,3,4	22,23,24,25,26,27,29
Adaptation/adoption (n = 5)	3,5	22,23,25,27,28
Evaluation and feedback (n = 5)	1,2,3	23,24,27,28,29
Training and education (n = 6)	1,2,3	23,24,25,27,28,29
Collaboration and partnership (n = 8)	3,4,5	22,23,24,25,26,27,28,29
Ongoing support (n = 4)	3,4	24,25,28,29

Level 1: Individual, Level 2: Interpersonal, Level 3: Organizational, Level 4: Community, Level 5: Public policy

interventions was mentioned by all of the eligible studies[22-29]. Most of the studies (n = 4) reported lower increases in body weight and BMI z-scores among children in the intervention group[22-25] than among children in the control group. Four studies[23,26-,28] reported that the physical activity level of the children increased after the interventions. Children significantly improved their academic achievement after intervention in one study[23]. Teachers reported that healthier food and drink consumption by students at school were higher after programme implementation[28]. One study[27] reported that the nutritional knowledge of the students improved after intervention. Another study[23] identified a positive change in children's attitudes and beliefs towards physical activity fostered by the intervention. The sustainability of increased physical activity in this case could have been due to changes in the children's attitudes and beliefs that were brought about by the intervention.

The interpersonal level in the SEM refers to the communication between several individuals such as the involvement of programme champions, the workforce from interventions, the engagement and relationship building with school teachers, parents, healthcare workers and community members, the evaluation to measure the effectiveness and intervention strategies and the training and education for school teachers, parents and healthcare providers to deliver intervention programmes.

In the Physical Activity Across the Curriculum (PAAC) intervention by Donnelly *et al.*[23] and a study by Schetzina *et al.*[28], programme champions were school teachers. Teachers who taught the classes championed the programme and their participation in physical activity at school facilitated behavioural change among school children[23], while another study[28] indicated that school teachers championed the intervention by serving as role models for active living and healthy eating.

Five studies mentioned workforce in the interventions[23,24,26-28]. Three studies[23,26,28] reported the participation of school teachers in classroom physical activities and physical fitness. Healthcare staff were highlighted by two studies[27,28] in interventions to provide information on children's weight status to parents after screening and diet consultations to parents. The involvement of parents was also important, as reported in two studies[27,28]. Parents play a role in following recommendations for creating healthier school environments[28] and are also important in providing knowledge related to nutritional and physical activity to children[27].

Over half of the studies reviewed highlighted engagement and relationship building at the interpersonal level[22-27,29], where the engagement and relationship building included consultative decision making involving stakeholders[22], school administration and teachers[23,26], local priorities[26,27,29], healthcare professionals[22,24] and nonprofit organizations[25,26].

Although, eight studies were included in this review, only five studies were able to link evaluation to the sustainability of interventions programmes[23,25,27-29]. Donelley noted that extensive process evaluation measures were collected to monitor the teachers in delivering the lessons as planned[23]. One study reported feedback of healthier consumption of foods and drinks by students[28], which is similar to a study that acknowledged an improvement of lifestyle programming for pre-school children and parents[29]. Two studies conducted evaluation measures on weight status and fitness[27] and tracked logs to evaluate staff surveys monitoring implementation fidelity and sustainability of intervention[25].

Training and education were cited as important in the implementation and maintenance of interventions[23-25,27-29]. Four studies reported that training was given specifically to school teachers[23,24,27,28] by research assistants, exercise specialists or dietitians prior to intervention implementation. Training was also provided to office staff throughout the intervention approach for obesity prevention[25].

Sustainability at the organizational level: The sustainability of interventions at the organizational level based on the SEM

Table 3: Detailed sustainability components and outcomes of each eligible studies

Variables	Sanigorski *et al.*[22]	Donnelly *et al.*[23]	Schetzina *et al.*[28]	Chomitz *et al.*[27]	Benjamins and Whitman[24]	London and Gurantz[26]	Po'e *et al.*[29]	Polacsek *et al.*[25]
Programme champion	-	Teachers	School teachers	-	-	-	-	-
System/policy	-	-	School administration replaced soda with water and fat-free or reduced-fat milk	School stakeholders were trained to implement new guidelines and policies	A wellness council was formed and a wellness policy was subsequently written	-	-	-
Workforce	-	Teachers and school staff	Teachers, healthcare staffs, parents and community members	Multidisciplinary coalition of elected officials, educators, health care workers, public health professionals and parents	Epidemiologist, project director, dietitian, mental health consultant, social worker	School staffs and physical education teachers	-	-
Community capacity	Applied a community capacity-building approach	-	Train community to become experts, fund the training and media coverage	Engagement in all aspects of the research process	-	Intervention designed and conducted by community organizations	-	Community resources and partnership
Engagement/ Relationship building	Engagement of health professional and stakeholders	Engagement with school administrators and teachers	-	Incorporation of local priorities and strategies that leverage resources implementation.	Incorporating a health curriculum and a dietitian review the lunch offerings	Involved city departments, school districts and nonprofit organizations	Employed community liaisons to effectively communicate with the target population	Employed organizational structure to lead the programme
Adaptation/ Adoption	Designed to be transferable to other communities	Adopted as a curriculum	Adoption as a classroom teaching tool in a form of CD or DVD	-	Initiate to adapt the materials and model of the project	-	-	Adopted and adapted by providers nationwide
Evaluation and feedback	-	Evaluation measures were collected to monitor the extent of implementation	Healthier consumption of food and drinks by students in the school	Evaluation measures on weight status and fitness	-	-	Improvement of lifestyles programming for pre-school children and parents	Tracked logs to monitor attendance at learning sessions, site visits. conference, chart reviews and staff surveys
Training and education	-	Teachers and research assistants to deliver lessons	Teachers were trained by an exercise specialist	Physical education teachers and school nurses	Teachers were trained by a dietitian to provide education or training needed	-	Skills-building on healthy lifestyles for children and parents	Office staff and providers were trained.
Collaboration and partnership	Reoriented organizational priority to develop networks and partnerships	Partnered with TAKE 10!, a Centre for Health Promotion programme	Collaboration with Parents Teacher Organization and exercise specialists	Collaborative effort between members of The Healthy Children Task Force.	Collaboration with dietitian to support	Community partners from afterschool programmes, school districts and the County Health Department	Private and public organization such as parks, library and hospital	Private and government organization
Ongoing support	-	-	Support from the Parent Teacher Organization	New partnerships have emerged post-implementation	Schools have sought parent donations to support the programme	-	Built social networks and utilized social media to develop and sustain positive healthy behaviour.	-

model refers to interventions that are organizational-based, such as those at school. School teachers are identified as programme champions[23,28] as they act as role models for delivering lessons after the completion of interventions. Of three studies that discussed policy or system linked to sustainability, two studies[24,27,28] acknowledged that policy assisted with sustainable changes to healthier food environments within school settings promoted the sustainability of interventions by implementing new guidelines and school policies. The workforce involved in the organizational setting, namely, school teachers and school staff, was mentioned by three studies[23,26,28]. Training and education, as well as engagement and relationship building with school administrators and school teachers, were performed to ensure sustainability of the interventions[23,28].

Adaptability or adoption of intervention components to organizational context were discussed in two studies[23,28]. The PAAC[23] was sustained as school teachers were identified as the programme champions that facilitated the adoption, implementation and execution of the programme. One study[28] found that the intervention was adopted by making CDs or DVDs of the intervention available for teacher use in the classroom as a teaching tool. It was promising that the schools in PAAC[23] accepted the principles of a childhood obesity intervention programme and that the intervention was integrated with existing curricula at the school.

The effort required to establish effective collaboration and partnership was acknowledged in organizational settings. Collaboration with other organizations such as Parent Teacher Associations (PTA) and exercise specialists promoted the sustainability of the intervention[28]. One study[24] reported that collaboration with a dietitian in this school-based intervention showed the significant role of health advocates. These changes need to be supported by changes in the environments and social norms that support positive health decisions to facilitate the behavioural change of students to drive sustainability efforts. Ongoing support from these partners is required to sustain the success of partnerships at the organizational level. Two studies highlighted the continuous support received from PTA[28] and parent donations[24] to maintain the programme.

Sustainability at the community level: A workforce at the community level, including public health professionals, educators, healthcare providers and parents, was mentioned by one study[27]. Partnerships with health and literacy advocates were established to reduce television screening time. Five studies[22,25-28] discussed community capacity building, whereby individuals or community members obtain and retain the skills or knowledge from the interventions to archive sustainable results. Community ownership was cited as important in community capacity building, in which existing resources were community-oriented as the intervention was fully operated and owned by the community[22]. Integrating partnership from health advocates and the community in the implementation of interventions increases the likelihood of sustainability, as community members feel more ownership than they would if the intervention did not include them[27].

Five studies[22,24-26,29] reported engagement and relationship building at the community level with stakeholders, agencies, city departments and nonprofit organizations to lead the programme implementation. Partnership and collaboration with other organizations and some public community centres that provide physical activity access were selected to reinforce and utilize the facilities to promote healthy lifestyles and physical activity[29]. One study also highlighted the approach of engaging partners and incorporating local priorities to enhance community capacity building that led to the sustainability of the intervention. New partnerships were identified that were likely to support the previous work and champion the programme, which further supported the goal of the intervention to promote healthy weight and prevent childhood obesity with the involvement of the community[27].

The adaptability and adoption of interventions at the community level was discussed in two studies[22,25]. One study[22] reported that the intervention was neither adopted nor adapted but the intervention activities were designed to be transferable to other communities as it was delivered through fairly standard methods. Meanwhile, another study[25] showed that the intervention was also adopted and adapted by nationwide providers.

Sustainability at the public policy level: Interventions can be sustained at the public policy level by working with city departments on health policies that influence children during and after school to provide consistent healthcare services[27]. A positive change in attitudes or behaviour about policies that promote physical activity and a healthy eating environment can influence people's practices. Policies are often the driving force behind systematic change that facilitate behavioural change.

DISCUSSION

To the best of our knowledge, this is the first systematic review that explores the sustainability of childhood obesity intervention programmes at different levels of SEM. The eight

studies identified in this review found that long-term interventions (at least 12 months in duration) with factors that enhance sustainability were successful in reducing BMI z-scores, increasing levels of physical activity and lowering waist circumference.

Schools are viewed as the key setting for obesity prevention, as they provide the opportunity for children to undertake physical activity and learn about healthy eating behaviours. An intervention study known as The Malaysian Childhood Obesity Treatment Trial (MASCOT) found that obese children in the intervention group spent 89% of their waking hours on sedentary activities[30]. Therefore, school environments can promote physical activity and healthy eating, which influences a child's health[31]. Benjamin and Whitman[24] reported that a project's dietitian created a supportive environment in school, which promoted healthy eating and facilitated positive behavioural changes in students. A systematic review by Clarke *et al.*[31] also reported that stakeholders emphasized the importance of multiple physical education (PE) sessions, afterschool programmes, lunch-time activities and increased movement during classes. Therefore, it is important to involve stakeholders in programme planning prior to an intervention to ensure community empowerment and to develop capacity building[32] to enhance sustainability.

In this review, however, there were only two school-based interventions that aimed to increase physical activity to reduce gains in BMI[23] and to evaluate the knowledge, attitudes and behaviours among school children[24]. Children who are more physically active are more likely to have lower BMI and body fat percentage as well as waist circumference than their less physically active cohorts[33]. Teachers and parents can coordinate with the school principal, canteen operators and students to organize available resources to institutionalize the practices, which will promote sustainability. A study in 2018, namely, the Juara Sihat intervention, was a 12-week school-based obesity intervention conducted at a primary school in Kuala Lumpur, Malaysia to improve anthropometric status and physical activity level among overweight and obese primary school children. This study reported that the involvement of school teachers and the PTA in the intervention helped change the children's behaviour to eat healthily and to be more physically active[34]. The PTA played an important role in strengthening the relationship between school teachers and parents, which in turn provided strong social and peer support to all participants throughout the intervention. Empowering parents to participate in an intervention is also an effective way to manage childhood obesity[35].

When intervention programmes involve stakeholders, the coordination and partnership of the agencies involved are critically important for successful implementation and sustainability[6]. The coalition of stakeholders and agencies can engage people, ideas and resources across sectors and settings to create programmes with long-term impacts on peoples' health[36]. In the PAAC study, many teachers used the intervention module at school at least one day per week, even after the intervention ended. This observation supports and extends the results of other studies that found that integrating activities within existing programmes and involving stakeholders in organizing the programmes are more likely to be sustained in the long run[37,38]. Donnelly *et al.*[23] and Schetzina *et al.*[28] also reported that the PAAC programmes were successful because they cultivated a programme champion (a school teacher) and they were consistent with the schools' values. The identification of a programme champion someone who is strategically placed in an organization to support and promote the programme is crucial to the sustainability of the programme[39]. One study showed that it was crucial to have a programme champion; otherwise, the partnership between the organization and its programme manager would have collapsed[40]. Polacsek *et al.*[25] illustrated how an overweight intervention programme targeting Maine youth was institutionalized, from the adaptations made by providers nationwide to its dissemination by the National Cancer Institute Research-Tested Intervention Programmes (RTIPs) and others[25].

According to Harris and Sandor, the four features of sustainable practice in community-based intervention programmes include (1) Effective relationships and partnerships, (2) Evidence-based decision making and practice, (3) Building of community capacity and (4) supportive context for practice[41]. The eight eligible studies showed that the building of community capacity, in collaboration and partnership with stakeholders, seemed to have significant potential to slow weight gain in children[22,23,25-27,29]. The development of community capacity and relationships among community members enhanced community ownership, which, in turn, increased capacity and promoted programme maintenance. The engagement of partners, the recognition of local priorities and the use of strategic resources further enhanced community capacity. These findings suggest that the involvement of participants from a community positively affects the sustainability of an intervention.

Choosing an appropriate timeframe after an intervention ends is important when evaluating its sustainability. Although, there is no specific timeframe that defines an intervention as sustained, it is useful to separate the implementation period from the post-implementation phase. Most of the studies in

this review had a duration between one year and six months to four years and four months, which is consistent with suggestions in the literature regarding the duration needed to assess sustainability and the factors that influence it[42].

Research on the sustainability of childhood obesity interventions should move in the direction of applying sustainable components to ensure that the impact is felt over time. This review provides some evidence supporting the sustainability of an extended childhood obesity intervention. In some of the eligible studies, the participants continued to receive health benefits after the programme's initial funding had ended and /or the intervention programme was continued within the organization (institutionalization) and /or there was evidence of a continued community capacity to deliver programmes after the initial research programme had terminated. In addition, we also found limited evidence on sustainability at the public policy level. We believe that a sustained healthy behaviour intervention may also be related to the implementation strategies or integration with local practices at the organization level and community level.

This review considered the sustainability of childhood obesity intervention components and the need for future research on the sustainability of childhood obesity interventions. Sustainability may be enhanced at the individual level by targeting a child's knowledge, attitude and practices that lead to behavioural change. This review is very important, as the researchers revealed the critical areas of childhood obesity interventions leading to sustainability that many researchers did not explore. The influence of parents on the sustainability of childhood obesity interventions in the home environment should also be considered.

LIMITATIONS AND STRENGTHS

The present study and the previous studies reviewed have several limitations and strengths. Most of the studies identified in our search results were excluded due to the short duration of the interventions and a lack of reported sustainability outcomes. It is likely that many studies of intervention programmes did not attempt to determine the extent to which the interventions were sustained after the studies ended. Although, we attempted to identify studies using multiple search strategies, the range of key words related to sustainability used in the search may have limited the scope of the review.

Despite these limitations, the strengths of our review include that we addressed a novel and important topic and applied double-screening to determine study eligibility. Data extraction and quality appraisals were also independently checked by two reviewers. Quality appraisals were performed by preliminary synthesis by two reviewers who described each of the studies, summarized the same features for each study and tabulated results in order to identify patterns across the included studies. This review identified the factors which impacted the sustainability of intervention programmes using the SEM. Information from this review will help researchers and stakeholders who wish to develop and implement sustainable health intervention programmes.

CONCLUSION

This review found limited data on sustainability of childhood obesity intervention at various levels of the SEM. Overall, there is emerging evidence that factors such as programme champions, community capacity, engagement and relationship building, programme adaptation and training may contribute to the sustainability of the programme. However, attention should be given to enhancing sustainability for longer durations in future intervention studies. Future research is warranted especially on assessing the sustainability of childhood obesity interventions, particularly at public policy levels.

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