Published in final edited form as:

Curr Opin Endocr Metab Res. 2019 February ; 4: 62–69. doi:10.1016/j.coemr.2018.11.002.

Multilevel interventions to prevent and reduce obesity

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Abstract

The complex, multilevel causes of the ongoing obesity epidemic necessitate multilevel approaches to address the problem. Accordingly, interest in multilevel obesity interventions has expanded rapidly in recent years. We conducted an updated literature review of multilevel interventions for obesity prevention and reduction. We identified six protocols and six articles on completed studies that were published between January 2016 and September 2018. Of the completed studies, four found significant intervention effects on body mass index and/or waist circumference. Two showed significant improvements in diet and two showed significant improvements in physical activity. These studies highlight the promise multilevel interventions offer for addressing obesity at the population level.

Introduction

Global data demonstrate that obesity is a growing problem affecting countries at all development levels [1, 2]. Obesity is a major threat to public health because it increases the risk for several chronic diseases, including diabetes and cardiovascular disease. Underlying these trends are major population level shifts in intake of less healthy, low-nutrient-density foods and sugary beverages, changes in away from-home eating and snacking, and a rise in sedentary lifestyles [3–5]

Although obesity has been characterized as a consequence of excess energy intake over energy expenditure, it is nevertheless a complex problem affected by the interaction of biology, behavior, social and physical environments, and government policies. Social-ecological models of health promotion (Figure 1) posit that factors at multiple levels

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influence outcomes like obesity, and that these multi-level factors interact to impact these outcomes [6]. Specifically, they emphasize the contributions of organizations and policies to behavior, while incorporating individual and interpersonal influences. The Institute of Medicine has promoted the use of an ecological approach to understanding determinants of adverse health outcomes and for effectively promoting healthful behavior change [7]. The socialecological model serves as a framework for private and public institutions around the world [8, 9].

Obesity prevention efforts have primarily targeted a single layer of influence, usually at the individual-level, though policy-level targets are increasingly being tested. However, in recognition of the multilevel nature of obesity, interest in multi-level interventions has grown substantially over the last decade. Multilevel interventions are strategies that aim to change behaviors and address health outcomes by affecting more than one level of influence within the social-ecological model. For example, multilevel interventions can include behavioral changes at home, comprehensive health education at school, and environmental changes in the community.

Only one other review to our knowledge has summarized findings from multi-level obesity prevention interventions, and it was published in 2016 [10]. Since then there have been several commentaries and guidelines written to support efforts to conduct multilevel interventions [11–15]. Thus, the objective of the current review was to provide an updated synthesis of the literature on multilevel interventions to address obesity, to discuss the implications of these findings, and to identify remaining gaps in our current knowledge.

Methods

The challenge with identifying multilevel interventions is that many studies do not identify themselves in that way. Thus, we used multiple strategies to identify articles. Our primary search strategy replicated the literature search approach and terms used to identify multilevel obesity interventions in the 2016 review [10] (see Steps 1–3 below). This approach involved using a combination of inclusion and exclusion search terms to identify studies with intervention components at more than one of the levels illustrated in Figure 1 (i.e., multilevel) that also assessed a measure of anthropometry or body composition as the outcome. Our second strategy (Step 4) involved manually searching through articles identified from other sources. Our final strategy (Step 5) involved searching for findings from incomplete trials reported in the 2016 review.

Step 1: Initial search

In our initial search, we queried the PubMed database using a combination of Medical Subject Headings (MeSH) terms and Text Word field tags relating to: 1) obesity; 2) multilevel or multicomponent approaches; and 3) environmental influences and health behavior. We restricted our search to clinical studies that were written in English and published in journal articles between January 1, 2016 and September 30, 2018. This resulted in 236 articles.

Step 2: Application of primary exclusion criteria

We used the “NOT” option in PubMed to exclude studies outside the scope of this review. These included those that focused on testing or validating statistical methodologies, specific disease conditions or treatment, smoking, meal replacement diets, or specific single food or beverage consumption. We excluded 99 articles using these criteria, resulting in 137 articles.

Step 3: Full-text review

We manually reviewed the 137 remaining articles and coded them in Excel for two inclusion criteria: anthropometry and multilevel. Body mass index or waist circumference had to be measured and the intervention had to substantially target more than one level in the social ecological model. We discarded 122 articles because they were not multilevel, and an additional 6 articles because they did not include anthropometric measures. This left 8 articles.

Step 4: Second-pass literature search

We conducted another review of articles published between January 1, 2016 and September 30, 2018 using PubMed in order to capture articles that may have been missed in Steps 1–3. In this search we used keywords that included obesity-related terms (e.g., body mass index, adiposity, waist circumference, body fat percentage), diet-related terms (e.g. eating habits, health eating, junk food, fruits, vegetables), and physical activity-related terms (e.g., exercise, walking). We also filtered results to only show articles with “multilevel interventions” or “multi-level interventions” in the title and/or abstract. An initial search resulted in 61 articles. From these, titles and abstracts were reviewed, and only studies that contained relevant data to this review were included. After excluding duplicates ($n = 27$), reviews ($n = 9$), and irrelevant topics ($n = 20$), 5 articles not identified using Steps 1–3 remained for full-text review. After a full-text review of these articles, we excluded two for not including anthropometric measures as an outcome. The remaining 3 were included in this review.

Step 5: Literature search of incomplete studies from 2016 review

Six of the studies published in the 2016 review did not have results at the time that article was published. Thus, we searched the literature for follow-up articles with relevant results. Through this search we identified 1 additional study.

Results

The articles in this review include 12 trials from countries around the world including the US (6), Brazil, China, Scotland, Germany, Australia (2), and India. Half of the included articles were recently published protocols for trials that have not completed data collection [16–21], and the remaining six were completed studies that published obesity-related results between 2016 and 2018 [22–27]. Table 1 summarizes the general characteristics of the included studies, and Table 2 summarizes the intervention components.

Protocols

Most of the trial protocols were for interventions in children (PAAPAS, STRIDE, CHIRPY DRAGON, and JolintchenKids). With the exception of STRIDE, the primary setting for those interventions was the school or daycare. The three school-based interventions included educational activities to promote healthy eating and physical activity, support to help parents promote healthful behavior change at home, and modifications to the school environment to facilitate these changes (e.g., making school lunches healthier) [18, 19, 21]. The STRIDE intervention is distinct from the other protocols for children in that it will be a community-based intervention that has components across 4 levels [17]. The primary individual level intervention strategy will be the distribution of two comic books annually to children. These comic books will include targeted messages around healthy eating and physical activity. At the interpersonal level, families of the children will be invited to participate in an eight-week series of workshops to support healthy eating and physical activity behaviors at home. STRIDE researchers will also collaborate with schoolteachers to add educational sessions on media literacy and to offer short PA breaks during class. They will also organize several community activities including an annual Ciclovía, an event where a permit is obtained to close down the streets and community members are encouraged to engage in a variety of physical activities. They will also establish a farmers' market and a series of family nights where community members share a healthy meal and learn about nutrition and PA issues in their community.

Two trial protocols focused on adults. HelpMeDoIt! will intervene at the individual and interpersonal levels in a largely online setting [20]. OPREVENT2 is the only trial protocol to intervene at all levels of influence that comprise the Social Ecological Model [16]. They will establish Community Action Committees to initiate and promote policies relating to healthy eating and PA. They will modify the worksite environment to promote water consumption and PA, and they will train schoolteachers to teach children to become agents of healthful behavior change for their parents.

Completed studies

As with the protocols, most studies (5 out of 6) focused on children and adolescents. The design of four of these studies (Active Teen Leaders Avoiding Screen-time (ATLAS) Program, Healthy Caregivers-Healthy Children (HC2), Shaping Healthy Choices Program, and School-based Lifestyle Intervention Package) was similar to the school-based protocols in terms of levels of influence and general focus of each level. The fifth study in children, the Healthy Families Study [22], focused on mother-daughter pairs living in public housing developments. The individual-level intervention centered around educational training provided by lay health advisors (Healthy Living Advocates). Healthy Living Advocates also led weekly walking groups and promoted cooking demonstrations that were offered for residents every 3 months by a Registered Dietitian. The intervention public housing developments were also provided with access to healthy foods via a Fresh Truck van that sold fruits and vegetables and monthly health screenings. The Go! Program was in hospital and clinic employees at a worksite [23]. The intervention strategies centered more on modifying the cafeteria and using influential messaging and individuals to promote healthy eating and PA.

Of the six studies, four found the intervention group had better anthropometric outcomes than the control group (Table 3). The magnitude of these differences ranged across the studies. Findings for obesity-related health behaviors were largely null. PA only increased in Go! Program and Healthy Families Study trials [22, 23]. Fruit and vegetable intake increased in the Healthy Families Study trial [22], and total energy intake decreased in the School-based Lifestyle Intervention Package trial [27].

Discussion

In this updated review of the current literature on multilevel obesity prevention interventions, we found 12 trials across 5 continents. The majority of the studies were in children and took place in school settings. Findings were mixed in these studies, so it remains difficult to draw conclusions as to the utility of this approach over single-level interventions. School settings are easier environments to control than community and home environments, but there is some evidence suggesting trials that integrate approaches outside of the school and in the community have a greater impact. Further work is needed with these types of study designs such as those proposed in the STRIDE protocol [17].

Several studies showed significant reductions in BMI, but the effect sizes were rather small. This is typical of multilevel interventions, particularly in the short time frames under study. However, given these interventions occur at a population level, the potential reach is greater than that of individual-level interventions. The length of time it takes for multilevel interventions to take effect, especially those with community- and policy-level components is unclear, but it is possible that effect sizes in some of these studies will grow with longer follow-up. This was the case for the multilevel intervention in North Karelia, Finland where tobacco use declined over a ten-year period after the initiation of a communitywide multilevel intervention to reduce cardiovascular disease [28]. However, funding constraints make this type of follow-up impractical for most studies. This is evidenced by the Healthy Families Study in public housing developments which was intended to last three years but was cut to one due to a loss of funding [22].

Few of the multilevel trials we reviewed included community or policy level interventions. Policy changes are challenging to incorporate into interventions because the political processes leading up to them are often unpredictable. Uncertainty around timing makes it difficult to anticipate the opportunity to include a policy level intervention component and to secure resources to fund this type of study. In addition, policy changes cannot be randomly assigned to individuals or in many cases, communities, so they require the application of different study designs and modeling approaches than traditional RCTs.

Conclusions

In summary, while there are significant challenges to successfully implementing and evaluating multilevel interventions, this review provides some evidence that this approach has the potential to effectively reduce the burden of obesity, particularly among low-income and marginalized minority populations for whom behavioral weight loss interventions have been shown to be less effective.[29, 30] More training and resources are needed to support

the development of multi-disciplinary teams equipped to design and model the complexities underlying these types of interventions. Systems science and simulation modeling approaches have the potential to guide some of the planning of these studies, and time-sensitive funding mechanisms could help better equip researchers to design interventions around natural experiments.

Acknowledgements

This research was funded by the National Heart, Lung, and Blood Institute (NHLBI) grant number K01HL133531.

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Figure 1:
Social ecological model

Table 1: General characteristics of multilevel obesity prevention trial protocols and completed studies published January 2016 – September 2018

Reference	Study name	Location	Design	Years	Trial participants (N)	Sample characteristics
PROTOCOLS						
Cunha <i>et al.</i> , 2017	PAAPAS Nudge Study	Duque de Caxias, Brazil	Factorial randomized trial	1 school year (2018–2019)	<i>Estimated 1300 students across 18 schools</i>	Fifth and sixth grade students
Gittelsohn <i>et al.</i> , 2017	OPREVENT2	Six rural reservations in NM and WI, USA	Stratified, group randomized	6, 2-month phases (no start date listed)	<i>Estimated 480 adults across 6 reservations</i>	American Indian adults aged 18–75 years
Ko <i>et al.</i> , 2018	Together We STRIDE	Lower Yakima Valley, WA, USA	Quasi-experimental	2 years (no start date listed)	<i>Estimated 900 children in 2 communities</i>	8–12 year old Hispanic children
Li <i>et al.</i> , 2017	CHIRPY DRAGON Study	Guangzhou, China	Cluster randomized controlled trial (RCT)	1 year (2017–2018)	<i>Estimated 1640 students across 40 schools</i>	6–7 year old children
Matthews <i>et al.</i> , 2017	HelpMeDolt!	Glasgow, Scotland	RCT	1 year (Apr 2016-Feb 2018)	<i>Estimated 120 adults</i>	Adults aged 18–70 years with BMI 30 kg/m ² trying to lose weight
Steenbock <i>et al.</i> , 2017	JolinchenKids	Bremen, Germany	Cluster-controlled trial	3 years (no start date listed)	<i>Estimated 1360 children across 68 daycares</i>	3–6 year old children
COMPLETED STUDIES						
Bowen <i>et al.</i> , 2018	Healthy Families Study	Boston, MA, USA	Cluster RCT	1 year (date not specified)	211 mother-daughter pairs across 10 public housing developments	Mother-daughter pairs in public housing residents
LaCaille <i>et al.</i> , 2016	Go! Program	Duluth, MN, USA	Quasi-experimental	1 year (2010–2011)	500 worksite employees	Hospital employees (intervention) and clinic employees (control)
Lubans <i>et al.</i> , 2016	Active Teen Leaders Avoiding Screen-time (ATLAS) Program	New South Wales, Australia	Cluster RCT	20 weeks (date not specified)	361 students across 14 schools	Low-income, 12–14 year old boys at risk of obesity
Natale <i>et al.</i> , 2017	Healthy Caregivers-Healthy Children (HC2)	Miami-Dade County, FL, USA	Cluster RCT	2 years (2010–2012)	1211 children	Low-income, minority children in daycare, their parent, teachers
Scherr <i>et al.</i> , 2017	Shaping Healthy Choices Program	Central Valley and Northern California, USA	Cluster RCT	1 school year (2012–2013)	409 students across 4 schools	Fourth-grade students (aged 9–10 years)
Thakur <i>et al.</i> , 2016	School-based Lifestyle Intervention Package	Union Territory of Chandigarh, India	Cluster RCT	20 weeks (date not specified)	462 across 4 schools	Students coming from both public and private schools, average age 13.5 years old

Table 2: Intervention overview of multilevel obesity prevention trial protocols and completed studies published January 2016 – September 2018

Study	Intervention	Intervention levels			Community	Policy	Obesity-Related Outcomes
		Individual	Interpersonal	Organizational			
PROTOCOLS							
PAAPAS	Educational activities in classroom and changes in school environment	Children		Schools			BMI and body fat percentage.
OPREVENT2	Strategies employed at multiple levels to either improve access to or increase demand for healthy foods and PA	Adults	Children	Worksites, schools	Community food stores, community and social media campaigns	Community Action Committees	BMI, diet, PA
STRIDE	Targeted messaging around healthy eating and PA from multiple sources, increased availability of healthy foods and venues for physical activity	Children	Families	Schools	Community family nights, farmers' markets, and street festivals		BMI z-scores, diet, PA.
CHIRPY DRAGON	Educational activities at school and at home with family, improving school lunches, increasing PA at school and at home	Children	Parents, grandparents	Schools			BMI, dietary behavior, PA.
HelpMeDoIt!	Providing information on healthy eating and PA. Participants can choose "helpers" from social circle that will support them.	Adults	Friends				BMI, PA, diet, waist circumference.
JolichenKids	Changes to daycare environment to promote healthier eating habits and PA, implementation of parents as support system, health promotion among daycare staff	Children	Parents	Daycare			PA, body composition, dietary patterns.
COMPLETED STUDIES							
Healthy Families Study	Residence-based health screenings, walking groups, nutrition and cooking demos, and healthy purchasing options	Mother-daughter pairs	Healthy Living Advocates		Fresh Truck van to provide access to healthy foods, monthly health screenings		BMI, physical activity (PA), and eating behaviors
Go!	Pedometer distribution, nutrition labeling of food in cafeteria, persuasive messaging throughout worksite, integration of influential employees	Employees	Influential employees to reinforce healthy social norms	Hospital workplace, cafeteria			Weight, BMI, waist circumference, PA, dietary behavior
ATLAS	Professional development, fitness equipment for schools, PA sessions, parental strategies to reduce recreational screentime/sedentary behavior	Students	Parents, teachers	Schools			BMI, waist circumference, dietary behavior
HC2	Changes to daycare menus, snack policy, and drink policy; family-based education to increase PA and F	Children	Teachers, parents	Childcare center			Dietary patterns, BMI

Study	Intervention	Individual	Interpersonal	Organizational	Community	Policy	Obesity-Related Outcomes
	+V intake, and decrease simple carbohydrate snacks at home						
Shaping Healthy Choices Program	Nutrition education, family and community partnerships, supporting regional agriculture, improving food available at school, establishing school wellness committees and policies	Children	Parents	Schools, lunchrooms			BMI and dietary behavior
School-based Lifestyle Intervention Package	Health education, lifestyle diaries to self-record diet + PA, dietary recommendations to parents, healthier changes to school menu, reduction in TV screen-time, involvement of teachers	Students	Parents, teachers	Schools, cafeterias			Weight, BMI, waist circumference, PA, dietary behavior

Abbreviations: PA=physical activity; BMI=body mass index

Table 3:

Reported results of completed multilevel obesity prevention trials published January 2016 – September 2018

Study	Adiposity	Obesity-Related Health Behaviors
Healthy Families Study	Significant reduction in BMI (decreased by 1.5 kg/m ² in intervention vs. 0.2 kg/m ² in intervention, adjusted p=0.04)	Increased F+V intake (increased by 1.6 per day in intervention vs. 0.1 in controls, p=0.03) Decreased weekly SSB consumption (by 6% in intervention vs. 1% in controls) Increased PA (physical inactivity decreased by 30% in intervention vs. 2% in controls, p=0.007)
Go!	Significant differences in waist circumference at 6-month follow-up but not 12-month follow-up (6-month change was 2.99% larger in intervention vs. control, p=0.001; 12-month change was 0.54% larger in intervention, p=0.51) No significant differences in BMI at either follow-up (1.10% change at 6 months, p=0.09; 0.16% change at 12 months)	Increased PA (-1.71% lower in intervention vs. control at 6 months, p=0.83; 22.41% higher in intervention at 12 months, p=0.006) Decreased F+V servings in intervention vs. control (6.46% fewer servings at 6 months, p=0.24; 11.7% fewer servings at 12 months, p=0.04) No difference in SSB consumption (0.02 at 6 months, p=0.29; -0.01 at 12 months, p=0.38)
ATLAS	No significant changes in BMI (0.07 kg/m ² difference between intervention and control group; p=0.66) No significant changes in waist circumference (0.3 cm difference; p=0.55)	No changes in moderate to vigorous PA (0.1% difference; p=0.81) No changes in SSB consumption (0.2 glasses/day difference; p=0.56)
HCC	Significantly smaller increase in BMI percentile over time in intervention group vs. control (p=-1.95, SE=0.97; p=0.04)	No significant change in F+V intake over time (p=0.04, SE=0.04; p=0.34)
Shaping Healthy Choices Program	Significant intervention effect on BMI in Northern California district (p=-11.3, 95% CI=-19.2, -3.45; p=0.01) No significant intervention effect on BMI in Central Valley district (p=-1.43, 95% CI=-1.96, 4.82; p=0.40)	No significant changes in F intake (0.08 reduction in servings in intervention group vs. 0.15 reduction in controls; p=0.72) No significant changes in V intake (0.11 reduction in servings in intervention vs. 0.01 increase in control; p=0.26)
School-based Lifestyle Intervention Package	Decreased weight (0.7 kg smaller increase in intervention vs. control group; p=0.05) Significant decrease in waist circumference (0.14 cm smaller increase in intervention; p=0.01)	Significant reduction in total energy intake (0.18 fewer in intervention vs. control; p=0.02) No significant difference in total metabolic equivalents (METs; 0.06 unit difference between intervention and control; p=0.50), but significant difference in school related METs (0.56 more in intervention group; p<0.001)

Abbreviations: BMI=body mass index; F+V=fruits and vegetables; SSB=sugar-sweetened beverages; PA=physical activity