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"Whole-of-Community" Obesity Prevention: A Review of Challenges and Opportunities in Multilevel, Multicomponent Interventions

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Abstract

The causes of obesity worldwide are complex and multilevel, including changing food environments, physical activity levels, policies, and food production systems. This intricate context requires multilevel and multicomponent (MLMC) interventions to improve health outcomes. We conducted a literature review of MLMC interventions for obesity prevention and mitigation; 14 studies meeting search criteria were identified. We found examples of successes in preventing obesity, reducing overweight, improving healthful behaviors, and enhancing some psychosocial indicators. Of eight studies that reported health and behavioral results, five showed no significant impact and three showed reductions in obesity. Four studies showed significant improvement in dietary behavior, and five reported significant desirable effects in physical activity or screen time. Five studies reported psychosocial impacts, and three of these showed significant improvements. MLMC approaches show promising results, particularly when they are able to integrate components at the policy, community, and interpersonal levels.

Keywords

Obesity; Prevention; Multilevel; Multicomponent; Community-based interventions; Review; Health promotion; Research design; Health behavior; Lifestyle; Minority populations; Child; Adult

Introduction

The causes of the global rise in obesity are complex and multilevel, including changing food and physical activity environments, policies, and food production systems [1, 2]. In particular, widespread availability of low-cost, calorie-dense, nutrient-poor foods has led to increased energy intake without an equivalent rise in energy expenditure, resulting in population-level increases in overweight and obesity [1]. This complex context requires

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Compliance with Ethics Guidelines

Conflict of Interest Ella Ewart-Pierce, María José Mejía Ruiz, and Joel Gittelsohn declare that they have no conflict of interest.

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multilevel and multicomponent (MLMC) interventions that take a systems approach to effectively improve health outcomes [3, 4].

Multilevel approaches focus on changing health behaviors by acting on multiple contexts, communities, and environments that influence the individual. A common framework to describe this approach is the Social Ecological Model (SEM), which incorporates individual, interpersonal, organizational, community, and policy levels [5]. A single-level intervention impacts only one of these levels of influence, for example classes to provide nutrition education to children, operating only at the individual level. Multilevel interventions reach two or more levels, for example, by educating children at school and changing the school food service, operating at both the individual and organizational levels.

Multicomponent interventions incorporate more than one strategy or mechanism to achieve an improved health outcome within the same level. For example, at the organizational level, a corner store both enacts a marketing campaign with posters to promote healthy beverages and increases the supply and variety of options on the shelves. Thus, the store would be using two strategies at the same level.

The obesity prevention literature has frequently included interventions that reach only a single institution or only operate at the individual level. Commonly, within any particular level, multicomponent approaches are not employed. To date, there have been no literature reviews that broadly examine MLMC approaches for preventing obesity across all age groups. This review seeks to fill the gap by addressing the following key research questions:

- What MLMC interventions have been/are being tested for obesity prevention, and what study designs, intervention components/levels, and evaluation approaches are used?
- How effective have tested MLMC interventions been in improving health, behavioral, and psychosocial outcomes?

Methods

Overview

A literature review was performed to assess current studies using an MLMC approach for obesity prevention. Articles selected for inclusion met three inclusion criteria. First, a direct measure of obesity was required. Second, the study intervention components took place at more than one level (individual, interpersonal, organizational, community, or policy), engaging various stakeholders. Third, the study clearly articulated a strategy with multiple mechanisms for impact on behavior and weight status.

Literature Search Steps

As an emerging approach to obesity interventions, MLMC trials pose a unique challenge to review. Few studies characterize themselves as MLMC in the search terms or in the text, thus the electronic search terms were designed to encompass a broad body of literature producing a large number of articles that required both electronic and manual filtering. The search was limited to the last 10 years to include all indexed journal articles based on studies

using human subjects published in English between January 2006 and January 2016 (see Appendix). Notably, this excludes some foundational studies in community-based interventions that were published more than 10 years ago, or that did not specifically look at obesity, but instead focused exclusively on non-communicable diseases (NCDs) [6–8]. Figure 1 outlines the steps in the literature search.

Step 1: Initial Search—Three search concepts for (1) MLMC approach, (2) obesity, as well as (3) environmental influences and health behavior were constructed using a combination of Medical Subject Headings (MeSH), title and abstract text, and the full article text. The intersection of these three concepts resulted in 611 articles.

Step 2: Application of Primary Exclusion Criteria—Six exclusion concepts were constructed and applied to exclude studies with primary foci outside the scope, including smoking, meal replacement diets, specific single food or beverage consumption, surgical care or drugs, other disease conditions, and testing or validating novel statistical methodologies. Filtering based on these concepts excluded 232 articles and retained 379.

Step 3: Focused Application of Inclusion Criteria—Next, the 379 abstracts were re-reviewed manually and received binary codes in Excel for three inclusion criteria: obesity, multilevel, and multicomponent. Those that did not meet all three requirements were discarded. Requirements were defined in the following ways. Obesity had to be measured, for example, with body mass index (BMI), waist circumference, or other measure; of the 379 articles, 107 did not meet this criterion. The multilevel criterion necessitated that the intervention substantively engage subjects at more than one level. For example, studies conducted in school environments that simply sent information to parents reached only the organizational level and were discarded; of the 379 articles, 299 did not meet this criterion. Finally, multicomponent required more than one mechanism to impact the outcomes of focus. For example, a design that included both a curriculum intervention and organizational changes to improve cafeteria offerings in a school setting met the multicomponent requirement, whereas an intervention that consisted only of an educational strategy was not considered multicomponent; 217 did not meet this criterion. When the 324 articles that lacked any one of these three requirements were excluded (some studies lacked more than one criterion), 54 articles remained.

Step 4: Identification of Individual Studies—The remaining 54 articles were read and the specific study that had produced the publication was identified, resulting in 38 originating studies.

Step 5: Identification of Additional Articles Associated with Originating Studies—Further searches were conducted on each individual study by author and by study name to identify related publications that best explained the scope, method, intervention strategies, design, and relevant results of each. This was especially relevant for research that was scaled up over time or large multisite studies, and included 65 additional papers.

Step 6: Full-Text Review—Finally, the lead author (EE-P) read the full text and bibliography of the 119 papers remaining. The “backwards” search and full-text read did not

identify additional articles. Articles in early pilot stages were excluded, resulting in 56 articles published from 14 studies. The final included studies are Ballabeina Study (Ballabeina), Baltimore Healthy Eating Zones (BHEZ), Childhood Obesity Prevention and Treatment Research (COPTR), Childhood Obesity Research Demonstration (CORD), Children's Healthy Living (CHL), Girls Health Enrichment Multi-site Studies Phase II (GEMS), Healthy Caregivers-Healthy Children (HC2), Healthy Families Study (HFS), Intervention Centered on Adolescents Physical Activity and Sedentary Behavior (ICAPS), National Institute of Public Health (INSP), Shape Up Somerville (SUS), Switch What You Do, View, and Chew (Switch), Texas Expanded Food and Nutrition Education Program (TEFNEP), and TriAtiva Program: Education, Nutrition and Physical Activity (TriAtiva).

Coding Included Research Studies

The final set of studies were coded by EE-P and independently coded by a coauthor (MJMR) to identify study location, community and cultural context, demographics of the audience, design and methodology, intervention levels, process evaluation, and outcomes. Data in each of these categories were collected from one or more publications produced by each study and coded by study. Inconsistencies in coding were adjudicated by the third coauthor (JG).

Results

Fourteen studies met the search criteria. Studies took place in the continental U.S. (9 of 14), Europe (2), Latin America (2), and the Pacific Islands (1). Evaluation sample sizes ranged from more than 4300 (CORD) to 211 households (HFS). All studies in the final pool targeted childhood obesity. Adults were also targeted in five of the studies. Table 1 describes general characteristics of included studies; Table 2 reports the intervention, levels, and process evaluation; and Table 3 shows the outcomes.

Approaches

Theoretical Foundations—Thirteen studies identified a theoretical framework foundation; Social Cognitive Theory (SCT) and SEM were the most common theoretical frameworks used. Only three of the studies (BHEZ, CHL, and SUS) discussed using community-based or community-based participatory research approaches. Behavior change theories were also referenced by four studies (CORD, CHL, HC2, and INSP).

Study Design—Most studies (12 of 14) were randomized controlled trials (RCTs), one used a quasi-experimental design (SUS), and one used a factorial design (CORD). Half of the studies (COPTR, CORD, CHL, HC2, SUS, Switch, and TEFNEP) evaluate samples of more than 1000 participants. Four include 501 to 1000 participants (Ballabeina, ICAPS, INSP, and TriAtiva) and three include 500 participants or fewer (BHEZ, GEMS, and HFS). The durations varied—four lasted less than one calendar year, four covered a period of 1 to 2 years, and six lasted or are planned to last for more than two calendar years.

Population Characteristics—Unique socio-cultural contexts and the policy environment were described for all studies and varied widely across studies. Nonetheless, poor

accessibility of affordable healthy foods, declining levels of physical activity (PA), and lifestyles not conducive to healthful options due to urbanization were commonly reported.

A focus on children was not an inclusion criterion, yet all of the included studies center on children, adolescents, or youth and four also focused on adults (HC2, HFS, Switch, and TEFNEP). Many targeted vulnerable sub-populations, like racial and ethnic minorities (11), low-income families (8), or girls and women (3).

Venues of Intervention—All studies included multiple venues or locations for implementation. Six included a school-based component. Other venues included food stores, restaurants, or small food vendor businesses (5), community recreation centers (rec. centers) (4), primary care settings (3), and public assistance programs (3).

Levels and Components—All studies incorporated components acting at the individual and interpersonal levels. Most frequently, these were individual children and their caregivers working at an interpersonal level with teachers or trained paraprofessionals, such as community health workers. Organizational entities like schools or clinics were involved in 12 studies. Seven studies included community-level institutions like stores, wholesalers, or rec. centers (BHEZ, COPTR, CORD, CHL, GEMS, ICAPS, and SUS). Nine studies involved, or were influenced by, a policy component such as leveraging a local law or execution within a public assistance program (Ballabeina, CORD, CHL, HC2, HFS, INSP, SUS, TEFNEP, and TriAtiva).

Observed Impacts

Process evaluations were conducted in most studies to report reach, dose, and fidelity (Table 2), and study results have been grouped into three outcome categories: psychosocial, behavioral, and health (Table 3).

Process Evaluation—Most studies include a process evaluation (13 of 14), and eight of these published results in the period of this review. The number of participants who received any amount of the intervention was the reach, dose was the amount and frequency of delivery to the target population, and fidelity was how closely the implementation reflected the design. Studies did not report specific reach, dose, or fidelity scores, but selected various indicators. Ballabeina reported better than 75 % achievement at all levels. GEMS experienced low adherence to the two individual-level components while the family level had strong adherence. ICAPS reported that students achieved some components while parent, teacher, and community achievement was low. BHEZ reported achievement of two of six intervention components. CHL developed “crosscutting functions” (similar to components) and performed “somewhat well” in three of the four. INSP reported above 70 % achievement for all components. SUS reported high adherence in school components and lower adherence in restaurant components. Finally, TEFNEP reported high fidelity and did not report dose or reach.

For the purpose of generalizing process evaluation results, a measure of *community adherence* was developed. Good community adherence was defined as achieving more than half of the study components at most (more than half) of the observations, while poor

community adherence meant reporting that same level of success at fewer than half of the observations. Six studies reported good community adherence (Ballabeina, CHL, ICAPS, INSP, SUS, and TEFNEP) and two studies reported poor adherence (BHEZ and GEMS). The remaining five studies have not yet published their process evaluation results (COPTR, CORD, HC2, HFS, and Switch). Neither of the two studies that reported poor adherence included a policy component and both reported challenges with community support for at least one intervention component.

Health Outcomes—Eight of the fourteen studies reported impact on health outcomes. The other six studies are ongoing. An obesity measure like BMI or waist circumference was an inclusion criterion for this study, so all studies utilized at least one. Ballabeina ($p = 0.001$ for BMI, sum of four skinfolds, and waist circumference), BHEZ ($p = 0.04$ for BMI for age percentile and $p < 0.001$ among only overweight and obese children), SUS ($p = 0.0054$ for child BMI z-score and parent BMI decrease 0.411 kg/m^2, 95 % CI (−0.725 to −0.097)), and TEFNEP (BMI decrease at post $p < 0.05$ but not maintained at followup) showed improvements among the intervention group or an intervention sub-group. Two studies reported success in preventing an increase in BMI within the intervention group as opposed to the control group (GEMS and ICAPS), but no overall reduction in BMI among overweight or obese participants in the intervention group. HC2 and Switch showed no impact on BMI or other obesity measure among the intervention group.

Additionally, blood tests (lipids, insulin, etc.) were included in the GEMS, ICAPS, and COPTR studies. One of the two GEMS sites showed improvements in total cholesterol (−3.49 adjusted mean difference in fasting total cholesterol, 95 % CI (−5.28 to −1.70)), low-density cholesterol (LDL) (−3.02 mg/dL per year, 95 % CI (−4.74 to −1.31)), and incidence of hyperinsulinemia (RR=0.35, 95 % CI (0.13 to 0.93)), and ICAPS showed improved high-density cholesterol concentrations (HDL) ($p < 0.0001$), while COPTR is still ongoing.

Several studies showed differences among sub-groups. SUS ($p = 0.0054$) showed a sustained reduction in BMI among child participants who were overweight or obese at baseline. SUS further showed BMI decrease among parents of children in the intervention group relative to the control group parents (−0.411 kg/m^2, 95 % CI (−0.725 to −0.097)). Ballabeina showed greater beneficial impacts on low-fit ($p = 0.027$) and overweight children ($p = 0.001$) than on fit and normal weight children. BHEZ showed greater impact on overweight and obese girls and boys ($p < 0.001$).

Behavioral Outcomes—All studies included behavioral change measures, centering on diet, PA, or both, and eight published results by January 2016 (Ballabeina, BHEZ, GEMS, HC2, ICAPS, SUS, Switch, and TEFNEP). Six reported desirable behavioral results as a consequence of the intervention (Ballabeina, BHEZ, HC2, ICAPS, SUS, and Switch).

Ballabeina, BHEZ, SUS, and Switch showed that the intervention seemed to impact at least one dietary outcome positively, while TEFNEP showed significant desirable dietary changes in both the intervention and the control groups and GEMS showed mixed outcomes. Ballabeina, HC2, ICAPS, SUS, and Switch showed improvements in PA indicators (including screen time/media use (ST)).

Ballabeina showed improvements in diet ($p = 0.04$) and BHEZ showed reduced purchasing of less-healthful snacks ($p = 0.02$) and fast food ($p = 0.02$). However, BHEZ also showed a reduction in purchasing healthful snacks ($p = 0.01$) and overall negative behavioral impacts in both the intervention and control groups. GEMS showed no significant dietary impacts at one site, and the other site showed worsened behaviors for both control and intervention groups, but the intervention group was less negatively impacted. The intervention arm showed 0.19 fewer servings per day of SSBs ($p = 0.075$), 0.21 more servings per day of water ($p = 0.022$), and 0.15 more servings per day of vegetables ($p = 0.069$) consumed when compared to the control. SUS showed reduced sugar-sweetened beverage (SSB) intake (−2.0 oz per day (95 % CI −3.8 to −0.2)) and improved foods available (21 restaurants joined the program). Switch showed improved fruit and vegetable (FV) consumption ($p < 0.05$). TEFNEP showed an association between better goal attainment and improved dietary outcomes in the intervention and control groups.

For PA outcomes, Ballabeina showed reduced ST ($p = 0.03$). HC2 showed that control group children spent more time on the computer ($p < 0.01$) and watching television ($p < 0.0001$) than the intervention. ICAPS showed increased PA ($p < 0.0001$) and decreased ST ($p < 0.01$). SUS showed increases in PA (0.20 sports or activities per year (95 % CI 0.06 to 0.33)) and reduced ST (−0.24 h per day, 95 % CI (−0.42 to −0.06)). Finally, Switch showed reduced ST ($p < 0.05$).

Psychosocial Outcomes—Five of eight studies reported impact on psychosocial outcomes, including quality of life, behavioral intentions, self-efficacy, depressive symptoms, perceived social support, and knowledge (Ballabeina, BHEZ, GEMS, ICAPS, and TEFNEP). Ballabeina showed no significant impact on quality of life or cognitive ability. BHEZ showed decreased behavioral intentions ($p = 0.01$), increased outcome expectancies ($p = 0.02$), and increased knowledge ($p < 0.001$) associated with the intervention. GEMS showed a significant difference in depressive symptoms (−0.21 Children's Depression Inventory (0–20 scale), 95 % CI (−0.42 to −0.001)). ICAPS reported changes in self-efficacy and social support toward exercise at post, but these were not significant at follow-up. Intention to practice exercise was significantly improved at follow-up ($p < 0.001$). TEFNEP reported significant time effects for most indicators in both the control and the intervention groups at follow-up. For example, mean parent self-efficacy for modeling fruit, juice, and vegetable (FJV) consumption control mean 1.6 self-efficacy units (scale 0–2) (SE = 0.02) versus intervention 1.6 self-efficacy units (scale 0–2) (0.02).

Discussion

This is the first literature review to examine MLMC interventions for obesity prevention and reduction. We identified 14 trials that met inclusion criteria, 8 of which reported on impact.

Impact of Tested Interventions

The MLMC intervention studies reviewed clearly show promising behavioral impacts, particularly in terms of increasing intake of healthier foods and beverages. Additionally, improvements in PA and reduction in screen time were seen in some studies. Elsewhere, researchers have reported that PA interventions have had only limited impact on children's

overall activity levels [9], so our findings provide support for MLMC interventions as a more effective approach.

MLMC interventions were associated with obesity reductions in some (three of eight) of the study results reviewed. Sustained reductions in BMI among overweight and obese participants appear to be difficult to demonstrate in these interventions, most likely due to their limited time scope. In addition, the longest duration studies included in this pool lasted only 5 years and are not yet complete, so whether or not the interventions for children reduce the risk of NCDs later in life is unknown.

Psychosocial variables appear to be reported less frequently than other types of outcomes in MLMC trials. The studies reviewed did show some desirable impacts in psychosocial outcomes, but results were mixed.

Our review suggests that MLMC interventions may perform better than single-level interventions as approaches for obesity prevention. Integrated approaches outside of the school or other single-level focus, and especially within the community, for the purpose of NCD prevention are supported by the research as early as the 1980s [8]. The North Karelia Project, a large-scale, long-term MLMC intervention in Finland, showed successful behavioral changes resulting in significant improvements in mortality and morbidity among adults [10]. The program's success strongly suggests that theory-based sustained activity within a national policy framework can support community aims to bridge cultural, political, economic, and psychological obstacles to health [10]. Our literature review provides support for these approaches to child health. Where most previous trials have been school-based and have had limited impact on obesity, school-based trials that have had impact have almost always integrated approaches outside the school and in the community [11, 12•].

Evaluating MLMC Interventions

Several authors expressed inability to determine which components of the intervention worked best and lacked clarification on synergies between interventions [13••, 14]. Future studies such as cluster randomized trials that compare a control group to an intervention with some components to an intervention with all components might prove fruitful. Also, future reviews evaluating the quality of MLMC studies may be helpful in understanding the overall quality of the existing evidence [15].

Process evaluations and other forms of evaluation should help address these questions. However, while process evaluations were completed by nearly all studies, methodology varied considerably. Few reported on how well studies set and met standards for intervention implementation, which made it difficult to assess implementation fidelity or compare one study with another. Increased consistency in process evaluation methods might help answer questions about which types of components are implementable in varied contexts. One strategy to test different MLMC interventions alone or in combination might use systems science modeling as a means of identifying best strategies and potential unintended consequences [16].

Context Matters

Our work supports the finding of the North Karelia Project that close collaboration with community and full participation from various levels are key for successful intervention programs [10]. BHEZ, CHL, and SUS employed community-based participatory techniques to develop and pilot intervention strategies. Their work suggests that knowing the specific context and program beneficiaries' needs impacts the way that programs are developed, implemented, and how effective they will be. Researchers reported needing additional information to parse the relationship between the context of the intervention and the efficacy of the intervention in the context or population [17].

Policy Intervention Components

Policy interventions seem essential, but can be difficult to measure because the control group is often affected by the same policies as the test group. Further, administrative or policy-level buy-in is required to facilitate implementation of the intervention and lack of buy-in limits implementation. Nine studies in this pool involved a policy component. For example, in Porto Alegre, Brazil, a municipal law was passed that requires more healthful food options be sold at shops located within schools and prohibits sale of some types of less healthful foods, providing foundational support for the TriAtiva study. Similarly, the Ballabeina study in Switzerland builds on a new national health policy for schools. In the U.S., SUS is built on a state policy called, "Mass in Motion" which supports PA. These could not be explicitly tested in the study designs because the policy affected both the intervention and control groups. Nonetheless, the policy foundation is an essential component of the intervention and implementation. It is important for the field to continue to pursue research methods that permit and support evaluations of policy interventions (e.g., natural experiments with comparison communities), include strong process evaluations, and possibly find ways to compare across contexts to better understand the impact of these policies. For example, the Staple Food Ordinance Evaluation (STORE) Study examines the effect of the Staple Foods Ordinance passed in October of 2014 in the City of Minneapolis, MN, U.S. [18]. STORE researchers will compare the nutritional quality of customer purchases at small stores in Minneapolis to those in nearby St. Paul, MN where no such ordinance exists [18].

Conclusions

MLMC approaches are being tested in RCTs and to a lesser extent with quasi-experimental designs worldwide for obesity prevention and mitigation. These designs seem to be primarily focused on children in vulnerable or minority populations. Interventions integrate multiple components both related to diet and PA that act across multiple levels of the social and environmental context. These approaches are showing promising results in health, behavioral, and some psychosocial outcomes, particularly when they are able to integrate policy and community level components.

Future research may benefit from comprehensive, holistic interventions that support longer-term strategies, and which integrate policy and community components. Further, factorial study designs that test groups of intervention components are needed. Evaluations must be

conducted of programs that capture effects outside of the individual, at the interpersonal, organizational, community, and policy levels.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix 1: Search Terms

Inclusion Search Syntax

The search below is numbered by component for clarity. When utilized in the PubMed database, these components were run together as a single search procedure. See PubMed's Medical Subject Heading (MeSH) Database Resource for additional details on search syntax.

1. Obesity Sphere

   ((“obesity “[MeSH Terms] AND (“prevention and control”[Subheading] OR “therapy”[Subheading]))

2. Multilevel Multicomponent Approach

   ((multi level[tw] OR multi leveled[tw] OR multi leveling[tw] OR multi levelled[tw] OR multi levels[tw]) OR (multilevel[tw] OR multilevel’[tw] OR multileveled[tw] OR multileveling[tw] OR multilevelled[tw] OR multilevelness[tw] OR multilevelpsa[tw] OR multilevels[tw] OR multilevelsupertree[tw]) OR (multi component[tw] OR multi componented[tw] OR multi componential[tw] OR multi components[tw]) OR (multicomponent[tw] OR multicomponent’[tw] OR multicomponental[tw] OR multicomponented[tw] OR multicomponential[tw] OR multicomponentness[tw] OR multicomponents[tw]) OR “health promotion”[MeSH Terms] OR “health education”[MeSH Terms]))

3. Obesity as a Risk Condition Within the MLMC Approach

   (“overweight”[MeSH Terms] OR “obesity”[MeSH Terms] OR “obesity”[MeSH Terms] OR “risk”[MeSH Terms] OR Overweight[tw] OR obesity[tw] OR obese[tw])

4. Behavioral or Environmental Risk for Obesity

   (“food habits”[MeSH Terms] OR “health behavior”[MeSH Terms] OR “diet” [MeSH Terms] OR “cooperative behavior”[MeSH Terms] OR “sedentary

lifestyle"[MeSH Terms] OR "environment design"[MeSH Terms] OR "residence characteristics"[MeSH Terms] OR "risk reduction behavior"[MeSH Terms])

5. Study Type, Time frame, Focus Species, Language, and Article Type

   Clinical Study[ptyp] AND "2006/01/28"[PDAT]: "2016/01/25"[PDAT] AND "humans"[MeSH Terms] AND English[lang] AND "journal article"[Publication Type]

Exclusion Filters Syntax

1. Smoking behavior

   smoking[mh] OR tobacco[mh] OR Tobacco Smoke Pollution[mh] OR Smoking Cessation[mh]

2. Cancer

   Mammography[mh] OR mastectomy[mh] OR neoplasms[mh] OR Lymphedema[mh] OR Breast Neoplasms[mh] OR Neoplasm Staging[mh]

3. Non-Food Diets

   food, formulated[mh] OR "Meal replacements"[tw] OR edible grain[mh] OR Sweetening Agents[mh] OR Carbonated Beverages[mh] OR Beverages[mh] OR Dietary Carbohydrates[mh] OR Plant Extracts[mh] OR Sodium Chloride[mh] OR

4. Clinical Care

   patient compliance[mh] OR postoperative complications[mh] OR nurses[mh] OR nursing[mh] OR nurse practitioners[mh] OR medication adherence[mh] OR adherence[tiab] OR Preoperative Period[mh] OR Insulin Resistance[mh] OR mass screening[mh] OR "Dietary Inflammatory Index"[tiab] OR Patient satisfaction[mh] OR Intention to Treat Analysis[mh] OR hospital[tiab] OR "bariatric surgery"[tiab] OR bariatric surgery[mh] OR bariatrics[mh] OR gastric bypass[mh]

5. Disease Conditions and Treatments Outside of the Scope

   Cognitive Therapy/methods*[mh] OR Psychological Theory[mh] OR Inflammation*[mh] OR Bone Resorption[mh] OR atherosclerosis[mh] OR leptin[mh] OR "spinal stenosis"[tiab] OR "Endothelial dysfunction"[tiab] OR "spinal cord"[tiab]

6. Statistical Methods Focus

   Reproducibility of Results[mh] OR Models, Statistical*[mh]

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•• Of major importance

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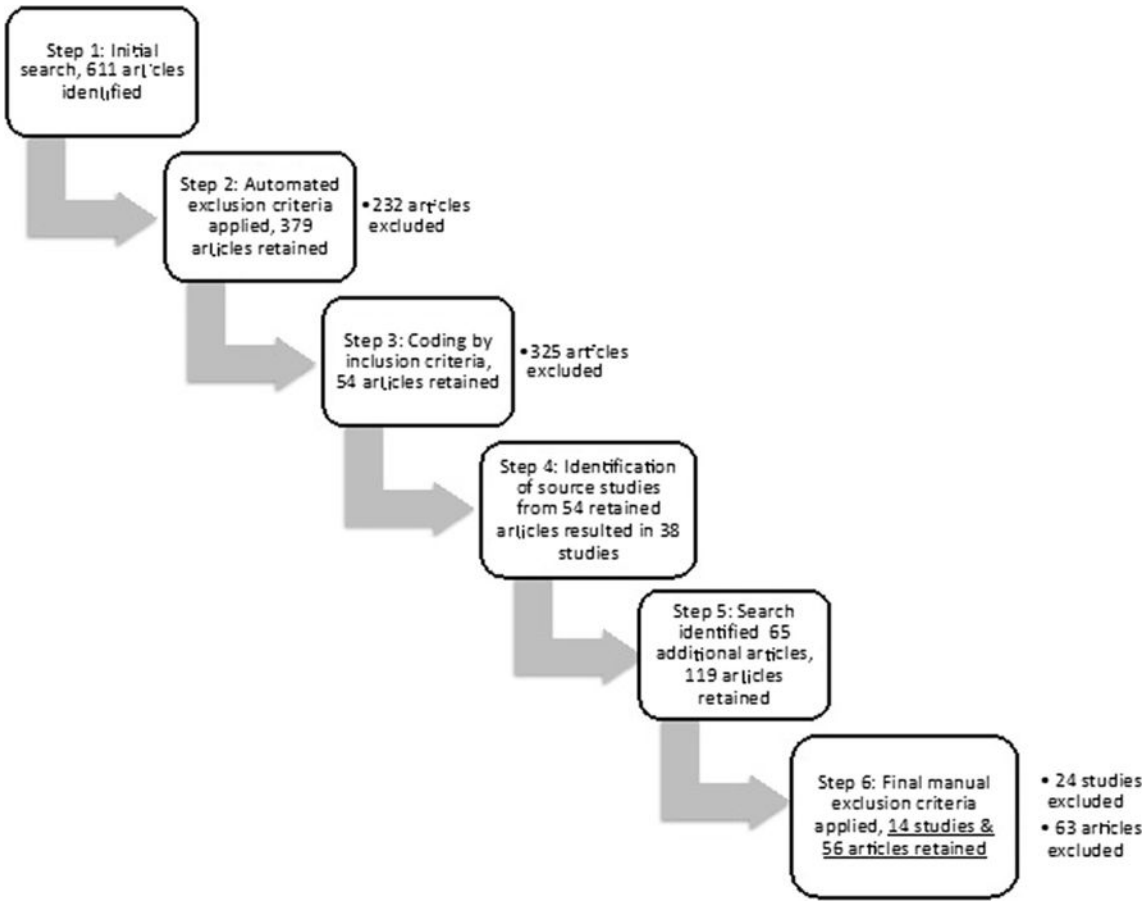

Fig. 1.

Literature search procedures to identify multilevel, multicomponent obesity prevention and control studies

Table 1

General characteristics of selected multilevel multicomponent trials published January 2006–January 2016

Study name	Citations	Location	Design	Years	Trial participants (*N*)	Participant group characteristics
Ballabeina Study (Ballabeina)	[19–24]	St. Gallen and Vaud, Switzerland	Cluster randomized controlled trial (RCT)	2008–2009 (1 academic year)	655	Preschool students, largely immigrants
Baltimore Healthy Eating Zones (BHEZ)	[25, 26]	Baltimore, MD, USA	Cluster RCT	2009–2010 (8 months)	242 pairs	Pairs of African-American youth ages 10–14 years and a primary caregiver
Childhood Obesity Prevention and Treatment Research (COPTR)	[27••, 28–31]	Cleveland, OH, Davidson County, TN, East Palo Alto, Menlo Park and Redwood City, CA and MN, USA	Individually randomized group treatment and RCT	~2012–2018 (7 years)	1700	Low-income, minority 3–13-year-olds and their parents
Childhood Obesity Research Demonstration (CORD)	[32–41]	Brawley, El Centro and Calexico, CA, Fitchburg, New Bedford and Lowell MA, and Austin and Houston, TX, USA	Factorial	2011–2014 (2 years)	4314 in 3 sites	Low-income, minority 2–12-year-olds
Children's Healthy Living(CHL)	[4, 42–48]	AK and HI, USA, American Samoa, Northern Mariana Islands and Guam	Cluster RCT	2011–2016 (5 years)	4100	Children ages 2–8 in communities with large native Pacific Islander populations
Girls health Enrichment Multi-site Studies Phase II (GEMS)	[49–53]	Oakland, CA and Memphis, TN, USA	RCT	(2 years)	303	Low-income, minority girls ages 8–10 years, who are overweight or who have one overweight or obese caregiver, and the caregiver
Healthy Caregivers-Healthy Children (HC2)	[54, 55]	Miami-Dade County, FL, USA	Cluster RCT	2010–2013 (3 years)	1211 children, 1080 parents, and 122 teachers	Low-income, minority children in daycare, their parent, and teachers
Healthy Families Study (HFS)	[56]	Boston, MA, USA	Cluster randomized	(3 years)	211 households	Mother-daughter pairs in public housing residents
Intervention Centered on Adolescents Physical activity and Sedentary behavior (ICAPS)	[57–60]	Bas-Rhin, France	RCT	2002–2006 (4 academic years)	954	Students, grade 6 in public middle schools
National Institute of Public Health (INSP)	[14, 17]	Mexico City, Mexico	RCT	2003–2005 (2 years)	886 students and 27 schools	Students 9–11 years old
Shape Up Somerville (SUS)	[13••, 61, 62, 63•, 64, 65]	Somerville, MA, USA	Community-based participatory research and non-randomized controlled trial	2003–2005 (3 years)	1178	Students grades 1–3 in public elementary schools in low-income, ethnically and racially diverse, high proportion of non-English-speaking communities
Switch what you Do, View, and Chew (Switch)	[66, 67]	Lakeville, MN and Cedar Rapids, IA, USA	RCT	2005–2006 (1 academic year)	1323 students and 10 schools	Students graded 3–5 and their families

Study name	Citations	Location	Design	Years	Trial participants (*N*)	Participant group characteristics
Texas Expanded Food and Nutrition Education Program (TEFNEP)	[68, 69]	Austin, Houston and San Antonio, TX, USA	RCT	2006–2007 (13 months)	1006	Clients of a publicly funded nutrition assistance program
TriAtiva Program: Education, Nutrition and Physical Activity (TriAtiva)	[70]	Porto Alegre, Brazil	Cluster RCT	2013 (6 months)	600	Brazilian public primary school students

Table 2

Intervention overview of selected multilevel multicomponent obesity prevention trials and process evaluation

Study	Intervention	Intervention levels					Process evaluation
		Individual	Interpersonal	Organizational	Community	Policy	
Ballabeina	Increase PA, improve diet and reduce ST	Students	Parents, teachers and local health promoters	Schools		New national PA program	88 % achievement of teacher outcomes, 85 % of environmental outcomes, and more than 75 % of all child outcomes
BHEZ	Promotion of food alternatives and messages on food-related behaviors	Youth and caregiver pairs	Peer educators, primary caregiver and graduate students	we	Wholesalers, restaurants, carryouts, corner stores, rec. centers and community-based orgs		Measures of reach, dose, and fidelity by level and phase showed that 4 intervention components were not achieved and 2 were achieved
COPTR	Visitation program and parenting classes aimed at parents; social media and phone coaching; primary-care counseling, screen-time reduction; goal-setting, skill building, changing family environment. Interventions tailored to site	Children and parents	Teachers	Primary care facilities	Rec. centers and other community resources		Evaluation plans are site specific and vary in design. Results not yet published
CORD	Tailored interventions at each study site focused on improvements in FV and water consumption, PA, and quality sleep	Children	Community health workers, teachers, and parents	Schools, child care centers and healthcare facilities	Restaurants and rec. centers	Families are eligible for benefits under Title XXI (CHIP) or Title XIX (Medicaid)	Context, reach, dose delivered, dose received, and intervention fidelity. Results not yet published
CHL	Community prioritized, tailored intervention strategies: policy supports, growing and eating local healthy foods, role models,	Children	University students	Health workforce training programs	Community orgs and community leader advisory committee	Support policy for healthy eating and PA. Increase accessibility of environments for safe play and PA	Fidelity measures scored “somewhat well” in 3 of the 4 crosscutting functions

Study	Intervention	Intervention levels					Process evaluation
		Individual	Interpersonal	Organizational	Community	Policy	
	accessibility of PA environments, water access, and health workforce training						
GEMS	Culturally tailored after-school dance classes with daily transportation provided to centers. Home-based screen-time reduction lessons, monitoring, and mentorship	Youth and caregivers	Family screen-time intervention mentor		Rec. centers		Attendance at dance classes and family receipt of screen-time intervention was lower than planned. Strong receipt and reading of newsletters
HC2	Childcare centers healthy menu changes and family-based education focused on increased PA and FV intake, decreased intake of simple carbohydrate snacks, and decreased ST	Parents and children	Teachers			New center policy for dietary requirements for diet, PA, and ST	Attendance, activity engagement, newsletter use, and satisfaction completed. Results not yet published
HFS	Residence-based health screenings, walking groups, nutrition and cooking demos, and healthy purchasing options	Mother-daughter pairs	Residents trained in community outreach support program and families	Public housing residences		Public housing program	Surveys group activities, participant evaluations, and paraprofessional leaders on activities, communication, and satisfaction. Results not yet published
ICAPS	Change knowledge, attitudes, beliefs, and motivation toward PA and improved environmental conditions supporting PA	Youth	Teachers, medical staff and families	PA clubs	Rec. centers		~50 % of the students participated in at least one weekly activity. All intervention students exposed to at least two educational sessions. Mobilization and implication of the teachers, the families, and partners in and outside schools increased throughout
INSP	Education curriculum and environmental	Students	Parents, families, and PE teachers	Principals and school authorities		Policy makers and researchers collaborate	Year one: intervention 75 % of nutrition, 70 % of PA, 90 % communication/ed.

Study	Intervention	Intervention levels					Process evaluation
		Individual	Interpersonal	Organizational	Community	Policy	
	changes to diet and PA						implemented. Year two: 80, 70, and 95 %, respectively
SUS	Diet and PA campaigns, improved foods available in schools and restaurants, education, and community activities	Students and parents	Families, teachers	Schools	Restaurant owners and community organizations	New school wellness policy and state-level policy base	100 % of 1 to 3 grade classrooms implemented school curriculum 21 restaurants recruited to become SUS approved and 10 of 21 restaurants fully complied with all approval criteria
Switch	Students increase the amount of habitual PA, reduce the amount of total ST, and increase FV intake	Children and families	Parents, teachers	Schools			Child, parent, and teacher surveys. Results not yet published
TEFNEP	Increase habitual PA, reduce ST, and increase FV consumption	Parents	Trained paraprofessional teachers			TEFNEP state program used as foundation	Fidelity to the intervention class session structure was high
TriAtiva	Students receive nutrition education and increased PA with families and school. Policy regulation of foods available	Students	Families, teachers and nutritionists	Schools		Law regulates snack food sold and school lunches	Not evaluated

Table 3

Reported results of multilevel multicomponent obesity prevention trials

Study	Health	Behavior	Psychosocial
Ballabeina	More beneficial effects on overweight (OW) vs. normal weight children on waist circumference interaction $p = 0.001$, and for low fit children vs. normal fit on all adiposity outcomes (BMI, sum of four skinfolds, and waist circumference) interaction $p = 0.027$. Intervention children showed reductions in % body fat $p = 0.02$, sum of four skinfolds $p = 0.001$, and lower increases in waist circumference $p = 0.001$ than control children. No effect of prevalence of overweight $p = 0.23$ or BMI $p = 0.31$. No difference in effects on migrants vs. non-migrants. Interaction BMI $p = 0.849$, % body fat $p = 0.966$, waist $p = 0.824$. No difference in effects by educational level (EL), BMI interaction $p = 0.306$, body fat $p = 0.181$, waist $p = 0.454$	No differential effect on OW vs. normal weight children, interaction $p = 0.60$, $p = 0.18$, respectively. On low fit vs. normal fit interaction $p = 0.318$, $p = 0.467$, respectively. Significantly higher increase in aerobic fitness $p = 0.01$, motor agility $p = 0.004$, reduced ST $p = 0.03$, higher prevalence of active children $p = 0.01$ and improved healthy eating $p = 0.04$ in the intervention group than in the control group. No effect on measured PA $p = 0.54$ or sleep duration $p = 0.97$. No difference in effects on migrants vs. non-migrants. Interaction shuttle run $p = 0.085$ and obstacle course $p = 0.685$. No difference in effects by EL, interaction shuttle run $p = 0.058$, obstacle course $p = 0.258$	No effect on the quality of life $p = 0.17$ or cognitive abilities: attention duration $p = 0.98$, attention accuracy $p = 0.87$, spatial working memory $p = 0.58$
BHEZ	BMI for age percentiles significantly decreased on average in the intervention group but not in the comparison group in all analyses, entire sample: $p = 0.04$, overweight and obese girls and boys: $p < 0.001$, and overweight and obese girls only $p = 0.001$	Intervention arm significantly decreased purchasing healthful beverage $p = 0.003$ and snacks $p = 0.01$, as well as purchasing unhealthful snacks $p = 0.02$ and eating fast food $p = 0.02$. No significant impact on purchasing healthful food $p = 0.13$, purchasing unhealthful food $p = 0.31$ or beverage $p = 0.52$, or healthful food preparation $p = 0.13$	Significant impact in intervention group: decreased behavioral intentions $p = 0.01$, increased outcome expectancies $p = 0.02$, and increased knowledge $p < 0.001$. No significant impact on self-efficacy $p = 0.54$
GEMS	No significant difference in adjusted BMI difference per year 0.04 kg/m^2, 95 % CI (−0.18 to 0.27). Significant decrease in total cholesterol −3.49 mean adjusted fasting, 95 % CI (−5.28 to −1.70), LDL cholesterol −3.02 mg/dL, 95 % CI (−4.74 to −1.31) and hyperinsulinemia relative risk RR = 0.35, 95 % CI (0.13 to 0.93). Greater effectiveness (lower mean BMI change per year) in high-risk groups	No difference in most measured behavioral outcomes: accelerometer counts, vigorous PA, or ST. At the Memphis site, eating habits worsened less for the intervention than control group: SSB 0.19 fewer servings/day ($p = 0.075$), 0.21 more servings/day water ($p = 0.022$), 0.15 more servings/day vegetables ($p = 0.069$). No significant difference in eating habits observed at Oakland site	Significant difference in depressive symptoms in intervention compared to control −0.21 (0–20 Child Depression Inventory scale), 95 % CI (−0.42 to −0.001). No difference in self-esteem, school performance, activity preferences, or other outcomes
HC2	No statistically significant association found between parent/home intervention activities and BMI $p = 0.81$	No statistically significant differences in PA levels between the control and intervention groups and from baseline to 6-month follow-up in both groups. Analysis of lesson plans and class schedules revealed that over time, children in the control centers spent significantly more time on the computer $p < 0.01$ and watching TV $p < 0.0001$ than children attending intervention centers	None reported
ICAPS	Intervention students had a lower increase in BMI $p = 0.01$ and age- and gender-adjusted BMI $p < 0.02$ over time than controls; increase of high-density cholesterol concentrations $p < 0.0001$	Independent of initial weight status, compared with controls, intervention adolescents had an increase in supervised PA $p < 0.0001$, and a decrease of TV/video viewing $p < 0.01$	Self-efficacy and social support toward PA not significant at follow-up. Intention to PA significantly improved $p < 0.001$
SUS	Parent BMI decreases 0.411 kg/m^2 95 % CI (−0.725 to −0.097). Significant change in child z-BMI at 2 years $p = 0.0054$. Prevalence of child overweight/obesity decreased in males OR = 0.61, $p = 0.01$ and females OR = 0.78, $p = 0.013$. Average change in BMI z-score = 0.1005 95 % CI (0.1151 to 0.0859), $p = 0.001$ after controlling for covariates	Reduced SSB consumption −2.0 oz per day; 95 % CI (−3.8 to −0.2). Increased PA 0.20 sports or activities per year 95 % CI (0.06 to 0.33). Reduced ST −0.24 h per day 95 % CI (−0.42 to −0.06). Participation in school breakfast and lunch up 3 %. Fresh produce expenditure up $27,000 from previous year; 21 restaurants joined	None reported
Switch	No significant impact on BMI	At post, parent report of ST $p < 0.05$, Cohen's $d = 0.69$ and FV consumption significant $p < 0.05$,	None reported

Study	Health	Behavior	Psychosocial
		Cohen's $d = 1.36$. Child report of FV consumption near significant $p < 0.06$, Cohen's $d = 0.52$. Changes in PA or child report of ST not significant	
TEFNEP	Significant BMI decrease at post compared to baseline for the intervention group only; change was not maintained at follow-up $p < 0.05$	Greater goal attainment significantly associated with improvement in various dietary practices $p < 0.05$. Parents who reported attaining more goals reported greater self-efficacy $p < 0.05$. Goals for regular vegetables and water use correlated with regular vegetable $p < 0.05$ and water $p < 0.01$ consumption at post. Water significant at follow-up $p < 0.05$. Various significant dietary changes at post in control group	Significant time effect regardless of group for all measured variables