Comparative Effectiveness Review
Number 115

Effective Health Care Program

Childhood Obesity Prevention Programs: Comparative Effectiveness Review and Meta-Analysis

Executive Summary

Background

The epidemic of childhood obesity is threatening America's children.[1-3] Overweight children and adolescents are at greater risk for health problems compared with their normal-weight counterparts and are more likely to become obese adults.[4] Obese children and adolescents are more likely to have serious health conditions, such as cardiovascular, metabolic, and psychosocial illnesses; type 2 diabetes; hypertension; high cholesterol; stroke; heart disease; nonalcoholic fatty liver disease; certain cancers; and arthritis. Other reported health consequences of childhood obesity include eating disorders and mental health issues, such as depression and low self-esteem.

Childhood obesity is highly prevalent in the United States.[5] Data from the 2007–08 National Health and Nutrition Examination Survey indicate that 17 percent of U.S. children and adolescents (ages 2–19 years) were obese, and approximately 30 percent were either overweight or obese.[2] Some minority groups, such as African-Americans, Hispanics, and Native Americans, and low-income groups are at higher risk of obesity.[1] Obesity is the result of biological, behavioral, social, environmental, and economic factors and the complex interactions among these factors that promote a positive energy balance. At present, the way that these factors contribute to the disparities in obesity prevalence among population

Effective Health Care Program

The Effective Health Care Program was initiated in 2005 to provide valid evidence about the comparative effectiveness of different medical interventions. The object is to help consumers, health care providers, and others in making informed choices among treatment alternatives. Through its Comparative Effectiveness Reviews, the program supports systematic appraisals of existing scientific evidence regarding treatments for high-priority health conditions. It also promotes and generates new scientific evidence by identifying gaps in existing scientific evidence and supporting new research. The program puts special emphasis on translating findings into a variety of useful formats for different stakeholders, including consumers.

The full report and this summary are available at **www.effectivehealthcare.ahrq.gov/reports/final.cfm**.

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groups in the United States is poorly understood. Nevertheless, a growing body of research suggests that many factors interact, including individual factors, home influences, the school environment, factors in the local community, and policies implemented at the regional and national level. They can contribute to obesogenic environments and affect children's weight.[6] A number of leading health organizations and expert panels, including the World Health Organization[7] and an Institute of Medicine expert panel, have recommended comprehensive interventions to fight the growing obesity epidemic.[8,9]

For this review, we differentiate between prevention, often called "intervention" in the childhood obesity research field, and treatment, also called "weight management" or "weight loss." The main goal of most childhood obesity prevention programs is to prevent nonoverweight children from becoming overweight or obese, while the primary objective of obesity treatment programs is for pediatric patients to lose weight. Programs designed for obesity prevention may also help overweight or obese children lose or stabilize their weight. The present review focuses on prevention. A recent Agency for Healthcare Research and Quality (AHRQ) report[10] reviewed the targeted treatment of overweight or obese children, so we did not address that topic in this review.

Types of Interventions

This report focuses on childhood obesity prevention studies, which are aimed at preventing children from gaining excessive body weight and reducing their risk of developing obesity. Unlike weight-loss interventions for obese or overweight children, these interventions may not have a goal of helping children lose weight. However, prevention studies often include all children in a population, and therefore include obese and overweight children.

Interventions to prevent obesity in children largely aim to modify diet, physical activity, or sedentary activity. Because the interventions vary substantially depending on the setting, we have organized this report first by the primary setting where the interventions took place (e.g., school, home) and then by the interventions within that setting. This should facilitate use of the report, as it is expected that decisionmakers are best able to implement interventions in the settings over which they have control (e.g., schools). We focus in this report on the comparative effectiveness of interventions; thus, outcomes need to be compared between two groups, each of which received an intervention, or between two groups, one of which received usual care or no intervention.

School-Based Interventions

These interventions took place primarily in schools, although they might also have involved parents and/or community or home activities (e.g., homework, students bringing home fliers).

Home-Based Interventions

These took place in the child's home (e.g., interventions to alter the foods purchased for home use, family fitness).

Primary Care-Based Interventions

These took place in the offices of a primary care practitioner, a clinic, or other health care entity delivering primary health care to children. We classified primary care–based interventions that included a health informatics component under primary-care interventions. Note that we classified any school-based health care as a school-based intervention.

Childcare-Based Interventions

These were interventions in settings where children received nonparental/noncustodial care, generally outside the home. We classified interventions delivered in school-based aftercare programs as school-based interventions. We classified childcare interventions delivered in other settings as childcare-based interventions.

Community-Based and Environment-Level Interventions

These included interventions delivered by enforcement of policies or legislation, or by changes to the built environment. Additionally, these interventions involved interaction with the community (a group of individuals that existed prior to the intervention and that shared one or more common characteristics, such as the YMCA or church groups).[11] Note that we classified school-based policies with the school-based interventions.

Consumer Health Informatics-Based Interventions

Consumer health informatics (CHI) are technologies that deliver interventions and information indirectly (as opposed to in person) to patients or individuals in the community. These interventions might include Web-based, phone-based, and video-based programs, games, and information storehouses.

Scope of the Review

We compared the effectiveness of obesity prevention programs for children and adolescents conducted in the United States and other high-income countries.

We reviewed all studies of children that tested interventions of diet, physical activity, or any combination of these in any setting or combinations of settings (e.g., school, home, primary care, childcare, CHI) over at least 1 year, with the exception of school-based studies or studies in other settings with a school component, which required only 6 months.

We compared the effects of the interventions on outcomes related to weight or body composition (e.g., body mass index [BMI], weight, BMI-z score [measure of relative weight adjusted for age and sex], waist circumference, percent body fat, skinfold thickness, prevalence of obesity or overweight); clinical outcomes related to obesity (e.g., blood pressure, blood lipids); behavioral outcomes related to energy balance (e.g., dietary intake, physical activity, sedentary behaviors); and adverse effects of interventions (Table A and Figure A).

Key Questions

The Key Questions (KQs) are as follows:

Key Question 1. What is the comparative effectiveness of school-based interventions for the prevention of obesity or overweight in children?

Key Question 2. What is the comparative effectiveness of home-based interventions for the prevention of obesity or overweight in children?

Key Question 3. What is the comparative effectiveness of primary care–based interventions for the prevention of obesity or overweight in children?

Key Question 4. What is the comparative effectiveness of childcare setting–based interventions for the prevention of obesity or overweight in children?

Key Question 5. What is the comparative effectiveness of community-based or environment-level interventions for the prevention of obesity or overweight in children?

Key Question 6. What is the comparative effectiveness of consumer health informatics applications for the prevention of obesity or overweight in children?

Key Question 7. What is the comparative effectiveness of multisetting interventions for the prevention of obesity or overweight in children?

Methods

Topic Refinement and Protocol Review

We developed the KQs with the input of a Key Informant Panel that included experts in childhood nutrition policy, academic clinicians treating obese children, representatives from public school systems, parents of obese children, representatives from professional societies focusing on nutrition and obesity, and AHRQ staff. We recruited a Technical Expert Panel that provided input to the Evidence-based Practice Center during our development of the protocol for the Comparative Effectiveness Review.

Literature Search Strategy

We searched the following databases for primary studies: MEDLINE®, Embase®, PsycInfo®, CINAHL®, and the Cochrane Library through August 11, 2012. We did not add any date limits to the search. We developed a search strategy for MEDLINE®, accessed via PubMed®, based on medical subject headings (MeSH®) terms and text words of key articles that we identified a priori. We reviewed the reference lists of all included articles, relevant review articles, and related systematic reviews to identify articles that the database searches might have missed. We uploaded the articles into DistillerSR (Evidence Partners, Ottawa, Ontario, Canada), a Web-based software package developed for systematic review and data management. We used this database to track the search results at the levels of title review, abstract review, article inclusion/exclusion, and data abstraction.

We conducted a gray literature search in ClinicalTrials.gov to identify unpublished research that was relevant to our review on July 23, 2012. The search strategies we used were comparable to those we used in the MEDLINE search, and we report them in Appendix B of the full report.

Study Selection

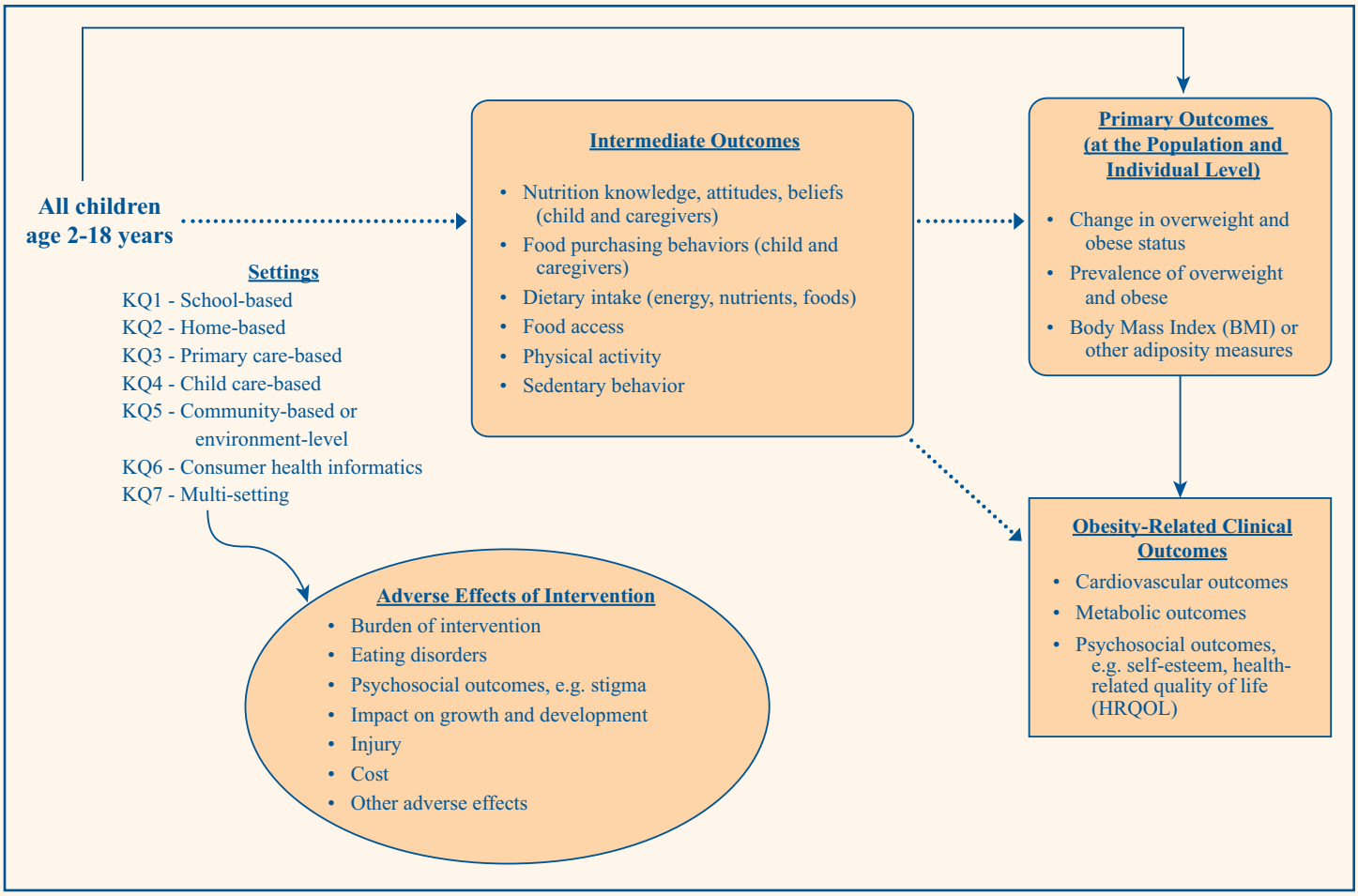
We identified studies conducted in the United States or other high-income countries with a very high Human Development Index[12] that described the comparative effectiveness of interventions to prevent obesity (or "excessive weight gain") in children and adolescents ages 2 to 18 years. We included only randomized controlled trials (RCTs), quasi-experimental studies, and natural experiments. (We call the latter two types "non-RCTs" in this report.)

Studies were eligible for inclusion if they followed children for at least 1 year after the intervention, or for at least 6 months for school-based intervention studies (given the length of a typical school year in the United States). We also included studies that described results from natural experiments, such as those that described outcomes from a community that had a food policy change compared with another community that did not. We did not include

Table A. Characteristics of the studies according to the PICOTS framework	
PICOTS Elements	**Characteristics**
Population(s)	All children are in the range of 2–18 years, regardless of BMI classification.
Interventions	KQ1: Diet, physical activity, or combination interventions delivered in schools • Includes nutrition education, nutrition, diet, healthy eating, parenting styles, education, policy KQ2: Diet, physical activity, or combination interventions delivered or implemented in the home • Includes healthy eating education, parenting styles, education KQ3: Diet, physical activity, or combination interventions delivered or recommended in a primary care setting • Includes patient, parent, and family counseling; referrals to nutritionists KQ4: Diet, physical activity, or combination interventions delivered in a childcare setting • Includes menu changes, physical activity, policy KQ5: Diet, physical activity, or combination interventions delivered or implemented at the community level or through environmental modification • Includes physical activity, farmers' markets, community gardens, cooking lessons, policy, green space, food store accessibility, access to healthy food choices KQ6: Diet, physical activity, or combination interventions delivered with consumer health informatics • Includes Web-based interventions, cell phone–based interventions KQ7: Diet, physical activity, or combination interventions delivered across a combination of settings
Comparisons	No intervention Usual care or other interventions by settings Note: We compare the intervention group vs. the control group (i.e., those who did not receive the intervention or received usual care or other interventions) within each study and then across studies within the same setting (e.g., schools, childcare centers).
Outcomes	Primary outcomes • Weight-related or body composition outcomes, including BMI or BMI distribution in the population, adiposity or other weight measures, and prevalence of obesity or overweight Intermediate outcomes • Dietary intake, fruit and vegetable intake, fatty food intake, sugar-sweetened beverage intake, physical activity, sedentary activity Adverse effects • Eating disorders, psychosocial outcomes, impact on growth and development, injury, cost Obesity-related clinical outcomes • Cardiovascular outcomes, metabolic outcomes
Timing	Outcome assessment must be at least 6 months from the baseline assessment for KQ1 school-based interventions. Outcome assessment must be at least 1 year from the baseline assessment for KQs 2 through 7 if it does not include school-based interventions. Outcome assessment must be at least 6 months from the baseline assessment for KQs 2 through 7 if the KQ does include school-based interventions.
Setting	Schools, home, primary care clinics, childcare settings, or community organizations; environment-level interventions; consumer health informatics; or across these settings

BMI = body mass index; KQ = Key Question; PICOTS = population(s), interventions, comparisons, outcomes, timing, and setting

Figure A. Analytic framework for comparative effectiveness of childhood obesity intervention programs



KQ = Key Question

other observational studies, such as cross-sectional or cohort studies. We did not exclude studies based on study sample size (Table A).

Studies identified in the gray literature search had to meet the same inclusion criteria as studies identified in the regular searches.

The studies needed to compare results of an intervention with results from usual care, a different intervention, or no intervention. The interventions of interest were those that involved a modification of diet, a modification of physical activity or sedentary activity, or a combination of these. We required that the study reported on the attained differences between the intervention and control groups in weight-related outcomes, including prevalence of obesity or/and overweight, BMI or BMI distribution in the groups, and other weight and adiposity measures such as waist circumference or body fat.

We excluded studies that targeted only overweight or obese children or adolescents, and similarly excluded studies that targeted children with a chronic medical condition such as diabetes or heart disease. We excluded studies that expressly aimed to induce weight loss in the participants. We did not include studies that collected only qualitative results, such as results from interviews or focus groups. We included only articles published in English but reviewed the abstracts of non–English-language articles to assess agreement with the results published in English.

Data Extraction

Two independent reviewers conducted title scans and abstract reviews, and reviewed the full articles to assess eligibility for inclusion for each study. We created standardized forms for data extraction. Each article received a double review by study investigators for data abstraction. The second reviewer confirmed the first

reviewer's data abstraction for completeness and accuracy. Reviewers extracted information on study characteristics, study participants, eligibility criteria, interventions, outcome measures, the method of ascertainment, and the outcomes, including measures of variability where available.

In data extraction, we focused on primary outcomes, including BMI and related measures, such as BMI z-score and percentile, waist circumference, percent body fat, skinfold thickness, prevalence of obesity and overweight, dietary intake, physical activity, and obesity-related clinical outcomes (e.g., blood pressure and blood lipids). We also extracted behavioral outcomes that we considered to be intermediate outcomes.

Data extraction was similar for the studies we identified during the gray literature search.

Quality (Risk-of-Bias) Assessment of Individual Studies

We used the Downs and Black instrument to assess the risk of bias in the included studies.[13] We categorized the studies as having low, moderate, or high risk of bias. We rated a study as having low risk of bias only when the researchers had done all of the following: stated the objective clearly, described the main outcomes, described the characteristics of the enrolled subjects, described the intervention clearly, described the main findings, randomized the subjects to the intervention group, and concealed the intervention assignment until recruitment was complete. Additionally, the study had to have at least partially described the distributions of potential principal confounders in each treatment group. If one of the above items was not completed or if this was difficult to verify, we considered the study to have at least a moderate risk of bias. If two or more of the above items definitively were not done, we considered the study to have a high risk of bias.

Data Synthesis

For each KQ, we created a set of detailed evidence tables containing all information abstracted from eligible studies. We organized the results for each KQ by grouping the studies first according to the combination of settings where the intervention took place (e.g., a school setting along with a home setting) and then by intervention. We eliminated KQ7 in our reporting of the results because we reported on these multisetting interventions within KQs 1 through 6. Note that we reported the detailed findings of studies that examined CHI for KQ6 under other KQs. Only a summary was provided under KQ6.

We described the interventions based on their focus: (a) the targeted behavior outcomes (e.g., dietary intake or physical activity, sedentary behaviors such as recreational screentime [the time spent in front of an electronic device, including television, video games, email], or both diet and physical activity) and (b) the modality the study used to deliver the intervention (e.g., education, a modification of the environment, or instruction in self-management techniques). We reviewed the studies for outcomes for key subgroups, including outcomes reported by sex, age, or racial group, and reported the results separately by subgroups.

When we had three or more studies that had similar interventions and reported outcomes in comparable settings that were homogeneous, we pooled the primary outcomes (i.e., BMI-related measures) quantitatively (i.e., meta-analysis). We calculated pooled mean differences using a DerSimonian and Laird random-effects model.[14] We could not conduct the analysis for other outcomes due to the lack of enough comparable studies. We conducted all meta-analyses using Stata (Intercooled, version 11, StataCorp, College Station, TX). The results of each meta-analysis contributed to our assessment of the precision of the estimate of the outcome, which we used in grading the strength of evidence. We also assessed the precision of the estimate of the outcome when we could not conduct meta-analysis and used it in grading the strength of evidence.

Strength of the Body of Evidence

In our results, we reported both the strength of evidence and the magnitude of effect (e.g., the difference in changes in BMI between the intervention and control group), but strength of evidence was the primary focus. Our meta-analysis reported magnitude of effect.

We graded the quantity, quality, and consistency of the best available evidence addressing each of our KQs by adapting an evidence-grading scheme recommended in the AHRQ "Methods Guide for Effectiveness and Comparative Effectiveness Reviews" (Methods Guide).[15] We assigned grades for all weight-related outcomes by setting up a hierarchy of outcomes. Within this hierarchy, each study contributed only one weight-related measure to the grade. The hierarchy is as follows: BMI z-score, BMI, prevalence of obesity and overweight, percent body fat, waist circumference, skinfold thickness. For example, if a study measured BMI z-score and body fat, we graded only BMI z-score. We chose to use this hierarchy because these outcomes are closely correlated and encompass the scope of work. We chose six categories of intermediate

outcomes: energy intake (i.e., calories), fruit and vegetable intake, fatty food intake, sugar-sweetened beverage intake, physical activity, and sedentary activity. We did not grade adverse events or clinical outcomes. We considered the four recommended domains: risk of bias, directness of the evidence, consistency across studies, and precision of the pooled estimate or the individual study estimates. We found that few studies reported precision.

We classified evidence pertaining to the KQs into four categories: (1) "high" grade, indicating high confidence that the evidence reflects the true effect, and further research is very unlikely to change our confidence in the estimate of the effect; (2) "moderate" grade, indicating moderate confidence that the evidence reflects the true effect, and further research may change our confidence in the estimate of the effect and may change the estimate; (3) "low" grade, indicating low confidence that the evidence reflects the true effect, and further research is likely to change our confidence in the estimate of the effect and is likely to change the estimate; and (4) "insufficient" grade, indicating that evidence is unavailable, there was only one study and it had moderate to high risk of bias, or a conclusion could not be drawn based on the data. We caution that a high strength-of-evidence grade is not necessarily an indicator of effectiveness; there can be strong evidence that an intervention is ineffective or even strong evidence of no effect.

We applied a grading algorithm to the body of evidence in order to have consistent grading across questions. We discussed the grades with the full group of investigators. We assessed risk of bias as described above. If the majority of studies for a given setting and comparison had the same risk of bias (low, moderate, or high), this was the risk category we assigned to that group.

We considered the body of evidence consistent in direction if 70 percent or more of the studies had an effect in the same direction (i.e., showed desirable effect vs. no desirable effect). We did not require a minimum number of studies to apply this rule; for example, a body of evidence with two positive and one negative study would be graded as inconsistent. We identified all studies as providing direct evidence, since all of the studied interventions would directly affect one of our primary outcomes. We considered a study precise if the results for the given outcome were significant at a p value less than 0.05 or had narrow confidence intervals that excluded the null. If 70 percent or more of the studies that reported statistical significance had significant results, we considered the body of evidence precise. We did not require a minimum number of studies to apply this rule; for example, a body of evidence with two precise and one imprecise study would be graded as imprecise although we recognize that, if the studies had been amenable to pooling, the precision might have increased with pooling.

Applicability

We assessed applicability (called "interpretability" in this report) separately for each question. We were guided by the PICOTS (populations, interventions, comparisons, outcomes, timing, and setting) framework, recommended in the Methods Guide.[16] We assessed whether there were features of the individual studies that limited the applicability of the study's findings, including whether the intensity of the intervention was such that it was unlikely to be widely implemented or whether the study subjects were atypical in some way.

Results

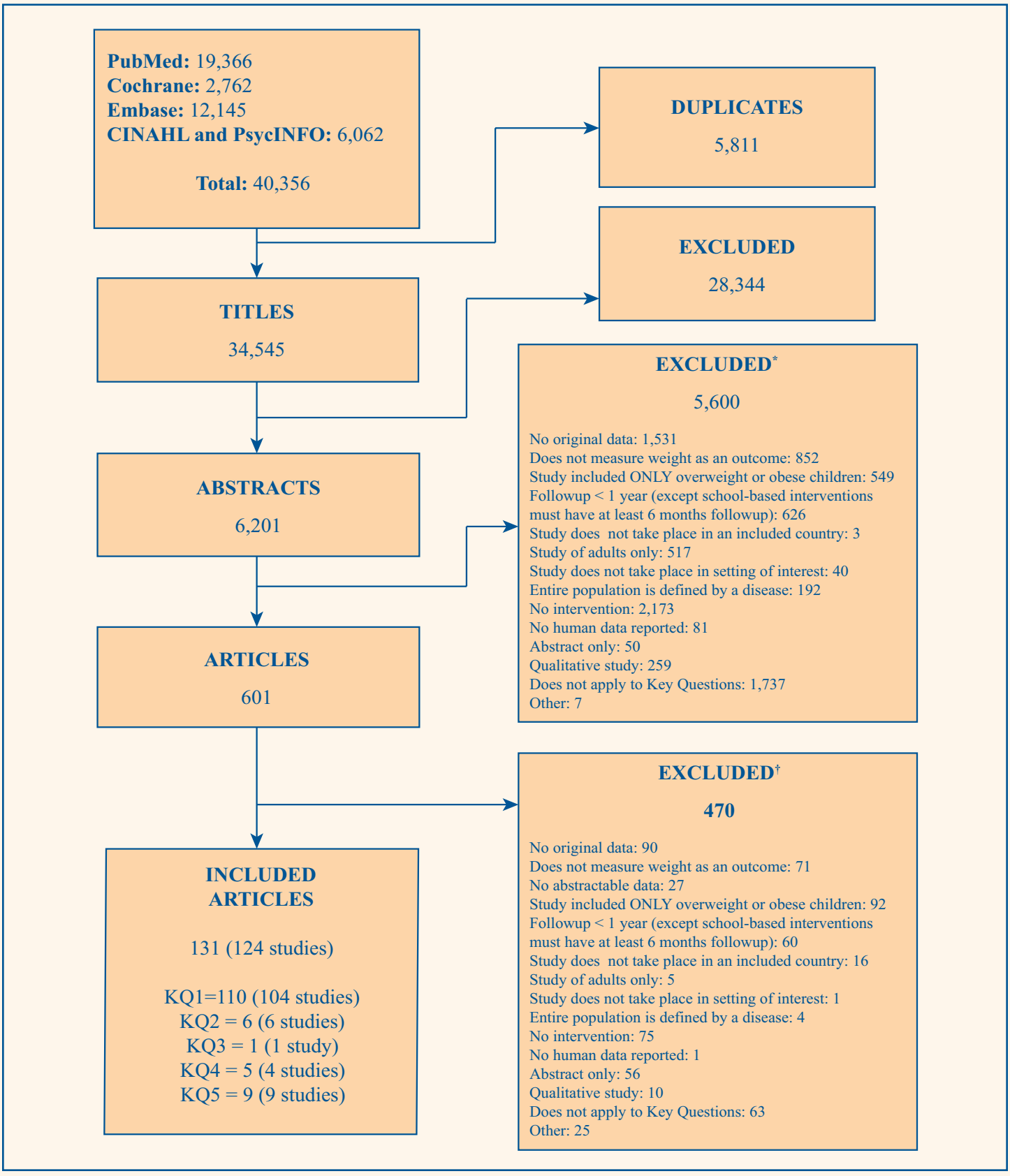
Results of the Literature Search

The literature search identified 34,545 unique citations. We excluded 28,344 citations during title screening and excluded an additional 5,600 during abstract screening. During article screening, we excluded an additional 470 articles that did not meet one or more of the inclusion criteria. We included 124 interventional studies described in 131 articles (Figure B). (Some studies were described in multiple articles.) Our gray literature search of ClinicalTrials.gov identified 3,186 potentially relevant titles. A title screen excluded 2,826 trials. Of the 342 potentially relevant trials, none met our inclusion criteria.

In total, 104 studies assessed school-based interventions, which might include other settings (KQ1). Six studies addressed home-based interventions (KQ2); one study addressed primary care–based interventions (KQ3); four studies addressed childcare-based interventions (KQ4); and nine studies addressed community-based interventions (KQ5). Several studies addressed CHI interventions (KQ6), but we describe them under other KQs. Most (83) of the 124 studies were RCTs: 69 trials for KQ1, 6 for KQ2, none for KQ3, 3 for KQ4, and 5 for KQ5. Six studies addressed KQ6.

We describe the following weight-related outcomes: BMI, BMI z-score, prevalence of obesity and overweight, waist circumference, skinfold thickness, percent body fat, and adverse events. In the full report, we also describe clinical outcomes (e.g., blood pressure, blood lipids) and intermediate behavioral outcomes (e.g., dietary intake, physical activity).

Figure B. Results of the literature search



*Sum of excluded abstracts exceeded 5,600 because reviewers were not required to agree on reasons for exclusion.
†Sum of excluded abstracts exceeds 470 because reviewers were not required to agree on reasons for exclusion.

Key Question 1. What is the comparative effectiveness of school-based interventions for the prevention of obesity or overweight in children?

We describe here the large body of evidence about interventions that occurred entirely in schools and the other large body of evidence regarding interventions that occurred predominantly in schools but required the child's commitment to activities at home. Additionally, in the full report we describe interventions that occurred in the school but required involvement of the community or informatics support.

School Based Only

The strength of evidence is moderate that school-based diet or physical activity interventions prevent obesity or overweight in children. The strength of evidence is low that school-based combination diet and physical activity interventions prevent obesity or overweight in children (Table B, Appendix F).

Two RCTs, described in three articles, evaluated the effects of diet interventions on weight-related outcomes and showed a decrease in BMI or BMI z-score measures over a period of at least 1 year. These studies were specifically designed to prevent weight gain, and focused on promoting a healthy diet and reducing the consumption of carbonated drinks.

Fifteen studies reported on the effects of physical activity interventions in school on weight-related outcomes. Physical activity interventions had an impact on BMI, waist circumference in girls, skinfold thickness at 52 weeks, and percent body fat in children. These studies were designed to prevent weight gain, reducing screen-based sedentary behavior time, promoting participation in physical activity, and improving fundamental movement skills among children. One of these physical activity intervention studies that had a significant effect on percent body fat enrolled prepubertal girls, who participated in daily physical education classes led by schoolteachers. Some of the physical activity interventions also had an impact on clinical outcomes (e.g., lowering systolic blood pressure) and intermediate outcomes (e.g., increasing physical activity and reducing sedentary activities). These studies were designed to affect the cardiovascular disease risk profile and promoted daily physical activity in elementary-school children. None of these studies reported on adverse events (harms).

Thirty-seven studies assessed the effect of a combined diet and physical activity intervention on weight-related outcomes. Combination interventions show a low strength of evidence that they are effective at reducing BMI, BMI z-score, prevalence of obesity and overweight, percent body fat, waist circumference, and skinfold thickness. Studies reporting on these outcomes were designed to affect weight gain and included intensive classroom physical activity lessons led by trained teachers, moderate to vigorous physical activity sessions, nutrition education materials, and promoting and providing a healthy diet. The intervention studies with significant impact had a duration of 52 to 156 weeks. Children who followed long-term intervention programs showed significant positive changes in physical performance, whereas children in shorter studies had nonsignificant results. Similarly, the long studies had a significant effect on energy intake, reduced consumption of sweetened beverages, and increased fruit and vegetable intake.

School Based With a Home Component

The strength of the evidence is insufficient that diet interventions within school-based studies with a home component prevent obesity or overweight in children. However, the strength of evidence is high that physical activity interventions within school-based studies with a home component prevent obesity or overweight in children. The strength of evidence is moderate that combined diet and physical activity interventions within school-based studies with a home component prevent obesity or overweight in children (Table B, Appendix F).

The total number of participants in the 30 studies combined was 28,413. The mean age of participants ranged from 5.8 years to 13.2 years. Only one study tested a diet intervention alone. The more intensive of the two intervention arms showed a reduction in the prevalence of overweight and obese children. Three studies focused exclusively on physical activity interventions. All of them reported statistically significant beneficial effects of the intervention compared with the control group based on the various weight-related outcomes.

Ten (39 percent) of the 26 studies that tested diet and physical activity interventions reported a statistically significant beneficial effect (Table B). Among the 17 studies that measured BMI change, 14 showed a reduction in BMI in the intervention group relative to the control group, with the magnitude of difference ranging from -0.4 to -1.20 kg/m^2. However, only four of these changes were statistically significant.

The meta-analysis, which included four studies, was not statistically significant ($p = 0.219$). Among the seven studies that measured BMI z-score, two showed significant

reductions in favor of the intervention (-0.34 and -0.38) and the rest did not.

Only one study examined and reported a significant desirable intervention effect on the prevalence of overweight and obesity (adjusted odds ratio, 0.67; 95% confidence interval, 0.47 to 0.96; $p < 0.03$). One other study found a significant difference in the prevalence of overweight (3.7%; $p < 0.05$) and obesity (2.3%; $p < 0.05$) in favor of the intervention versus the control.

School Based With a Home and Community Component

The strength of evidence is insufficient that school-based physical activity interventions with a home and community component prevent obesity or overweight, as there was only one study and it had a moderate risk of bias. The strength of evidence is high that combined diet and physical activity interventions prevent obesity or overweight, as one study with a low risk of bias and most of the studies with a moderate risk of bias showed a favorable effect (Table B, Appendix F).

Studies on a combination of diet and physical activity interventions generally showed significant improvements in weight outcomes. Most interventions focused on education as well as structural changes to promote a healthful diet and increased physical activity. Many of the interventions did not specifically target obesity prevention.

School Based With a Community Component

The strength of evidence is insufficient that a diet approach or an approach combining physical activity with self-management can impact weight outcomes in a community and school setting, as only one study was included for each approach. The strength of evidence is moderate that diet with physical activity impacts BMI or BMI z-score in a community and school setting, as two of the four studies with moderate risk of bias showed a favorable effect.

Out of six studies, the one study on diet intervention showed significant improvements in BMI and prevalence of overweight and obesity.[17] It specifically targeted weight gain prevention. The intervention focused on education as well as making structural changes to promote active

Table B. Summary of the strength of evidence for weight-related outcomes in studies taking place in a school setting

Setting	Intervention Type, Number	Number of Enrolled Participants	Number of Studies With L/M/H RoB	ROB	Consistency	Precision	Directness	SOE
School[a]	D, 2	1,782	0/2/0	Moderate	Consistent	Imprecise	Direct	Moderate
	PA, 15	10,086	0/13/2	Moderate	Consistent	Imprecise	Direct	Moderate
	C, 37	41,875	2/27/8	Low	Inconsistent	Imprecise	Direct	Insufficient
School-home	D, 1	1,321	0/1/0	Moderate	NA	Precise	Direct	Insufficient
	PA, 3	1,654	1/2/0	Moderate	Consistent	Precise	Direct	High
	C, 26	25,438	2/20/4	Moderate	Consistent	Precise	Direct	Moderate
School-home-community	PA, 1	2,829	0/1/0	Moderate	NA	Precise	Direct	Insufficient
	C, 8	11,525	1/4/3	Moderate	Consistent	Imprecise	Direct	High
School-community	D, 1	2,950	0/1/0	Moderate	NA	Precise	Direct	Insufficient
	PA, 1	1,721	0/0/1	High	NA	Imprecise	Direct	Insufficient
	C, 4	3,017	0/2/2	Moderate	Consistent	Imprecise	Direct	Moderate
School-CHI	PA, 2	1,335	0/2/0	Moderate	Inconsistent	Imprecise	Direct	Insufficient
	C, 2	1,896	0/2/0	Moderate	Inconsistent	Imprecise	Direct	Insufficient
School-home-CHI	C, 1	589	0/0/1	High	NA	Imprecise	Direct	Insufficient

C = combination of diet and physical activity interventions; CHI = consumer health informatics; D = diet intervention; H = high; L = low; M = medium; NA = not applicable; PA = physical activity intervention; RoB = risk of bias; SOE = strength of evidence

[a]Total = 54. One study reported on diet, physical activity, and combination interventions; therefore, it was counted more than once.

physical activity. Reasons for the significant desirable effect on weight outcomes might be that the intervention specifically targeted weight gain prevention and that the sample size was large (2,950 participants).

One study reported on a physical activity intervention among girls and showed no (or nonsignificant) improvements in weight outcomes over 3 years. The intervention focused on education as well as structural changes to promote healthy diets.

Four studies on a combination of diet with physical activity interventions generally showed nonsignificant improvements in weight outcomes over a period of at least 6 months. The majority of these studies specifically targeted weight gain prevention. The focus of the interventions varied greatly—education, structural changes to promote diet changes and physical activity, or both. One reason for the nonsignificant effect on weight outcomes might have been that the sample sizes were small.

School Based With a Consumer Health Informatics Component

The strength of evidence is insufficient that school-based physical activity interventions with a CHI component prevent obesity or overweight in children. We graded the body of evidence as insufficient because it lacked precision and both studies had a moderate risk of bias. The strength of evidence is insufficient that a combination of diet and physical activity interventions prevent obesity or overweight in children. We graded the body of evidence as insufficient because it lacked precision and included studies with moderate risk of bias (Table B, Appendix F).

Two studies evaluated the effect of a physical activity intervention on weight outcomes. One quasi-experimental study included only female adolescents and the other study randomized adolescents to a control or one of two intervention groups. None of the four identified studies showed a significant intervention effect on weight outcomes.

School Based With a Home and Consumer Health Informatics Component

The strength of evidence is insufficient that school, home, and CHI approaches using combined diet and physical activity interventions prevent obesity or overweight in children. We graded the body of evidence as insufficient because it comprised only a single study with high risk of bias. No studies measured adverse events (Table B, Appendix F).

The one included study did not demonstrate significant beneficial effects on weight outcomes. The use of a non-RCT design and low intervention intensity limited this study.

Key Question 2. What is the comparative effectiveness of home-based interventions for the prevention of obesity or overweight in children?

Home Based Only

The strength of evidence is low that home-based combination interventions prevent overweight or obesity in children, and there was insufficient evidence to determine the effect of diet-only intervention in the home (Table C, Appendix F).

We included four home-based intervention studies. One study reported on a diet intervention and the remaining three studies reported on combined diet and physical activity interventions. They all were RCTs. The total followup period ranged from 52 to 104 weeks. The age range of the participants was 3 to 17 years.

None of the four studies detected a statistically significant beneficial intervention effect on BMI or other weight outcomes. However, one study demonstrated a change in the percentage of children who were overweight in favor of one intervention group. One study employed a diet intervention for girls and reported no difference in BMI, fat mass, or weight at 104 weeks between the intervention and control arms. Three combined diet and physical activity intervention trials did not detect a significant beneficial intervention effect on weight outcomes.

Home Based With a School and Community Component

No conclusions can be made about the effectiveness of a combined diet and physical activity intervention in a home setting with school and community components in prevention of obesity or overweight (Table C, Appendix F). The study we identified reported no significant difference overall in BMI between the control group and a group with combined diet and physical activity intervention.

Home Based With a Primary Care and Consumer Health Informatics Component

No conclusions can be made about the effectiveness of a combined diet and physical activity intervention in a home setting with primary care and CHI components in prevention of obesity or overweight (Table C, Appendix F).

Table C. Summary of the strength of evidence for weight-related outcomes in studies taking place in the home

Setting	Intervention Type, Number	Number of Enrolled Participants	Number of Studies With L/M/H RoB	ROB	Consistency	Precision	Directness	SOE
Home	D, 1	59	0/1/0	Moderate	NA	Imprecise	Direct	Insufficient
	C, 3	262	0/2/1	Moderate	Inconsistent	Imprecise	Direct	Low
Home-PC-CHI	C, 1	878	1/0/0	Low	NA	Imprecise	Direct	Insufficient
Home-school-community	C, 1	1,323	0/0/1	High	NA	Imprecise	Direct	Insufficient

C = combination of diet and physical activity interventions; CHI = consumer health informatics; D = diet intervention; H = high; L = low; M = moderate; NA = not applicable; PC = primary care; RoB = risk of bias; SOE = strength of evidence

In the single study we identified, there was no difference in BMI z-score between the control group and a group with combined diet and physical activity intervention. This study was small and imprecise.

Key Question 3. What is the comparative effectiveness of primary care–based interventions for the prevention of obesity or overweight in children?

No conclusions can be made regarding the effectiveness of a combined diet and physical activity intervention in a primary care setting on obesity or overweight prevention (Table D, Appendix F). The one study in this setting used a quasi-experimental design. The study used educational and physical environmental approaches to target improvements in clinical decision support, counseling of families and patients on behavioral goals, and overall practice and provider management over a 78-week study period. The intervention did not result in decreased prevalence of overweight or obesity.

Key Question 4. What is the comparative effectiveness of childcare center–based interventions for the prevention of obesity or overweight in children?

We identified four studies that were reported in five articles. Three RCTs and one non-RCT addressed this question. The non-RCTs tested a physical activity intervention and found significant differences in BMI and percent body fat between intervention and control groups. The remaining studies evaluated the effect of combined diet and physical activity interventions. One of them showed significant differences between intervention and control groups in weight outcomes. No studies reported on adverse events.

We could not make a conclusion about the effectiveness of interventions involving physical activity alone on prevention of obesity and overweight in a childcare setting. The strength of evidence is insufficient that a physical activity intervention in a childcare setting positively affects obesity prevention. Only one study, with a high risk of bias

Table D. Summary of the strength of evidence for weight-related outcomes in studies taking place in primary care

Setting	Intervention Type, Number	Number of Enrolled Participants	Number of Studies With L/M/H RoB	ROB	Consistency	Precision	Directness	SOE
Primary care	C, 1	600	0/1/0	Moderate	NA	Imprecise	Direct	Insufficient

C = combination of diet and physical activity interventions; H = high; L = low; M = moderate; NA = not applicable; RoB = risk of bias; SOE = strength of evidence

Table E. Summary of the strength of evidence for weight-related outcomes in studies taking place in childcare

Setting	Intervention Type, Number	Number of Enrolled Participants	Number of Studies With L/M/H RoB	ROB	Consistency	Precision	Directness	SOE
Childcare	C, 3	2,393	1/2/0	Moderate	Inconsistent	Imprecise	Direct	Low
	PA, 1	268	0/0/1	High	NA	Precise	Direct	Insufficient

C = combination of diet and physical activity interventions; H = high; L = low; M = moderate; NA = not applicable; RoB = risk of bias; SOE = strength of evidence

and imprecision, addressed the effect of the intervention on weight outcome. Combined diet and physical activity interventions showed no beneficial effect on childhood obesity and overweight prevention, with a low strength of evidence based on studies with moderate risk of bias and direct, consistent, and imprecise results (Table E, Appendix F).

Key Question 5. What is the comparative effectiveness of community-based or environment-level interventions for the prevention of obesity or overweight in children?

The strength of evidence that diet, physical activity, or combinations of these interventions implemented in the community prevent obesity or overweight in children is insufficient. However, the strength of evidence is moderate that a combination of diet and physical activity interventions, when implemented in the community with some school involvement, prevents obesity or overweight in children (Table F, Appendix F).

We identified nine studies reporting on community-based or environment-level interventions. Three studies took place in the community with school involvement and used a combined diet and physical activity intervention; there was moderate strength of evidence that this setting and intervention impacted childhood obesity prevention. These studies included 4,071 participants. Two were RCTs: one was conducted in the Netherlands and another in the

Table F. Summary of the strength of evidence for weight-related outcomes in studies taking place in the community

Setting	Intervention Type, Number	Number of Enrolled Participants	Number of Studies With L/M/H RoB	ROB	Consistency	Precision	Directness	SOE
Community only	PA, 1	46	0/1/0	Moderate	NA	Imprecise	Direct	Insufficient
Community-school	C, 3	2,966 and children at 24 schools[a]	0/3/0	Moderate	Consistent	Imprecise	Direct	Moderate
Community-school-home	C, 1	1,989	0/2/0	Moderate	NA	Precise	Direct	Insufficient
Community-home	C, 2	564	0/1/1	High	Consistent	Imprecise	Direct	Insufficient
Community-home-PC-CC	C, 1	43,811	0/1/0	Moderate	NA	Precise	Direct	Insufficient
Community-school-PC-CC	C, 1	NR	0/0/1	High	NA	Precise	Direct	Insufficient

C = combination of diet and physical activity interventions; CC = childcare; H = high; L = low; M = moderate; NA = not applicable; NR = not reported; PA = physical activity intervention; PC = primary care; RoB = risk of bias; SOE = strength of evidence

[a]Mean enrollment = 1,109.

United States. The third was a non-RCT that took place in the United States and enrolled children over 5 years old. Two of the RCTs detected a statistically significant beneficial effect of the intervention compared with the control. No studies reported on adverse events.

Key Question 6. What is the comparative effectiveness of consumer health informatics applications for the prevention of obesity or overweight in children?

We identified six studies meeting our inclusion criteria that evaluated the effects of CHI interventions, but they are reported in other KQs according to their settings.

KQ1 included five studies with a CHI component: four in a school-based setting with a CHI component to the intervention and one in a school-based setting with a home and CHI component. Two of the school-CHI studies reported on physical activity interventions and showed no significant intervention effect on weight outcomes. Two reported on combined diet and physical activity interventions; one showed a significant intervention effect on BMI ($p < 0.001$), while the other failed to show an intervention effect. The study reporting on the school-home-CHI intervention used a combined diet and physical activity intervention and demonstrated no intervention effect on weight outcomes.

KQ2 included one study with a CHI component. It took place in a home-based setting with primary care and CHI components. This study used a combination diet and physical activity intervention. It showed no difference in BMI z-score between the intervention and control during followup after adjusting for baseline BMI z-score, age, and ethnicity, but it showed significant improvements in sedentary behaviors for both sexes and in active days per week among boys. Subgroup analysis for participants with BMI at or above the 95th percentile showed a desirable but insignificant intervention effect: BMI z-score was 2.08 ± 0.02 for the intervention group and 2.12 ± 0.02 for the control during followup ($p = 0.10$). The intervention did not demonstrate an overall effect on BMI z-scores.

The six CHI intervention studies identified took place only in concert with other interventions, primarily school based, but also home-based physical activity and dietary interventions. CHI interventions contributed to improvements in intermediate outcomes, particularly physical activity, but only one of these six studies, which used a school-based diet and physical activity intervention in concert with a CHI component, demonstrated a change in weight outcomes.

Discussion

Key Findings

In total, 124 interventional studies (reported in 131 articles) met our inclusion criteria. The majority (104, 84%) were school-based studies, although many of them also included interventional components implemented in other settings, such as the home or local community. A small number of studies tested interventions primarily implemented in other settings, such as at home, in primary health care, in childcare settings, or in communities.

Based on studies conducted over periods of 6 months to 6 years, the strength of evidence is high that school-based diet and physical activity interventions with a home component or school-based combination interventions with a home and community component prevent obesity or overweight. The strength of evidence is moderate that school-based interventions contribute to obesity prevention. The strength of evidence is moderate that school-based diet or physical activity interventions with either home or community components using a combination intervention contribute to obesity prevention The evidence is either low or insufficient regarding interventions in other settings due to the small number of published studies, their moderate or high risk of bias, and conflicting results across studies.

Over half of the school-based interventions reported statistically significant beneficial effects of the intervention compared with the control in at least some of the body weight–related measures, such as BMI, BMI z-score, prevalence of overweight and obesity, waist circumference, skinfold thickness, and percent body fat.This typically means a less steep increase over time in the intervention group relative to the control group. Additionally, almost all of the studies that reported results regarding intermediate outcomes detected some statistically significant desirable effects, such as increased vegetable and fruit consumption or increased physical activity. Approximately half of the studies that reported clinical outcomes reported some statistically significant desirable effects, predominantly regarding lowered blood pressure.

Applicability

The results of this review are primarily applicable to children in high-income countries. Results are not necessarily applicable to children in middle- and low-income countries where obesity is increasing. The participants were diverse across studies, with a mix of girls and boys of multiple ethnic groups; however, only a

small number of studies reported outcomes by subgroups defined by sex, race, or age. Therefore, one should apply the results cautiously to subgroups of children, particularly subgroups underrepresented in these studies. This includes very young children and selected ethnic groups, as few studies addressed these populations. The results of RCTs are often better than non-RCT results. These results address obesity prevention, not treatment.

Implications for Clinical and Policy Decisionmaking

The findings of this review can help researchers, clinical and public health practitioners, and policymakers decide on appropriate intervention strategies to combat the prevailing obesity epidemic in developed countries, and they help provide insight for future research. We need more research to test interventions that are not school based and those with innovative study design and intervention approaches. The promising results suggest that school-based childhood obesity prevention programs may help fight the rise in childhood obesity. After careful review of the individual components of the successful studies, health care professionals should be able to replicate the results in new settings, which could lead to broad implementation.

Limitations

The review was limited in scope, focusing only on prevention of obesity.

There are many differences across studies in term of settings, design, sample size and characteristics, intervention approaches, primary measures used and reported to assess the intervention effects, length of followup, and statistical analysis approaches. Such variability made it challenging to make cross-comparisons.

Given that we identified so few studies outside of the school setting, we could conduct meta-analysis only for KQ1, and we could include only a small number of interventional studies in the analysis.

We stratified the findings first based on their study settings and then by the intervention (diet, physical activity, or both). However, due to the limited sample size, we could not conduct further stratifications to explore the comparative effectiveness of the specific intervention approaches (e.g., compare educational interventions to environmental changes with pooled analyses) or the specific intermediate outcomes (e.g., compare fruit and vegetable intake to total energy intake). The reported weight outcomes and statistical methods we used to evaluate the intervention effects were heterogeneous across studies. We used BMI or related measures, such as BMI z-score, BMI percentile, and prevalence of overweight and obesity based on BMI cutpoints, as the primary outcomes, but BMI has its limitations as an indirect measure of adiposity, and it is not an ideal indicator for cardiometabolic risks. In addition, studies use different BMI cutpoints to define overweight and obesity.

Another challenge was that some studies assessed the intervention effect by comparing changes in the outcomes between the intervention and control groups, some compared between-group difference in weight outcomes only at followup, some reported on odds ratios of being overweight/obese, and others reported on the between-group difference in continuous outcome measures such as BMI. This too made comparing or pooling results challenging.

For school-based studies, we reduced the requirement for length of followup to 6 months, considering the usual length of school years. However, 6 months may be too short a time to observe the intervention effect on weight outcomes. Some studies did not state that their original goals were obesity prevention but rather stated that they aimed to reduce cardiovascular risk. We included these in the review because they included diet and physical activity interventions and reported results regarding body weight-related outcomes; thus they could shed light on the effect of childhood obesity interventions. These studies may differ from those that were primarily designed to target childhood obesity prevention. We also note that studies had variable analytic approaches and that not all accounted for correlations between individual students within classrooms. We did not differentiate those studies that did or did not address this clustering.

We attempted to identify non-English studies, but none of those we reviewed met our inclusion criteria. We limited our review to studies conducted only in high-income countries, as these results are more applicable to a U.S. population.

Future Research Needs

Many questions remain unanswered. We have identified a number of evidence gaps, many of which may warrant future research.

1. Intervention Studies Conducted in Nonschool Settings

The literature is sparse on interventions that take place in settings other than schools. We need more studies that test

environment- and policy-based interventions. Although environment is a critical area for obesity prevention,[9] very few studies have tested such interventions. In addition, there is scant evidence on the impact of regional or national policies on childhood obesity prevention, including agriculture policies and regulations on food retailing and distribution.[9]

Very few studies took place in clinical settings such as primary care. Primary health care providers could play an important role in childhood obesity prevention and treatment by providing healthful eating and exercise guidelines, and regularly monitoring body weight. Studies might also be designed to compare outcomes of interventions delivered in school with comparable interventions delivered at home or in other settings.

2. Innovative Study Design and Intervention Approaches

Using well-developed behavioral theories when designing interventions may help researchers increase study success. For example, only a few studies used social marketing to deliver messages on nutrition, physical activity, and health. Studies can integrate this approach with other intervention components to promote desirable lifestyle changes. In addition, CHI may provide promise for health promotion programs such as obesity prevention. However, only six studies used CHI and only one of these significantly reduced obesity risk.

3. Intervention Studies Guided by Systems Science

Obesity in children is the result of a complex mix of biological, behavioral, social, economic, and environmental factors. Thus, the effective and sustainable prevention of obesity in children may have to target many factors, which calls for a systems approach to study design, implementation, and evaluation that takes into account multiple risk factors and the complex interactions and feedback loops among them.[18] To fill in the gaps, researchers first need to understand the contexts and challenges associated with implementing prevention programs in different settings. For example, to conduct a childhood obesity prevention program in a community setting, researchers often need to work with the local community and its key stakeholders, which usually requires considerable effort and resources. Such demand may help explain the small number of intervention studies conducted in nonschool settings. Researchers should report these contextual factors to help decisionmakers get a better idea of the applicability of a specific intervention program to their own community.

4. Studies That Test the Potential Differential Effect of Interventions

We need research that generates information about important subgroups—such as populations stratified by sex, age, race/ethnicity, or socioeconomic status—to test whether different groups respond differently to the same intervention and help tailor future interventions to maximize their benefits. To allow for such analysis we may need larger studies, which will be more costly. However, they are essential to provide valuable information for disseminating successful interventions. Such studies will test whether different groups respond to the same intervention differently and can help tailor future interventions to maximize their benefits.

Most of the studies we reviewed did not report results by population subgroup. Subgroup analysis is necessary, as the effect size of a specific intervention may be small due to the heterogeneity of intervention effects among different subgroups. For example, an intervention may have worked in girls but not in boys. This may result in overall effectiveness being insignificant. We might conduct further research that includes a stratified analysis of subgroups by sex, age, race/ethnicity, or socioeconomic status. This will help test how different groups may respond to the same intervention, and help tailor future interventions to maximize their benefits. In addition, studies have found that obesity in older children is more predictive of obesity during adulthood than obesity in younger children is.[19] We need more studies to find effective prevention strategies for obesity that occurs in late childhood and adolescence.

5. Studies With High Statistical Power

We need more studies with large sample sizes and adequate length of followup. Most childhood obesity intervention programs are not intensive enough and result in only modest behavioral changes, perhaps because many factors can affect individuals' eating and physical activity.

6. Publication of Process Evaluation Results on Interventions

The publication of process evaluation results on interventions, especially those that attempt to compare multiple intervention options, should be encouraged. Such knowledge is important for translational research and dissemination. Very few of the studies we reviewed reported process evaluation, which would provide useful insights regarding why some studies might detect a desirable effect of an intervention, while others do not. We should encourage future studies to consider study design, data collection, final analysis, and publication.

7. Application of Rigorous Analytic Approaches

We need more rigorous analytic approaches to better analyze the repeated measures collected during followup, to control for confounders remaining after randomization, and to test effect modification and heterogeneity in the treatment effect. Future studies should consider process evaluation in study design, data collection, final analysis, and publication. Very few of the studies we reviewed reported process evaluation, which would provide useful insight about why some studies but not others noted desirable effects of an intervention.

8. Obesity Prevention Research on Adolescents

Obesity in adolescents has been found to be more predictive of obesity during adulthood than obesity in younger children is.[19] We need more studies to find effective prevention strategies for obesity that occurs in late childhood and adolescence. This is an important stage of life when young people are exposed to various social and environmental factors that establish lifelong habits.

Conclusions

A large number of childhood obesity intervention studies have been conducted in high-income counties over the past three decades. They predominantly took place in school settings, and mostly in the United States. Many of the school-based studies also included intervention components implemented in other settings, such as the home and community. Overall, there is moderate to high strength of evidence that diet and/or physical activity interventions that are implemented in schools help prevent weight gain or reduce the prevalence of overweight and obesity. However, the evidence on the effectiveness of interventions primarily implemented in other settings is largely low or insufficient. We need more research to test interventions conducted in settings other than schools, especially to test the impact of policy and environmental changes. We need to encourage research that tests innovative interventions that take advantage of new technologies, behavioral theories, and methodologies, including systems science.

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Full Report

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