HHS Public Access

Author manuscript

JBI Evid Synth. Author manuscript; available in PMC 2023 June 19.

Published in final edited form as:

JBI Evid Synth. ; 20(12): 2936–2985. doi:10.11124/JBIES-21-00233.

School-based obesity prevention programs in rural communities: a scoping review

Crystal S. Lim[1,2], **Jennifer Robinson**[2,3], **Elizabeth Hinton**[2,3,4], **Xiaoshan Z. Gordy**[5], **Abigail Gamble**[6], **Caroline Compretta**[7], **Megan E. Holmes**[8], **Martha Ravola**[9]

[1]Department of Psychiatry and Human Behavior, University of Mississippi Medical Center, Jackson, MS, USA,

[2]Mississippi Centre for Evidence Based Practice: A JBI Centre of Excellence, Jackson, MS, USA,

[3]School of Nursing, University of Mississippi Medical Center, Jackson, MS, USA,

[4]Rowland Medical Library, University of Mississippi Medical Center, Jackson, MS, USA,

[5]School of Health Related Professions, University of Mississippi Medical Center, Jackson, MS, USA,

[6]School of Population Health, University of Mississippi Medical Center, Jackson, MS, USA,

[7]Department of Preventive Medicine, University of Mississippi Medical Center, Jackson, MS, USA,

[8]Department of Kinesiology, Mississippi State University, Starkville, MS, USA,

[9]School of Agriculture and Applied Sciences, Alcorn State University, Lorman, MS, USA

Abstract

Objective: The objective of this review was to examine existing literature and conceptually map the evidence for school-based obesity prevention programs implemented in rural communities, as well as identify current gaps in the literature.

Introduction: Pediatric obesity is a significant public health condition worldwide. Rural residency places children at increased risk of obesity. Schools have been identified as an avenue for obesity prevention in rural communities.

Inclusion criteria: We considered citations focused on children (5 to 18 years of age) enrolled in a rural educational setting. We included obesity prevention programs delivered in rural schools that focused on nutrition or dietary changes, physical activity or exercise, decreasing screen time, or combined nutrition and physical activity that aimed to prevent childhood obesity. We included all quantitative, qualitative, and mixed methods research designs, as well as text and opinion data.

Methods: A search was conducted of published and unpublished studies in English from 1990 through April 2020 using PubMed, CINAHL Complete, ERIC, Embase, Scopus, Academic Search Premier, Cochrane Register of Controlled Trials, and ClinicalTrials.gov. Gray literature was also searched. After title and abstract review, potentially relevant citations were retrieved in full text.

Correspondence: Crystal S. Lim, cstacklim@umc.edu.

The authors declare no conflict of interest.

The full texts were assessed in detail against the inclusion criteria by 2 independent reviewers. Included citations were reviewed and data extracted by 2 independent reviewers and captured on a spreadsheet targeting the review objectives.

Results: Of the 105 studies selected for full-text review, 72 (68.6%) were included in the final study. Most of the studies (n = 50) were published between 2010 and 2019 and were conducted in the United States (n = 57). Most studies included children in rural elementary or middle schools (n = 57) and targeted obesity prevention (n = 67). Teachers implemented the programs in half of the studies (n = 36). Most studies included a combination of physical activity and nutrition components (n = 43). Other studies focused solely on nutrition (n = 9) or physical activity (n = 9), targeted obesity prevention policies (n = 9), or other components (n = 8). Programs ranged in length from weeks to years. Overall, weight-related, physical activity–specific, and nutrition-specific outcomes were most commonly examined in the included citations.

Conclusions: Obesity prevention programs that focused on a combination of physical activity and nutrition were the most common. Multiple outcomes were examined, but most programs included weight-specific and health behavior–specific outcomes. The length and intensity of rural school-based obesity prevention programs varied. More research examining scientific rigor and specific outcomes of rural school-based obesity prevention programs is needed.

Keywords

child health; pediatric obesity; preventive health programs; rural health; school health promotion

Introduction

High prevalence rates of pediatric overweight and obesity are global concerns because of their associations with poor health in childhood and adulthood.[1–11] Recent data from some countries reveal that prevalence rates of obesity in disadvantaged subpopulations continue to increase,[1] and rates of severe obesity in youth are growing.[12] It is recognized that people living in rural-designated areas are one of the largest medically under-served populations.[13] People living in rural areas encompasses a substantial portion of the world's population. In 2016, approximately 19% of Americans (60 million), including 13 million children under 18 years of age, lived in a rural area.[13] Worldwide, it is estimated that more than 45% of the population, or about 3.5 billion people, live in rural areas.[14]

Although findings are mixed, living in a rural community has been identified as a risk factor for overweight (ie, body mass index [BMI] greater than or equal to the 85th percentile for age and sex) and obesity (ie, BMI greater than or equal to the 95th percentile for age and sex) in adults and children,[15–18] even after adjusting for poverty.[17] Multiple factors related to rurality may increase the risk of obesity in adults and children. Residents living in rural areas are more likely to experience economic problems and have limited access to quality physical and mental health care.[19] Some findings also suggest higher prevalence of diabetes, stroke, and cancer, as well as worse morbidity and mortality, among individuals living in rural compared with non-rural communities.[20,21] Multiple sources indicate that youth from rural areas may engage in more unhealthy behaviors,[22] such as spending more time in sedentary activities compared to those living in urban areas.[15,16]

Additional intersecting features that may influence health disparities in rural communities should also be considered. In some Western countries, such as the United States (US), there is evidence that rural communities are becoming increasingly more racially and ethnically diverse,[23] which may result in additional disparity given that the prevalence of overweight and obesity in racial and ethnic minority youth is increasing, while stabilizing in non-Hispanic Whites in the US.[12] The intersection between rurality and structural factors, such as minority vs. majority culture, should be considered in the context of obesity risk worldwide.

Prevention efforts in rural and under-served communities are needed to combat obesity in these high-risk groups.[24] Schools are one avenue for intervening, given that children spend a large amount of time attending school each week; many children eat multiple meals at school each day, such as breakfast and lunch; and education about healthy nutrition and physical activity (PA) can be incorporated into academic classes. In addition, schools in rural communities and school personnel are well-respected and viewed by parents as important sources of information.[25] In addition to educating students, schools may be an avenue to facilitate community health[17] by providing parents with education regarding current nutrition and PA recommendations for children, which may not otherwise be available because of limited access and availability of primary care medical services in rural areas.

The role of schools has been recognized in the World Health Organization's (WHO) Commission on Ending Childhood Obesity, which provided 6 recommendations for policy makers worldwide. One recommendation was specific to the ways schools can be involved to reduce the prevalence of obesity in youth. The school-specific recommendation is to: "Implement comprehensive programmes that promote healthy school environments, health and nutrition literacy and PA among school-age children and adolescents."[26(p.xi)] In addition to worldwide efforts, specific countries have also recognized how schools promote improvements in child health. The US Centers for Disease Control and Prevention's Whole School, Whole Community, Whole Child model[27] also emphasizes the role schools play in promoting health in children and adolescents by facilitating the adaptation of health behaviors throughout life, with the recognition that health behaviors are easier to modify—and more effectively modified—when addressed in youth as opposed to changing unhealthy behaviors in adults.[27]

Given the importance of schools in promoting health in children, in recent years researchers have developed, implemented, and evaluated school-based obesity prevention programs focused on lifestyle behaviors and the school environment, such as healthy diet, increased PA, a motivating environment, educational curricula, and training teachers[28–30]; however, it is unclear what obesity prevention strategies have been implemented in schools in rural communities. Programs implemented in rural communities may need to take into account limited access to heathy foods and places to engage in safe PA, transportation and time-related issues (eg, need to travel farther distances), and economic-related issues.[31] A preliminary search for existing systematic and scoping reviews was conducted in January 2018 to locate literature related to rural school-based obesity prevention programs, and no systematic reviews were identified. Thus, the current review was needed to increase understanding about the types of school-based obesity prevention programs that have been

implemented in rural schools in order to inform future development of school-based obesity prevention programs in rural communities.

The objective of this scoping review was to examine the existing literature related to school-based obesity prevention programs implemented in rural communities, conceptually map the evidence, and identify current gaps in the literature.

Review questions

i. What types of school-based obesity prevention programs have been implemented in rural schools?

ii. What specific elements/components of school-based obesity prevention programs have been implemented in rural schools?

iii. What outcomes have been reported regarding school-based obesity prevention programs that have been implemented in rural schools?

Inclusion criteria

Participants

This review considered studies that included children aged 5 to 18 years of age who were enrolled in an institution that provided instruction and teaching of children, such as elementary, middle, or high school, and were conducted in a rural setting. Elementary schools were considered those that generally provided instruction to children in the first 4 years of formal education and also included schools that taught children through the first 8 years of instruction and self-identified as elementary. High school was defined as schools that included grades 9–12 or 10–12. Middle schools usually included grades 5–8 or 6–8, and were defined as such for this study. Schools included those classified as private, parochial, or publicly funded. Private schools were defined as schools that were supported by a non-governmental agency; public schools were free, tax-supported, and controlled by a local governmental authority; and parochial schools were defined as private schools maintained by a religious body. Children who were home-schooled or in an alternative setting, such as juvenile detention or hospitalized for prolonged periods, were excluded.

Concept

This scoping review considered studies about school-based obesity prevention programs implemented in rural schools, including, but not limited to, those focused on nutrition and dietary changes, PA or exercise, decreasing screen time, or mixed nutrition and PA programs aimed at childhood obesity prevention. Physical activity was defined as bodily movement produced by skeletal muscle contraction with increased energy expenditure, whereas exercise, a kind of PA, is planned, structured, repetitive movement that is often intentional and aimed at improving or maintaining health or fitness. We also considered whether the school-based obesity prevention programs implemented in rural schools incorporated behavioral components. Behavioral components included goal-setting, monitoring, self-regulation strategies, rewards/incentives, time management skills, counseling, and/or strategies to improve body image.

The school-based programs could be designed and delivered by health professionals, members of a community organization, or educators whose occupation is to teach; however, programs had to be delivered in the school setting. Health professionals could be registered dietitians, occupational therapists, physical therapists, public health practitioners, licensed nurses, dentists, physicians, pharmacists, nutritionists, mental health providers (eg, counselors, psychologists), or health educators. Studies that focused on physical fitness as an outcome and those conducted by health paraprofessionals, such as dental hygienists or nursing assistants, were excluded. Studies with obesity programs delivered to children outside of elementary, middle, or high schools, or programs offered at community facilities were also excluded.

Context

The context for this scoping review focused on schools in rural settings in any country. "Rural" is usually defined by individual countries[13,14,32,33] and is often defined by exclusion, such that any area that is not urban is considered rural.[34,35] This review considered any study in which the authors conducting the study classified the area as rural, as well as any study in an area designated as rural by the country's census geographic entity.

Types of sources

This scoping review considered quantitative, qualitative, and text and opinion data. For quantitative studies, the review considered both experimental and quasi-experimental quantitative study designs including randomized controlled trials, non-randomized controlled trials, before and after studies, and interrupted time-series studies. In addition, analytical observational studies, including prospective and retrospective cohort studies, case-control studies, analytical cross-sectional studies, and systematic reviews were considered for inclusion. This review also considered descriptive observational study designs including case series, individual case reports, descriptive cross-sectional studies, and gray literature for inclusion.

Qualitative studies that focused on qualitative data, including, but not limited to, designs such as phenomenology, grounded theory, ethnography, qualitative description, action research, and feminist research were considered. Text and opinion papers were also considered for inclusion.

Methods

This review was conducted in accordance with an a priori protocol[36] and the JBI methodology for scoping reviews.[37]

Search strategy

The search strategy aimed to find both published and unpublished studies. A three-step strategy was used, and included electronic and manual searches of reference lists, as well as government or agency websites for gray literature. The initial step included a limited search of MEDLINE (PubMed) and CINAHL, and an analysis of the text words contained in the title and abstract and of the index terms used to describe the articles. This informed

the development of the search strategy, which was tailored for each information source. The second step was a search using all keywords and index terms identified in the electronic databases listed below. The third step was to search reference lists of included studies, trial registers, and unpublished studies.

Studies published in English since 1990 were included, as the rise in prevalence of childhood obesity began to be recognized during the 1980s in the US, closely followed by recognized increases in trends in other developed countries. In addition, surveillance data and analysis of rates frequently use the baseline comparator of 1990 or later.[26,38–40]

The databases searched included PubMed (US National Library of Medicine), CINAHL Complete (EBSCO), ERIC (EBSCO), Embase (Elsevier), Scopus (Elsevier), and Academic Search Premier (EBSCO). The trial registers searched included Cochrane Register of Controlled Trials (Wiley) and ClinicalTrials.gov. The search for unpublished studies included ProQuest Dissertations and Theses Sciences and Engineering Collection (ProQuest), OpenGrey, Open Access Theses and Dissertations, Directory of Open Access Journals, and OCLC PapersFirst. Organization websites searched included the Centers for Disease Control and Prevention (MedNar), and the US Department of Education. All searches were performed in April 2019 and updated in April 2020. The full search strategies are presented in Appendix I.

Study selection

Following the search, all identified citations were imported into EndNote v.20 (Clarivate Analytics, PA, USA) and duplicates were removed. Titles and abstracts of citations were screened by 2 independent reviewers (CL, JR, XG, MH) and compared to the inclusion criteria for the scoping review. Potentially relevant studies were retrieved in full and their citation details imported into the data extraction spreadsheet in MS Excel (Redmond, Washington, USA). The full text of selected citations was assessed in detail against the inclusion criteria by 2 independent reviewers (CL, JR, XG, AG, CC, MR). Full-text studies that did not meet inclusion criteria were excluded. Reasons for their exclusion are reported in Appendix II. Disagreements that arose between the reviewers at each stage of the study selection process were resolved through consensus or by a third reviewer (CL, JR). The results of the search are reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.[41]

Data extraction

Data were extracted from studies included in the scoping review by 2 independent reviewers using an a priori data extraction tool that was modified from the JBI extraction tool (CL, JR, XG, AG, CC, MR). The data extracted included specific author details, year and country of publication, defined rural designation, type of school-based prevention or intervention used, intervention components, duration of intervention, provider of the intervention, study sample and size (when reported), types of outcomes, and key findings. Any disagreements that arose between the reviewers were resolved through discussion or with a third reviewer (CL, JR).

Data analysis and presentation

While addressing the objectives proposed in the scoping review protocol, common groupings across the included articles were analyzed. The first and second authors (CL and JR) reviewed the data extracted from each included study to identify key features of school-based obesity prevention programs in rural communities. Results were later verified by co-authors. Aligned with the PCC mnemonic (participants, concept, context), only 2 of the components were appropriate for analysis and discussion based on the review questions and literature analysis. “Participants” and “concept” were analyzed and discussed because context was limited to rural school settings and invariant given the inclusion criteria for this review.

Results

Source inclusion

Through database searches conducted in April 2019 and updated in April 2020, 3368 records were identified, and 1310 duplicates were removed. An additional 13 records were identified through reference list searches. A total of 2071 studies were screened by title and abstract for inclusion. Of those, 1966 were excluded. The remaining 105 records were assessed for inclusion based on full-text review, and 33 full-text records were excluded (see Appendix II for reasons for exclusion). The final data set consisted of 72 citations for data extraction. The search results are summarized in a PRISMA flow diagram (Figure 1).[41]

Characteristics of included sources

Three studies (4.2%) were published in the 1990s,[42–44] 18 (25.0%) were published between 2000 and 2009,[45–62] 50 (69.4%) were published between 2010 and 2019,[63–112] and 1 (1.4%) was published in 2020.[113]

Fifty-seven (79.2%) of the studies were conducted in the US,[43–55,57–63,65–71,75–81,84,85,87,89–104,106,108,109,113] four (5.6%) in Australia,[56,73,107,112] 3 in Canada (4.2%),[64,74,82] 2 in China (2.8%),[8,110] 1 each in Chile,[83] Italy,[42] New Zealand,[72] Spain,[86] and Taiwan,[111] and 1 additional study[105] that was conducted in multiple countries (US, Australia, and England).

In regard to definition of rurality, most authors reported that participants lived in a rural community or attended a rural school but did not provide a definition of how rurality was identified in their manuscript. Specifically, only 14 articles (19.4%) defined or described how rurality was determined in their manuscript. In terms of study designs, 27 (37.5%) used pre-post designs, 21 (29.2%) implemented a randomized controlled trial (RCT) design, 11 (15.3%) reported using quasi-experimental designs, 5 (6.9%) used qualitative methods,[62,67,71,98,107] 3 (4.2%) used both pre-post and qualitative designs,[48,59,64] 3 (4.2%) used cross-sectional designs,[42,89,90] 1 (1.4%) used both RCT and quasi-experimental designs,[105] and 1 (1.4%) study was descriptive.[81]

Extracted data from each of the included citations are presented in Appendix III.

Review findings

Review question #1: What types of school-based obesity prevention programs have been implemented in rural schools?

Population: children or adolescents: Of the 72 manuscripts, the majority (n = 57; 79.2%) were implemented with children, conceptualized as elementary or middle school students. Additionally, 9 (12.5) studies targeted high school students or adolescents,[55,66,69,73,91,99,102,106,113] and 6 (8.3%) were obesity prevention programs that included both children and adolescents (elementary, middle, and high school students).[64,74,81,82,88,97]

Concept: program type (prevention vs. intervention): Of the school-based obesity programs, the majority (n = 67; 93.1%) were identified as prevention programs.[42–44,46–104,106,108,109,111,112] Four (5.6%) were identified as intervention programs targeting student participants with overweight or obesity, or their engagement in specific health-related behaviors,[45,107,110,113] such as reported time engaged in moderate to vigorous PA or recreational screen time.[107] One (1.4%) additional study was a systematic review that included a combination of prevention and intervention programs.[105]

Concept: program providers: Teachers were identified as implementing the obesity prevention program in half of the studies (n = 36; 50%). Of the programs implemented by teachers, 7 were specifically identified as physical education teachers.[49,53,59,87,90,100,110] Twelve manuscripts reported researchers or study staff as the primary providers of the obesity prevention program.[56,57,60,65,71,74–76,84,104,109,111] Other providers included peers, such as older students serving as mentors (n = 8; 11.1%),[54,55,77,82,94,106,107,113] nutritionists or dietitians (n = 7; 9.7%),[44,46,61,66,97,105,110] community member volunteers (n = 4; 5.6%),[43,49,61,105] members of county extension offices (n = 3; 4.2%),[47,61,98] college undergraduate or graduate students (n = 3; 4.2%),[44,86,95] trained lifestyle coaches (n = 2; 2.8%),[78,85] school nurses (n = 1; 1.4%),[95] and other health care professionals (n = 5; 6.9%).[46,56,63,69,92] It is important to note that some of the articles reported including multiple types of program providers (eg,[66,91]); thus, those articles are included more than once in the numbers reported here. However, 13 articles (18.1%) did not provide specific information on who implemented or provided the school-based obesity prevention program in rural schools.[51,52,58,62,73,79,81,83,88,89,99,102,112]

Review question #2: What specific elements/components of school-based obesity prevention programs have been implemented in rural schools?

Concept: program components: With regard to the program component concept, some of the articles included in this scoping review were categorized as including multiple components; thus, they may be included and discussed under more than one component category.

Exercise/physical activity.: Specific to program components, only 9 (12.5%) studies focused on exercise or PA as an obesity prevention program.[53,55,71,87,89,90,100,106,113] Several of the studies also included a PA policy or program evaluation component, such as consistency of schools' implementation of PA mandates[90] and Walk to School Programs.[89] Two of

the programs focusing on PA also incorporated behavioral components.[71,113] The school-based intervention program developed by Smith *et al.*[113] taught self-regulation skills (eg, goal-setting, self-monitoring, time management, self-reward) related to PA in mentored and non-mentored groups. The program by Conway *et al.*[71] consisted of setting goals and keeping logs (ie, behavioral components).

Dietary/nutrition.: Nine (12.5%) of the included studies primarily focused on nutrition or dietary behaviors as the prevention component.[42,54,75,79,91,92,97,98,102] Two of the dietary interventions also incorporated behavioral components.[79,97] Murimi and colleagues'[97] program included medical screening for obesity, diabetes, cholesterol, and high blood pressure; individualized nutrition education and action plans based on screening findings; and group nutrition education classes for rural middle school and high school students. Moss *et al.*[79] implemented nutrition education via the dietary traffic light system and farm tour, and outcomes primarily focused on specific nutritional components, such as fiber and eating vegetables at school.

Combined dietary and physical activity.: Forty-three (59.7%) of the included citations incorporated both nutrition and PA in the school-based obesity prevention program. Seven of the reviewed studies included behavioral components, as well as PA and nutrition, in their prevention programs.[48,61,64,70,82,101,111]

Policy.: Nine (12.5%) articles focused on policy related to PA or diet as the pediatric obesity prevention component.[58,62,69,78,81,85,89–91]

Other obesity prevention programs.: Eight (11.1%) articles included in the review did not focus on diet, PA, combination of diet and PA, or policy and were classified as "other."[51,56,63,73,88,105,109,112]

As described previously, 12 (16.7%) citations included behavioral components, 7 (9.7%) were in programs with a combined focus on nutrition and PA,[48,61,64,70,82,101,111] 2 (2.8%) focused on combined nutrition and behavioral components,[79,97] 2 (2.8%) programs included PA and behavioral components,[71,113] and 1 (1.4%) included policy and behavioral aspects.[69]

Concept: length of prevention programs: The length of the prevention programs was typically implemented according to the school/academic calendar in the rural community. Specifically, 9 out of 72 (12.5%) reported being implemented across 1 school year or 2 academic semesters. In addition, 10 (13.9%) were described as being implemented during 1 semester, 22 (30.6%) reported that the prevention program was less than 1 semester in length, and 1 study[74] reported being conducted over more than 1 semester but not the entire school year. Other prevention programs were reported as being conducted over the course of multiple school or calendar years (n = 20; 27.8%). Ten articles (13.9%) did not include information regarding the length of the prevention program described/evaluated.

Review question #3: What outcomes have been reported regarding school-based obesity prevention programs that have been implemented in rural schools?

Concept: outcomes by program components

Exercise/physical activity.: Of the 9 PA programs, 6 examined weight-related outcomes, which were conceptualized as weight, height, BMI, BMI percentiles, BMI z-scores, relative BMI, body fat percentage, or waist circumference. PA-specific outcomes, such as pedometer steps, self-reported PA, and physical fitness, were also included as outcomes in 5 of these programs.[53,55,87,89,90] Self-efficacy and barriers to PA were also outcomes included in 3 the programs.[53,55,87] Conway and colleagues[71] conducted focus groups about their PA and behavioral program; thus, their reported outcomes were qualitative.

Dietary/nutrition.: Of the 9 dietary/nutrition interventions and related policies, 3 included weight-related outcomes[42,97,102] and 1 assessed other related health outcomes,[97] specifically outcomes from blood work examining cholesterol and triglycerides. Some programs also included nutrition consumption[54,75,79,92,102] and/or nutrition knowledge[54,75,79,97] as specific outcomes. One of the combined nutrition and policy programs specifically included water and sugar-sweetened beverage consumption as their outcomes of interest.[91] In addition to dietary-specific outcomes, Muth and colleagues also included PA-related outcomes in their study.[54] Rodriguez and colleagues[98] conducted focus groups that qualitatively examined students' perceptions of a school garden program.

Combined dietary and physical activity.: Of the 43 studies reviewed of combined PA and dietary programs, 33 examined BMI or other weight-related outcomes. In addition, 33 incorporated outcomes specific to PA and diet, 9 included health-related outcomes,[44–46,49,60,74,77,94,103] and 5 examined outcomes focused on psychological functioning, such as body image, self-esteem, and depressive symptoms.[49,65,82,93,101] Two citations reported qualitative outcomes.[64,67] The seven combined PA and nutrition programs that also included behavioral components all examined multiple outcomes.[48,61,64,70,82,101,111]

Policy.: Three of the policy-focused studies examined weight-related outcomes.[69,81,90] Ling and colleagues[78,85] implemented a multicomponent, school-level intervention, and focused on PA and dietary behavior outcomes. Three additional citations also included PA- and dietary-specific outcomes to examine policy-related programs. Schetzina and colleagues[62] described the design of an obesity-prevention program in response to a new state policy and included outcomes from a qualitative community-needs assessment. Belansky *et al.*[58] included the results of key informant interviews after the implementation of their policy-specific prevention program in rural elementary schools. Ritchie's[69] policy intervention also incorporated behavioral components (eg, cognitive-behavioral skill building), and examined beliefs and perceived difficulties related to healthy lifestyle behaviors.

Other obesity prevention programs.: Five of the other programs incorporated weight-related outcomes.[56,73,88,105,112] Some citations also included dietary- and PA-specific outcomes.[88,105,109,112] Schiller and colleagues'[51] Program ENERGY included outcomes

specific to health and science knowledge, and interest in science and health-related careers. Other policy-related programs included outcomes from qualitative interviews with school stakeholders.[109,112] Gabriele and colleagues[63] described treatment implementation information from an internet educational intervention that incorporated brief behavioral counseling related to weight management depending on the weight status of the student (non-overweight vs. overweight) and only reported implementation related outcomes.

Discussion

Pediatric overweight and obesity are a significant public health burden, and youth in rural areas worldwide are disproportionately impacted. Rural schools are one potential avenue for pediatric obesity prevention and intervention efforts. However, little is known about the components and effectiveness of rural school-based obesity prevention and treatment programs. The purpose of the current scoping was to answer the following questions: i) what types of school-based obesity prevention programs have been implemented in rural schools, ii) what specific elements/components of school-based obesity prevention programs have been implemented in rural schools, and iii) what outcomes have been reported regarding school-based obesity prevention programs that have been implemented in rural schools?

Summary of evidence

We identified 72 citations for inclusion in this scoping review. The majority of the included programs conducted in rural schools were implemented in North America during or after 2010. Among the other studies reviewed, 21 were published before 2009. Five were conducted in Australia or New Zealand, 3 were conducted in Asia, 2 in Europe, 1 in South America, and 1 in multiple countries. Only 14 of the included citations specifically described how rurality was defined or conceptualized in their study. The remaining reported the participants or the schools were located in a rural community.

Review question #1: what types of school-based obesity prevention programs have been implemented in rural schools?—Most of the studies included in this scoping review were implemented with children (elementary and middle school students) and focused on prevention (ie, included children with varying weight status) rather than treatment interventions (ie, included only those who were overweight or obese). Teachers were the primary interventionists, which is not surprising given that the programs were implemented in the school setting. Teachers implementing prevention programs in rural schools could potentially help with program sustainability. The length of the programs implemented in rural schools varied, with most lasting either less than 1 semester in length or over several years.

Review question #2: What specific elements/components of school-based obesity prevention programs have been implemented in rural schools?—The most common elements of school-based obesity prevention programs implemented in rural schools included a combination of nutrition and PA components. Some studies included solely nutrition or PA, and a small number focused on upstream programs aimed at policy changes locally within schools or more broadly with mandates that affected all schools.

Review question #3: What outcomes have been reported regarding school-based obesity prevention programs that have been implemented in rural schools?—Most of the studies reviewed examined multiple outcomes, with weight-related outcomes and PA/nutrition-specific outcomes being the most commonly examined. Several studies reported outcomes from blood work, such as high-density lipoproteins or triglycerides, and some examined psychological outcomes (eg, self-esteem, depressive symptoms), which are associated with pediatric overweight and obesity.

Additional information—While conducting this scoping review, we identified an exploratory interest in understanding characteristics of obesity prevention programs in rural schools that resulted in weight improvements. Therefore, we examined the articles that reported weight changes in more detail. Of the 72 articles included in this review, 14 (19.4%) reported improvements in weight-related outcomes.[45,56,57,68,73,82–84,91,95,99,108,110,112] Two of these programs were identified as treatment programs that only included children who were overweight or obese.[45,110] The majority of these programs included components focusing on nutrition and exercise, and a few described the inclusion of family involvement and community-based aspects. The programs ranged in length from 2 months to 6 years, but also ranged in intensity from every school day to weekly and monthly implementation.

Overall, conclusions cannot be made from this information because this review did not assess the quality of the research evidence or systematically examine outcomes. There was also variability in the programs that indicated significant improvements in weight outcomes. However, in general, it appears that in rural school-based settings, combined nutrition and PA obesity prevention programs that provide a high dose of prevention/intervention (length, intensity) may be the most effective at impacting weight-related outcomes. Future meta-analytic research is needed to confirm this finding.

Limitations

There are limitations of the current scoping review that are important to consider. First, the lack of information presented in some of the citations made it difficult to determine inclusion/exclusion criteria, as well as to extract data of interest. For example, most of the included citations did not use a specific definition of rurality, but instead the authors reported the school was located in a rural area or community. The definition of what constitutes a rural area is often ambiguous, and standards are not consistent across counties, given that it is often defined by each country differently.[32,33] Many definitions of rurality are based on exclusion, such that any area not considered urban is considered rural.[35] In addition, our search included “rural” as a term, which may have impacted our ability to include some studies if they were conducted in a rural community but were not identified as such by the authors. Whether the prevention programs were identified as school-based was also at times unclear during the initial citation review. For example, prevention programs that were implemented after school were not included, although they may have been identified as a school-based obesity prevention program by the authors. In addition, extracting specific information about the school-based prevention programs, such as treatment components, was difficult due to limited descriptions or information provided.

Second, we extracted data regarding the providers of the prevention programs but did not extract data on the training the providers may have received or their educational backgrounds. This information would be helpful for those interested in developing obesity prevention programs in rural schools, but it was often not described in the included citations. Also, regarding length of the programs, based on information included in the citations and what was able to be extracted, it was difficult to determine the intensity or dose of the reviewed prevention programs, such as frequency of treatment or hours of prevention/treatment received by students. Because there are specific recommendations regarding pediatric obesity treatment dose (eg, US Preventive Services Task force recommends 26 or more hours of treatment in one year[114]), this information could be helpful to extract in future scoping and systematic reviews of school-based obesity prevention programs. This could provide additional information regarding the potential impact of dose- and weight-related outcomes and allow comparisons to expert recommendations.

Third, although this information was not specifically intended to be extracted, some authors included information about specific theories that informed their obesity prevention program.[66,80,102] For many of the other articles, it was difficult to determine what theories, if any, had guided program development and implementation. It is unclear how this may impact program components or weight-related outcomes in school-based obesity prevention programs in rural communities.

Fourth, although examining the scientific rigor of the included citations was beyond the scope of this scoping review, it is important to consider both the statistical and clinical significance of the findings reported in the included studies. Many of the studies included multiple weight-related, dietary, and PA outcomes requiring multiple statistical analyses and comparisons. Overall, there were limited significant findings across all the reviewed citations, and some of the differences reported could be considered secondary outcomes (ie, the study was not powered to determine differences in specific secondary outcome). Thus, some of the findings could be the result of error due to multiple comparisons. Methodological and statistical rigor of school-based obesity prevention programs in rural communities are needed to guard against exaggerated effectiveness or ineffectiveness of these interventions (for example, see Brown *et al.*[115]). Future systematic reviews and meta-analyses are needed to better understand the methodological rigor of research previously conducted in this area.

Conclusions

This scoping review identifies and describes school-based obesity prevention programs that have been implemented in rural communities. Despite the heterogeneity of the programs reviewed, prevention programs that focus on a combination of PA and nutrition appear to be the most common. The length and intensity of the school-based obesity prevention programs reviewed varied. This scoping review provides important directions for future research.

Implications for research

First, future researchers should provide more specific information about obesity prevention programs and the schools and communities where they are implemented. Specifically,

understanding how rurality is conceptualized is important because there is increasing recognition that the extent of rurality in the community is associated with poor health outcomes.[116] This could impact the implementation and effectiveness of school-based obesity prevention programs. Additionally, there is a need for better reporting of the specific characteristics of programs implemented in rural schools, such as the training of providers, theories that informed program development, specific program components (including behavioral components utilized), and amount of time students are exposed to the prevention program. In addition, it would be helpful for authors to identify what specific aspects of their prevention programs have been modified due to being implemented in a rural location. School-based obesity prevention programs implemented in rural areas could help inform programs in other under-served and under-resourced communities, even if they are not located in a rural community.

Second, because the majority of programs included multiple components, it was difficult to ascertain critical components of school-based obesity prevention programs in rural areas. The studies in this review reported that few (if any) PA, dietary, or policy programs alone impacted weight status. However, more dismantling studies via meta-analyses should be conducted to determine if critical components of these programs can be identified. This would potentially save resources (eg, time, money) as a result of implementing future programs that have limited evidence of success.

Third, more rigorous research designs and outcome assessments should be included in future research, particularly RCTs, and future meta-analyses should focus on synthesizing the specific health- and school-related outcomes of the interventions. In addition, long-term follow-up of outcomes are needed given that weight and other related outcomes may take longer to change after the implementation of prevention programs.

Finally, given the structural nature of conditions that shape health in rural areas, including the increasing risk of obesity in adults and youth, multi-level structural interventions that target root causes of disparities (eg, socioeconomic factors, limited access to physical and mental health care) should be developed and evaluated in under-served rural community-based settings.

Funding

Research reported in this publication was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Number 5U54GM115428. The authors participated in the Community Engagement and Outreach Core Working Group, a resource of this award. JR, AG, and CC received funding support though this award. CL received partial funding support through the Federal Office of Rural Health Policy (FORHP), Health Resources and Services Administration (HRSA), US Department of Health and Human Services (HHS) under cooperative agreement award no. 6 U66RH31459-02-03, and partial funding support from NIH/ECHO/ISPCTN 8UG1OD024942-02 and U24 OD02495. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Appendix I: Search strategy

PubMed (US National Library of Medicine)

Search conducted: April 27, 2020

Search	Query
#1	prevent*[tw] OR intervention[tw] OR program[tw] OR “Health Promotion”[Mesh] OR “health promotion”[tw]
#2	“rural population”[MeSH] OR rural[tw]
#3	schools[MeSH] OR “school based”[tw] OR school-based[tw] OR “school health services”[MeSH] OR school*[tw]
#4	obes*[tw] OR obesity[MeSH] OR “pediatric obesity”[MeSH]
#5	teen*[tw] OR child[tw] OR children[tw] OR “school age”[tw] OR “school aged”[tw] OR child[MeSH] OR “child, preschool”[MeSH] OR adolescent [MeSH] OR adolescen*[tw] OR “high school”[tw] OR “middle school”[tw] OR “elementary school”[tw] OR “pre k”[tw] OR preschool[tw] OR “primary school”[tw] OR youth[tw] OR pediatric[tw] OR paediatric[tw] OR “secondary school”[tw] OR “head start”[tw] OR “nursery school”[tw] OR “Schools, Nursery”[Mesh]
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

413 results

CINAHL Complete (EBSCO)

Search conducted: April 23, 2020

Search	Query
#1	prevent* OR intervention OR program OR “health promotion” OR (MH “Health Promotion”)
#2	(MH “Rural Areas”) OR (MH “Rural Population”) OR rural
#3	(MH “Schools”) OR “school based” OR school-based OR school*
#4	obes* OR (MH “Obesity”) OR (MH “Pediatric Obesity”)
#5	(MH “Adolescence”) OR (MH “Child”) OR (MH “Child, Preschool”) OR teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR (MH “Students, High School”) OR (MH “Schools, Middle”) OR (MH “Schools, Secondary”) OR “secondary school” OR (MH “Schools, Elementary”) OR (MH “Students, Elementary”) OR “head start” OR “nursery school” OR (MH “Schools, Nursery”)
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

255 results

ERIC (EBSCO)

Search conducted: April 23, 2020

Search	Query
#1	prevent* OR intervention OR program OR DE “Prevention” OR DE “Health Programs” OR DE “Programs” OR DE “Health Promotion” OR DE “Intervention”
#2	rural OR DE “Rural Areas” OR DE “Rural Environment” OR DE “Rural Population” OR DE “Rural Schools”

Search	Query
#3	DE “Schools” OR “school based” OR school-based OR school*
#4	obes* OR DE “Obesity”
#5	teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR “secondary school” OR DE “Adolescents” OR DE “Children” OR DE “Early Adolescents” OR DE “Preadolescents” OR DE “Late Adolescents” OR DE “Youth” OR DE “High School Students” OR DE “Secondary School Students” OR DE “Young Children” OR DE “Preschool Children” OR DE “Middle School Students” OR DE “Middle Schools” OR DE “Secondary School Students” OR DE “Secondary Schools” OR DE “Elementary School Students” OR DE “Elementary Schools” OR “head start” OR “nursery school” OR DE “Nursery Schools”
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

55 results

Embase (Elsevier)

Search conducted: April 28, 2020

Search	Query
#1	prevention:ti,ab OR prevent:ti,ab OR ‘prevention and control’/exp OR ‘prevention’/exp OR intervention:ti,ab OR program:ti,ab OR ‘health program’/exp OR ‘health promotion’/exp
#2	‘rural area’/exp OR ‘rural population’/exp OR ‘rural health care’/exp OR ‘rural health’/exp OR rural:ti,ab
#3	‘school’/exp OR “school based”:ti,ab OR “school-based”:ti,ab OR school:ti,ab OR ‘school health service’/exp
#4	‘obesity’/exp OR ‘adolescent obesity’/exp OR ‘childhood obesity’/exp OR obese:ti,ab OR obesity:ti,ab
#5	‘juvenile’/exp OR ‘adolescent’/exp OR ‘child’/exp OR ‘preschool child’/exp OR ‘school child’/exp OR teen:ti,ab OR teenager:ti,ab OR teenaged:ti,ab OR adolescent:ti,ab OR adolescence:ti,ab OR children:ti,ab OR child:ti,ab OR ‘school age’/exp OR ‘school age population’/exp OR “school aged”:ti,ab OR “school age”:ti,ab OR ‘high school’/exp OR ‘high school student’/exp OR ‘middle school’/exp OR ‘middle school student’/exp OR ‘primary school’/exp OR ‘elementary student’/exp OR “elementary school”:ti,ab OR “pre k”:ti,ab OR ‘preschool’/exp OR ‘preschoolers’/exp OR youth:ti,ab OR pediatric:ti,ab OR paediatric:ti,ab OR ‘secondary schools’/exp OR “head start”:ti,ab OR ‘nursery school’/exp
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

421 results

Scopus (Elsevier)

Searched conducted: April 28, 2020

Search	Query
#1	prevent* OR intervention OR program OR “health promotion”
#2	rural
#3	“school based” OR school-based OR school*
#4	obes*

Search	Query
#5	teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR “secondary school” OR “head start” OR “nursery school”
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

653 results

Academic Search Premier (EBSCO)

Search conducted: April 24, 2020

Search	Query
#1	prevent* OR intervention OR program OR “health promotion” OR DE “PREVENTION” OR DE “HEALTH promotion”
#2	Rural OR DE “RURAL geography” OR DE “RURAL health” OR DE “RURAL population” OR DE “RURAL schools” OR DE “RURAL youth” OR DE “RURAL teenagers”
#3	“school based” OR school-based OR school* OR DE “SCHOOLS”
#4	obes* OR DE “OBESITY” OR DE “OBESITY in adolescence” OR DE “OBESITY in children”
#5	teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR “secondary school” OR DE “CHILDREN” OR DE “YOUTH” OR DE “ADOLESCENCE” OR DE “TEENAGERS” OR DE “HIGH school students” OR DE “SECONDARY school students” OR DE “HIGH schools” OR DE “MIDDLE school students” OR DE “MIDDLE schools” OR DE “SCHOOL children” OR DE “KINDERGARTEN children” OR DE “ELEMENTARY schools” OR DE “PRIMARY schools” OR DE “PRESCHOOL children” OR DE “SECONDARY schools” OR “head start” OR “nursery school” OR DE “HEAD Start programs” OR DE “NURSERY school education (Great Britain)” OR DE “NURSERY schools (Great Britain)”
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

557 results

Cochrane Central Register of Controlled Trials (Wiley)

Search conducted: April 24, 2020

Search	Query
#1	prevent* OR intervention OR program OR “health promotion”
#2	rural
#3	“school based” OR school-based OR school*
#4	obes*
#5	teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR “secondary school” OR “head start” OR “nursery school”
#6	#1 AND #2 AND #3 AND #4 AND #5

Limited to English language and years 1990—present

95 results

ClinicalTrials.gov

Search conducted on April 24, 2020

Search	Query
#1	Advanced Search:
	Condition or disease: obesity
	Other terms: school AND rural
	Study type: All
	Study results: All
	Age: Child
	Sex: All

Study Start: From 01/01/1990-present

10 results

ProQuest Dissertations and Theses Sciences and Engineering Collection (ProQuest)

Search conducted: April 23, 2020

Search	Query
#1	Exact(“Rural” OR “RURAL” OR “Rural adolescents” OR “rural populations” OR “rural adolescents” OR “rural” OR “Rural adolescent females” OR “Rural population” OR “Rural populations” OR “Rural schools”) AND (obesity OR obese) AND (teen* OR child OR children OR “school age” OR “school aged” OR adolescen* OR “high school” OR “middle school” OR “elementary school” OR “pre k” OR preschool OR “primary school” OR youth OR pediatric OR paediatric OR “secondary school” OR “head start” OR “nursery school”) AND (“school based” OR school-based OR school*)

Limited to English language and years 1990—present

207 results

OpenGrey (opengrey.eu)

Search conducted: April 23, 2020

Search	Query
#1	(prevention OR intervention) AND rural AND school AND (obesity OR obese) AND (child OR children OR teen)

Limited to English language and years 1990—present

0 results

Open Access Theses and Dissertations (oatd.org)

Search conducted: April 23, 2020

Search	Query
#1	(prevention OR intervention) AND rural AND school AND (obesity OR obese) AND (child OR children OR teen)

Limited to English language and years 1990—present

22 results

Directory of Open Access Journals (doaj.org)

Search conducted: April 23, 2020

Search	Query
#1	(prevention OR intervention) AND rural AND school AND (obesity OR obese) AND (child OR children OR teen)

Limited to English language and years 1990—present

21 results

PapersFirst (OCLC)

Search conducted: April 23, 2020

Search	Query
#1	(prevention OR intervention) AND rural AND school AND (obesity OR obese) AND (child OR children OR teen)

Limited to English language and years 1990—present

0 results

Centers for Disease Control and Prevention (MedNar)

Search conducted: April 24, 2020

Search	Query
#1	prevention AND rural AND school-based AND obesity AND child

Limited to English language and years 1990—present

99 results

US Department of Education (ed.gov)

Search conducted: April 23, 2020

Search	Query
#1	prevention AND rural AND school-based AND obesity AND child

Limited to English language and years 1990—present

560 results

Appendix III: Characteristics of included studies, organized by program components

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Exercise/physical activity (n = 9)								
Conway *et al.*[71] 2012 US (North Dakota)	Author reported rural county	Prevention (qualitative)	PA (and behavioral)[a]	5 weeks in winter	3 member evaluation team	N = 81 5th and 6th grade students	5 focus groups, qualitative data	Stu set kee sup par PA but cor cor stu the ele to l des fro tea mo inc and wa rec for
Eichner *et al.*[100] 2016 US (Oklahoma)	Author reported rural school	Prevention (pre-post design)	PA	2 school semesters (daily PA on school days)	PE teacher	N = 66 Middle school: 6th, 7th, and 8th grade students, 12–15 years old	BMI z-scores pre- and post-assessments	Sig dif BM wit stu the nor stu inc dec boy par wa gir
Manley[53] 2008 US (Kentucky)	Author reported rural	Prevention (RCT)	PA	12 weeks (wore pedometer every day and 10 minutes of moderate to vigorous PA)	PE teacher	N = 116 6th and 7th grade students Intervention n = 55 Control n = 61	Self-efficacy levels, PA (pedometers), aerobic fitness (1 mile walk test), and body composition (height, weight, BMI, BMI	No no dif bet cor sch sig hig sta

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
							%ile, relative BMI) pre- and postassessments	rel sch sig low aer cor cor not Tx gre imp sel aer lev rel cor
Manley *et al.*[87] 2014 US (Kentucky)	Author reported rural	Prevention (RCT)	PA	12 weeks (wore pedometer every day and 10 minutes of moderate to vigorous PA)	PE teacher	N = 116 11- and 13-year-olds (mean age 11.7 years) Intervention n = 55 Control n = 61	Self-efficacy levels, PA (pedometers), aerobic fitness (1 mile walk test), and body composition (BMI, BMI %ile, relative BMI) pre- and postassessments	No dif bet cor tho opt BM hig eff aer lev not sig gro imp me sco fitn rel
Oluyomi *et al.*[89] 2014 US (Texas)	Definition not included (home addresses were geocoded)	Prevention (cross-sectional)	PA (and policy)[b]	5-year implementation project	Not described	N = 830 parent-student dyads (4th grade)	Self-reported child walking to school; perceived traffic and personal safety concerns for neighborhood, en route to school, school environments; social capital	Od to s hig pro to t am sid int saf gua wa we str cor wa
Robinson *et al.*[90] 2014 US (Alabama)	Author reported 1 county in Black Belt Region	Prevention (cross-sectional)	PA (and policy)[b]	Daily PE for 30 minutes	Certified PE instructor	5 elementary schools; N = 683 school-age children (341 female; 342 male); mean age 8.22 years; 99.9% Black	BMI; weight status; waist circumference; PA behavior (pedometer step count, System for Observing Fitness Instruction Time, and the System for Observing Play and Leisure Activity in Youth)	Ov PA pol par imp larg bet sch sch wh bei imp dur stu opp sch
Rye *et al.*[55] 2008 US	Definition not included; state is in	Prevention (pre-post design)	PA	2 academic years	2 secondary teachers and	Y1, N = 16 Y2, N = 15 + 3	Daily step count (pedometer);	Pre dec me

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
(West Virginia)	Appalachia and ranks 3rd highest among all states on % rural population				high school students	repeaters from Y1, faculty, staff, parents, community members High school focus group: Health Sciences and Technology Academy students Y1, N = 12 Y2, N = 5 Adult focus group participants: teachers, parents, community members	perceptions of barriers to PA; self-efficacy; outcome expectations	sta sig tot we ene wil
Smith *et al.*[113] 2020 US (Ohio)	Author reported rural Appalachian high schools in Southern Ohio (based on population density, housing, and territory)	Intervention (RCT)	PA (and behavioral)[a]	10 weeks (10 40-minute weekly lessons)	Trained peer mentors and teachers	N = 190 (n = 106 obese and n = 84 extremely obese) in 9th-11th grades Mean age 15.03 years (standard deviation = 0.84)	Conducted baseline, 3-month follow-up, and 6-month postintervention of raw body weight, height, BMI, body fat %, BMI %	All ave fro 3-m up fro 6-m up; Me Pla Ac 77. we mo cor Pla Ac Ex in t Pla Ac 80 cor Pla Ac Ex fen we to anc sim you Me Pla Ac mo imp
Smith *et al.*[106] 2018 US (Ohio)	School districts in rural Appalachia counties	Prevention (RCT)	PA	10 40-minute sessions (2 possible sessions each week)	Teachers and trained teen mentors	N = 654 9th and 10th graders N = 119 older peer mentors N = 8 teachers N = 20 schools	BMI, height, weight	Pee me loc stu sch tail str sus beh cha

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Dietary/nutrition (n = 9)								
Angelico *et al.*[42] 1991 Italy (Sezze Romano)	Author reported small town (70 miles outside Rome)	Prevention (cross-sectional)	Nutrition	5 years (3 teacher trainings, 6 parent/ community interactions); frequency of nutrition education in classroom unclear	Trained school teachers	N = 150 children aged 6–7 years attending rural elementary school	Height, weight, BMI	He and inc tim
Moss *et al.*[79] 2013 US (Illinois)	US Department of Agriculture Rural designation	Prevention (pre-post design)	Nutrition (and behavioral)[a]	4-week intervention (2 30-minute lessons one week apart; 120-minute farm tour in week 4)	Unclear	N = 65 3rd grade students from one elementary school	Nutrition knowledge; fruit/vegetable consumption, farm exposure; Go, Slow, Whoa foods	Pos fib veg vita mo at s sig rel bet veg far
Murimi *et al.*[97] 2015 US (Louisiana)	Definition not included	Prevention (pre-post design)	Nutrition (and behavioral)[a]	Screening and point-of-testing counseling sessions offered every 6 months for 3 years; 6 possible testing and counseling session opportunities; 2040 minutes per counseling session; nutrition education 1 hour/week for 12 weeks	Registered dietitian, registered nurse, dietetic students	N = 233 6th-12th grade students (11–19 years old), 51% female, 58% White, 51% overweight or obese	BMI, BP, total cholesterol, HDL, LDL, triglycerides, student food knowledge	Sig inc and kn and no but we val Pa att ses ma we %i pa sy ch tri lo
Muth *et al.*[54] 2008 US (North Carolina)	Definition not included	Prevention (RCT)	Nutrition	12-week curriculum, 60-minute lessons; 15-hour high school student training	Peer modeling by medical and high school students	1 high school; 8 students trained as health educators, 10 medical students 1 elementary school, 4th grade classrooms, 2 intervention (38 students) and 2 control (37 students) classrooms	Nutrition servings per day: fruit/ vegetable, calcium foods, grains, sweet beverages, fried foods, sweets; nutrition knowledge and attitudes, PA score, sedentary score	Inc veg and kn
Nanney *et al.*[102] 2016 US (Minnesota)	50% rural town fringe and 50% rural using	Prevention (RCT)	Nutrition	1 academic year; School Breakfast Expansion	School personnel implemented school-level	8 schools in Wave 1; 3 schools in Wave 2; all	Increase systolic BP participation (primary), diet	Co bas tra pra

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
	National Center for Education Statistics and rural-urban commuting area codes			Team met 5 times; Tx or delayed Tx; block randomization with 4 Tx and 4 control in each wave	changes; no other detail about provider	9th and 10th graders screened for eligibility; 904 enrolled; 54% girls and 30% non-White	quality, intention to eat school breakfast; decrease calories, BMI, body fat	suc rec sch exc enr res int sch init cha go
Rodriguez *et al.*[98] 2015 US (Florida)	Author reported Florida Panhandle	Prevention (qualitative)	Nutrition	Not provided	Florida A&M Extension agents	N = 60 3 focus groups; 20 participants per group; 9–12 years	Student thoughts, feelings, and perceptions of school garden program	Stu gre kno like tim tall gro veg opi dif veg son des trie veg hov par not an hou veg cor
Smith *et al.*[91] 2014 US (Ohio)	Author reported a rural Appalachian county	Prevention (pre-post design)	Nutrition (and policy)[b]	30-day	Teen Advisory Council (teachers and students from 9th-12th grades)	N = 186 high school students in 9th-12th grades from 2 schools (mean age = 15.85 years)	Sugar-sweetened beverage consumption and water consumption: pre, post, and 30-day follow-up	Sug bev cor dec sig wa cor inc fro pos
Struempler *et al.*[92] 2014 US (Alabama)	Participants from schools eligible for SNAP-Ed, with over 50% students receiving free or reduced-price lunch	Prevention (pre-post design)	Nutrition	Weekly for 17 weeks, 45-minute classes	SNAP-Ed educators	N = 2477 3rd grade students eligible for SNAP-Ed	Fruit and vegetable consumption during lunch (self-reported food consumption)	Sch chi pre pro me mo inc veg cor thr sch pro
Tussing-Humphreys *et al.*[75] 2012 US (Mississippi)	Author reported "rural Lower Mississippi Delta" Hollandale, MS	Prevention (pre-post design)	Nutrition	3 times per week over a 6-week period	Research staff, teachers	N = 187 4th-6th graders completed the study	Fruit and vegetable recognition, willingness to try, and fruit and vegetable consumption pre- and postintervention	A f veg fee int inc fan pot am and cor sch
Combined nutrition and physical activity (n = 43)								

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Bergan[77] 2013 US (South Dakota)	Author reported "rural" students (125-mile radius from Brookings, South Dakota)	Prevention (RCT)	Combined nutrition and PA	6-month program; 6 40-minute lessons (6-month follow-up assessment) 2 interventions compared to control: KidsQuest (Intervention 1) and KidsQuest plus Family Fun Packs and Take 10! Activities (Intervention 2)	Trained teen teachers	N = 91 5th and 6th grade students. Mean age ranged from 10.85 to 11.04 years (128 invited to participate, 91 started the program, and 79 completed the whole study)	Total cholesterol, triglycerides, LDL, HDL, BMI (assessed pre-, post-, and 6 month [12-month] follow-up)	No gro in t cho trig HD pos fol sig dec fro in gro inc for pre pre for and
Brown[103] 2018 US (Washington)	Author reported rural community in eastern Washington	Prevention (quasi-experimental)	Combined nutrition and PA	6 months	Teachers; provider of child and family intervention unclear	N = 665 (Tx = 282, control = 383) 3rd-5th grade students N = 205 (Tx = 104 and control = 101) 3rd and 4th graders assessed for nutrition and PA for comparison	Height, weight, BMI z-scores, dietary intake, PA, sedentary behavior (assessed baseline and 6-month follow-up)	Sig imp ligh mo the gro to fro pos and dec mo vig cor sig dif die (fru and cor sed beh
Bumaryoum[94] 2015 US (South Dakota)	Author reported rural schools	Prevention (RCT)	Combined nutrition and PA	6 50-minute sessions over 4–6 months	Trained teen teachers and SNAP-Ed educators	N = 254 5th and 6th grade students	Nutrition, PA, BMI (height, weight), BP, total cholesterol, HDL, hemoglobin (assessed pre and 6 months after initiation)	No cha BP, cho her Sig red eat int gro inc gra cor
Canavera *et al.*[59] 2009 US (Kentucky)	Author reported rural Kentucky	Prevention (qualitative and pre-post design)	Combined nutrition and PA	12-week intervention (plus focus groups conducted before)	PE and health teachers (no specialized training)	N = 122 5th grade students (mean age not reported) N = 36 focus group parent and child dyads	PA, watching TV, drinking water, eating fruits and vegetables (pre- and post-assessments); focus group data	Ge sig pos wit sig pos for for exp dri and gla cor

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Carrel *et al.*[45] 2005 US (Wisconsin)	Author reported rural	Intervention (RCT)	Combined nutrition and PA	5 times every 2 weeks for 45 minutes; 9 months (school year)	Instructors	N = 50 obese middle school students (mean age 12 years)	BMI, fasting glucose, insulin, body fat, fat-free mass, cardiovascular fitness (maximal oxygen consumption)	Co the trea had dec fat imp car fitn sig imp fas lev
Cason *et al.*[47] 2006 US (South Carolina)	Author reported rural underserved communities	Prevention (quasi-experimental)	Combined nutrition and PA	7 1-hour sessions over 14 weeks	University Cooperative extension educator	N = 130 4th grade students (mean age 9 years); n = 72 control, n = 58 intervention	PA and dietary intake knowledge and behavior, 21 items (pre, post, and 5-month follow-up)	Sig dif gro wa cho sna veg day foo abo hea mo wo get PA exe dar TV enj phy ma gro par stra
Craven *et al.*[66] 2011 US (North Carolina)	Author reported rural high schools	Prevention (quasi-experimental)	Combined nutrition and PA	4 90-minute lessons (6 hours) of nutrition education and 6 hours of PA instruction in one semester	Nutritionist and classroom teacher	N = 399 9th graders (mean age = 14.7 years) N = 214 Tx group and N = 185 control group	Height, weight, BMI, self-reported eating behaviors (fruits, vegetables, dairy, sweet beverages, fast food), pre and post	No gro in cha BM Tx inc and inta int gro sta sig 0.0
Culbertson[49] 2007 US (Colorado)	Author reported rural	Prevention (quasi-experimental)	Combined nutrition and PA	Bimonthly classroom; 1 hour long; 11 hours total intervention time; 2 years	Grad student and community volunteers (PE teacher, high school and nursing students, police officer, veterinarian)	N = 82 2nd and 3rd graders; Cohort A = 37 2nd graders completing Year 1, Cohort B = 40 3rd graders completing Year 2, Cohort C = 29 2nd and 3rd graders who	Food and PA knowledge, attitude and behavior, BMI, waist circumference, body image, pedometer step counts; pre- and post-assessments	Sig imp PA kno gro to sig imp die and but dif cor sig imp boo esp fen

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
						completed both years		gro sig in no gro in ste
Davis *et al.*[43] 1993 US (New Mexico)	Author reported rural schools	Prevention (RCT)	Combined nutrition and PA	5 units; 18 hours of curriculum in one semester	Classroom teachers, older members of community	N = 1543 5th grade students, 9–13 years old (participated over 5-year period)	Health knowledge and attitudes, dietary habits, exercise behavior; height, weight, BMI, skin folds; pre and post	Sig imp ove in sch cor sig inc exe int cor sig dec but in cor
Donnelly *et al.*[44] 1996 US (Nebraska)	Author reported rural	Prevention (quasi-experimental)	Combined nutrition and PA	2 years; nutrition: 18 modules (9 modules per school year) PA: 3 days per week for 30–40 minutes	Existing classroom teachers	3rd and 5th grade elementary school students; N = 200 to collect lab data	Aerobic capacity, body composition, blood chemistry, nutrition knowledge, energy intake, and PA	No dif and sch BM ma cor ins glu hou stu sch sig soc cor pos sig dif alt had soc ene cho the cho HD imp vs. Tx sig act but les of cor
Gittelsohn and Rowan[67] 2011 US (Native American)	Author reported rural areas (American Indian and First Nation communities)	Prevention (qualitative)	Combined nutrition and PA	Unknown	Teachers	Elementary schools; 3rd-5th grade	Qualitative/ descriptive	Pos psy me imp die sig imp PA (pr out

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Gombosi *et al.*[50] 2007 US (Pennsylvania)	Author reported rural county	Prevention (pre-post design)	Combined nutrition and PA	5 years	Teachers, guest teachers, health curriculum coordinator	N = 4804 K-8th grade (ages 5–14 years)	BMI %, health assessments at health fairs; pre- and postassessments	Mi tea pro inc inc ove obe no eff
Hao *et al.*[110] 2019 China	Author reported rural (one district of Benxi City, Liaoning Province, in Northeast China)	Intervention (RCT)	Combined nutrition and PA	Exercise Tx: every school day for 30 minutes for 2 months; skipping rope, 3 times for 10 minutes; nutrition education, 8 45-minute meetings for 2 months (total of 6 hours)	Nutritionist, PE teacher	N = 229; n = 104 girls, n = 125 boys Overweight or obese primary school children 9–12 years of age	Anthropometric assessments (weight, height), dietary survey, nutrition knowledge, daily energy intake at baseline, after 2 months Tx (post), and 1 year follow-up	Co bas sig dec gro int fol nut kno sig imp gro rec edu pos fol bas sig dec ene pos fol wh nut edu sig cha sta sco and edu int nut edu int exe int cor fro low cor had and out
Harrell *et al.*[46] 2005 US (Mississippi)	Author reported rural southern community (Scott County, MS)	Prevention (quasi-experimental)	Combined nutrition and PA	16 weeks; 4 monthly sessions	Health care Professionals (pediatrician, pharmacist, Exercise physiologist, and registered dietitian)	N = 205 5th graders (mean age 11.9 years)	Health knowledge, height, weight, BMI, body fat %, waist circumference, dietary intake, blood lipids, blood glucose, and BP; pre and post test	Stu int sch hea cor cor sig inc hei and cir ove sig inc veg cor dec

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
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Harwood[60] 2009 US (Ohio)	Author reported rural Appalachia (federally designated, <2500 people)	Prevention (quasi-experimental)	Combined nutrition and PA	16 weeks: 6 45–60 minutes each (child part); parents (3 nutrition education, 5 packets); rowing twice a week for 30 minutes for 16 weeks	Research teachers	N = 35 (n = 19 Tx group and n = 16 control group) 2nd grade students (7 and 8 years old)	Dietary behaviors (nutrients, food groups): 3-day food log, height, weight, BMI, body fat % (skin fold), exercise test (aerobic fitness, BP, heart rate, respiratory function); pre- and postassessments	Ch gro sig inc and cor cor oth dif nut sig dif bet BM %.
Hawkins *et al.*[104] 2018 US (Louisiana)	Author reported rural	Prevention (RCT)	Combined nutrition and PA	28 months	Research personnel	N = 1626 4th-6th graders (mean age = 10.5 years); n = 1195 Tx and n = 431 control	Sodium, added sugars in lunches (baseline, 18 months, and 28 months); food selection and consumption based on digital photography	No gro in 18 28 gro sig few mo sel cor sig inc cor Tx 28 cor cor soc to at add cor inc cor cor gro mo sug cor sig dec gro gro did
Hawley *et al.*[48] 2006 US (Kansas)	Author reported rural	Prevention (qualitative and pre-post design)	Combined nutrition and PA (and behavioral)[a]	Five 40-minute session classroom program over 6 weeks	Unclear	N = 65 6th graders (and 25 families) 11–12 years old	Nutrition and exercise knowledge; self-reported PA and eating behavior; BMI (height and weight)	No cha hea and sig in hea fan sig inc sig

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
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Heelan *et al.*[95] 2015 US (Nebraska)	Author reported rural community (~30,000)	Prevention (pre-post design)	Combined nutrition and PA	Tx phased over 6 years	School nurses, trained university volunteers	N = 2400 each year, K-5th grade, across 9 schools	Student measurements: weight, height, BMI; implementation data (frequency, duration, and magnitude of change); reach and strength of Tx strategies; behavioral outcomes included increasing PA, decreasing unhealthy/high-calorie foods, and increasing healthy food consumption	Pre ove dec and dec ove per rela bet nur stra imp pre ove obe
Hoying *et al.*[101] 2016 US	Author reported Appalachian	Prevention (pre-post design)	Combined nutrition and PA (and behavioral)[a]	15 sessions during one academic year	Trained health teacher	N = 24 8th grade students (mean age = 13.6 years) completed Tx	Healthy lifestyle behaviors, physical health (BMI), and mental health symptoms, parent program evaluation; pre- and post-assessments	Sig imp hea beh at p app sig imp sel pos sig in a dep or beh eff for we obe
Langham[96] 2015 US (Alabama)	Author reported rural school system and medically under-served community	Prevention (pre-post design)	Combined nutrition and PA	One 30-minute session	Nursing students	N = 57 3rd graders (8 to 9 years old)	Height, weight, BMI, knowledge of nutrition, PA, and healthy behaviors (pre and post, 10 weeks)	Sig imp nut hea kno and sig in l
Lazorick *et al.*[84] 2014 US (North Carolina)	Author reported designed to reach rural youth	Prevention (pre-post design)	Combined nutrition and PA	55 contact hours over 14–16 weeks	Trained research team member	N = 106 participated as 7th graders and 8th graders who were retained at 11th and 12th grade (originally N = 195)	Weight category, BMI, BMI z-score, BMI %ile, rates of change in BMI per month	At gro % c cor inc gro dec z-s %i cor cor had inc

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
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Lazorick *et al.*[68] 2011 US (North Carolina)	Author reported rural school/ county	Prevention (pre-post design)	Combined nutrition and PA	55 contact hours over 14 weeks	Classroom teachers	N = 197 7th graders (mean age 13 years) Cohort 1: n = 92 Cohort 2: n = 102	BMI z-scores and BMI %ile (pre, post, 15 months, and 30 months)	Sli BM coh ove sig red z-s %i in l sub
Lin *et al.*[111] 2019 Taiwan	Author reported remote rural areas of Northern Taiwan	Prevention (RCT)	Combined nutrition and PA (and behavioral)[a]	8 weeks, 8 sessions, 40 minutes	Research group	N = 201 3rd and 4th graders from 8 elementary schools (8 to 12 years old)	Conducted before and after Tx; child interest in space exploration, satisfaction, healthy eating, and PA behaviors, knowledge, height and weight to calculate BMI; teachers and PE teachers evaluated sessions; appropriateness of content, relevance to space exploration, willingness to apply program to class	Co cor had inc hea no dif hea beh gro sig hig life kno sig dif act beh sig dif we inc int and we par
Ling[78] 2013 US (Kentucky)	Author reported rural	Prevention (pre-post design)	Combined nutrition and PA (and policy)[b]	5 months	Trained healthy lifestyle coaches	N = 1508 K-5th grade (mean age 8.32 years)	PA (pedometer) and eating behavior (dietary recall)	Sig imp % me rec aft sig imp % me rec aft sig eff beh inc cor fru veg on PA sch gra
Ling *et al.*[85] 2014 US (Kentucky)	School rural based on rural-urban commuting areas using census tract-	Prevention (pre-post design)	Combined nutrition and PA (and policy)[b]	5 months	Trained healthy lifestyle coaches	N = 1508 K-5th grade students (mean age 8.3 years)	Nutrition (dietary recall) and PA (pedometer)	Int sig on me rec and

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
	level demographic and work-commuting data, and economic integration with urban areas							had eff chi PA rec eff nut dep sch gra lin and qua nut tim
Llaurado *et al.*[86] 2014 Spain	Author reported semi-rural town (minimum of 500 7- and 8-year-olds)	Prevention (RCT)	Combined nutrition and PA	12 1-hour sessions implemented over 3-year period (22 months of Tx)	Health promoting agents (college students)	N = 690 primary school students (2nd and 3rd grade) mean age 8.04 years Intervention: n = 320, Control: n = 370	Obesity prevalence, BMI, dietary habits and lifestyles; pre- and postassessments	No gro in pre BM sco or pos Tx per PA hou sch cor cor boy als TV les Tx boy gro gro fou
Naylor *et al.*[64] 2010 Canada (British Columbia)	Population and distance from nearest city (Prince Rupert); author reported Aboriginal communities in northern British Columbia	Prevention (pre-post design and qualitative)	Combined nutrition and PA (and behavioral)[a]	15 minutes extra PA/day; ≥ 1 healthy eating activity per month	Teachers (received 2 half-days of training)	3 schools (K to 10th grade)	Action plans; type, frequency, duration of PA and healthy eating; minutes of PA and healthy eating; activities counted and categorized; qualitative feasibility of implementation	Lo for var sch mi ave sch ave tim hea 2.2 wit eac hea ave mi 4.6 we acc tea adr cul ada rec
Puma *et al.*[80] 2013 US (Colorado)	< 15,000 population; south-central Colorado	Prevention (quasi-experimental)	Combined nutrition and PA	Implementation in 3rd grade; 28 lessons in each grade for 2 years (3rd and 4th grades);	Trained resource teacher or regular classroom teacher	1 school district; 173 2nd graders; 190 2nd graders as controls;	Nutrition and PA knowledge, self-efficacy, attitudes and behaviors, BMI	Inc nut kn atti eff eff

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
				followed for ~6 years		follow-up in 8th grade (N = 190)		beh inc fru cor
Ronsley *et al.*[82] 2013 Canada (British Columbia)	Identified as remote; communities only accessible by boat or plane; author reported Aboriginal communities in northern British Columbia	Prevention (quasi-experimental)	Combined nutrition and PA (and behavioral)[a]	10-month study; 21 lessons, each for 30 minutes; 6 fitness loops, 2 conducted per week with 2 classes at one time	Older students trained to teach younger students	2 intervention schools (N = 118); 1 control school (N = 61); K-12th grades	BMI, waist circumference, BP, food frequency, PA frequency, sedentary and screen time, healthy living knowledge, selfesteem	Sig dec z-s 1.0 and cir (77 *P* < z-s He (co inc ove int suc dec z-s cir BP sta inc cor
Rush *et al.*[72] 2012 New Zealand (Waikato District)	Not defined, author reported	Prevention (RCT)	Combined nutrition and PA	Weekly newsletter with healthy eating nuggets; 2 academic-year study	Trained change agent (teachers or graduates in exercise and nutrition, or physical education)	124 schools, stratified by rurality; 62 control schools (N = 692; 5–7 years old), 62 intervention schools (N = 660; 10–12 years old)	BMI, BP, and body composition	Int mo but sta sig in sys sta sco nor low chi urb old sig low yea BP low clu cor (th nor
Schetzina *et al.*[61] 2009 US (Tennessee)	Author reported Appalachia	Prevention (pre-post design)	Combined nutrition and PA (and beha-vioral)[a]	Pre-post evaluation conducted over 18-month period	Registered dietitian, teachers, extension agents; school health staff, parent teacher organization	114 students (53% female; 94% White); teachers (98% of K-4th grade teachers); 1 elementary school; impact of school-wide program (K-4th) on 3rd and 4th graders	BMI, diet, PA (pedometer), knowledge attitudes, perceptions, acceptability, feasibility, sustainability	No cha stu sco firs pro eva gra hig BM if c sta in inc Wh ser caf sig cha or

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Schetzina *et al.*[70] 2011 US (Tennessee)	Author reported Appalachia	Prevention (pre-post design)	Combined nutrition and PA (and behavioral)[a]	1 academic year; 4-year follow-up of 1 academic year pilot study	School personnel (teachers and staff)	Follow-up, N = 65 4th grade students (45% female; 90.9% White); teachers (N = 23)	Diet, PA (pedometer), cafeteria offerings, teacher implementation, teacher perception of obesity as a problem	Imp hea foo day yel caf red (pe Wh tea per and cha
Slawson *et al.*[99] 2015 US (Tennessee)	Author reported rural Appalachia in northeastern Tennessee	Prevention (RCT [abstract])	Combined nutrition and PA	3 months; 8 40-minute sessions	Not specified	N = 1509 high school students	BMI	Pos on BM mo bas trea
Smith *et al.*[52] 2007 US (Colorado, Texas, and West Virginia)	Author reported suburban/ rural public schools	Prevention (pre-post design)	Combined nutrition and PA	One school year	Not specified	2nd-6th grade children in 40 classrooms in 3 states (more than 800 participants, total unknown)	Food knowledge, health knowledge, PA (steps/day), scientific knowledge of type 2 diabetes; pre and post school year	Sig inc kno to f dia pre inc sig inc
Tomlin *et al.*[74] 2012 Canada (British Columbia)	Author reported rural and remote communities	Prevention (pre-post design)	Combined nutrition and PA	7 months	Researchers (collaborated with schools, families and communities)	N = 148 children and youth, ages 12.5 ± 2.2 years	BMI z-score, waist circumference, aerobic fitness, PA, dietary intake (healthy eating) and cardiovascular risk; pre- and post-measurements	BM ren und wa cir sco No det car risk fitn The inc of cor oth die we
Valenzuela *et al.*[83] 2013 Chile (Pumanque, VI Region)	Author reported rural school	Prevention (pre-post design)	Combined nutrition and PA	8 educational sessions	Not reported	N = 94 students in 1st-5th year of primary school	Malnutrition rate, obesity rate, breakfast/ snack eating practices; pre and post	Ob by edu pro wa 10. wh twi pre sch wh fro als and dec
van Dongen *et al.*[107] 2018 Australia (New South Wales)	Author reported areas of social disadvantage	Intervention (qualitative)	Combined nutrition and PA	One 90-minute PA session per week, 20 weeks in total; teacher	Teachers (teacher-led PA), students (selfmonitoring),	361 boys in year 7 (eligible if self-reported less than 60	BMI, waist circumference, percentage body fat or for overall activity;	Stu inc of cor rel

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
				professional development: 2 full-day workshops (pre- and mid-program)	peers (peer-mentoring)	minutes of moderate to vigorous PA/day or more than two hours of recreational screen time per day)	boys' attitudes and behaviors relating to PA and nutrition; need-support practices and self-reported effects	int sig for cir per fat, act Sm 201 Ho wa int for tim mu enc res ski
Vogeltanz-Holm and Holm[108] 2018 US (North Dakota)	Author reported rural schools in the US upper Midwest	Prevention (pre-post design)	Combined nutrition and PA	3 years	Trained teachers	N = 308 students followed from 3rd-5th grades, ages 6–11 years	BMI z-score (height and weight), assessments beginning of school year, end of school year, and yearly for 2 additional years	Th sig dec z-s 3-y per ana tha stu ove in wh An stu sco sta pro
Williamson *et al.*[57] 2008 US (Louisiana)	Author reported rural schools	Prevention (RCT)	Combined nutrition and PA	28-month; weekly lessons	Research staff and teachers	N = 2097 children in 4th-6th grades (mean age 10.5 years)	Body weight, body fat, food intake, PA, sedentary behavior, and social support: assessed at 18 and 28 months	Pri pre pro in we Wh gir mi Ad sec pre pro pri pre pro sor cha mi on adi
Williamson *et al.*[65] 2010 US (Louisiana)	Author reported rural schools	Prevention (RCT)	Combined nutrition and PA	3 years; weekly lessons of 20–25 minutes, PA of 30 minutes	Research staff and teachers	17 school clusters; N = 2102 students from 4th-6th grades	BMI z-scores, BMI %ile, body fat, food selections, food intakes, PA, sedentary behavior, psychosocial variables (mood, eating attitudes, and social support for diet and PA)	No pro res ong res

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Williamson *et al.*[76] 2012 US (Louisiana)	Author reported rural communities	Prevention (RCT)	Combined nutrition and PA	28-month; weekly lessons of 20–25 minutes, PA of 30 minutes	Research staff and teachers	N = 2060 children 4th-6th grades	Body fat, BMI z-scores, dietary intake, PA, and sedentary behavior	Ch per % sco cha beh to we Pre pro eff red % atte fat gir Co two arn on boo z-s dif
Zaremba Morgan *et al.*[93] 2014 US (Alabama)	Author reported rural elementary schools	Prevention (quasi-experimental)	Combined nutrition and PA	10-week	Trained teachers	N = 85 4th graders	Anthropometric measures: height, weight, and BMI; nutrition-related knowledge, attitudes, and behaviors; food self-efficacy, PA self-efficacy, and PA knowledge; healthy body image and attempted weight loss, healthy body size perception, food intake, self-perceptions, avatar assessment	Int imp nut kno atti sig cha ant me inta sel
Policy (n = 9)								
Belansky *et al.*[58] 2009 US (Colorado)	Author defined rural and low-income schools (outside urban areas)	Prevention (pre-post design)	Policy	Not specified	Not specified	45 rural elementary schools	School environment and health policy survey: PA and nutrition, presence and enforcement of policies; key informant interviews	Co 06 200 yea inc mi (no cha rec 19 (no cha did par bar inc cor pre res to pri unf

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
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Ling[78] 2013 US (Kentucky)	Author reported rural	Prevention (pre-post design)	Policy (and combined nutrition and PA)[b]	5 months	Trained healthy lifestyle coaches	N = 1508 K-5th grade (mean age 8.3 years)	PA (pedometer) and eating behavior (dietary recall)	Sig imp % me rec aft sig imp % me rec aft sig trea on and cor fru veg on PA sch gra
Ling *et al.*[85] 2014 US (Kentucky)	School rural based on rural-urban commuting areas, using census tract-level demographic and work-commuting data, and economic integration with urban areas	Prevention (pre-post design)	Policy (and combined nutrition and PA)[b]	5 months	Trained healthy lifestyle coaches	N = 1508 K-5th grade students (mean age 8.3 years)	Nutrition (dietary recall) and PA (pedometer)	Int sig on me rec and chi PA rec eff nut dep sch gra lin and qua nut tim
Oluyomi *et al.*[89] 2014 US (Texas)	Definition not included (home addresses were geocoded)	Prevention (cross-sectional)	Policy (and PA)[b]	5 year implementation project; Texas Childhood Obesity Prevention Policy Evaluation; cross- sectional study	Not described	N = 830 parent-student (4th grade) dyads	Self-reported child walking to school; perceived traffic and personal safety concerns for neighborhood, en route to school, school environments, social capital	Od to s hig pro to t am sid int saf gua wa we str cor wa
Ramirez and Stafford[81] 2013 US (California)	Stated rural region, town of < 6000 population)	Prevention (descriptive)	Policy	state-wide; ongoing	Policy implementation at school level	Students in San Joaquin Valley, CA	Weight, decrease in sugar-sweetened beverage, increased water consumption	So hav bec cor ov ado nee inf

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
								pro stu cle wa pre in a
Ritchie[69] 2011 US (West Virginia)	Not defined	Prevention (pre-post design)	Policy (and behavioral)[a]	15 weeks; 30 minutes of cognitive behavior skills building education, followed by 20 minutes of PA; parental newsletter every 4 weeks during 15 week intervention	Nurse practitioner or registered nurse	N = 55 9th graders	BMI, BMI %, teen healthy lifestyle behavior, cognitive beliefs, perceived difficulty in leading a healthy lifestyle, self-esteem, and parent's healthy lifestyle behaviors, beliefs, and perceived difficulty in leading a healthy lifestyle	Stu beh imp Tim 51. dev to = 5 dev t (4 0.0 wit est 49% 6% the % i tee fro ove ove hea inc
Robinson *et al.*[90] 2014 US (Alabama)	Author reported 1 county in Black Belt Region	Prevention (cross-sectional)	Policy (and PA)[b]	Alabama requires daily PE for 30 minutes per day by certified PE teacher; recess and other activities are not included and are considered extra	Certified PE instructor	5 elementary schools; N = 683 school-age children (341 female; 342 male); mean age 8.2 years; 99.9% Black	BMI, weight status, waist circumference; PA behavior (pedometer step count, System for Observing Fitness Instruction Time, and the System for Observing Play and Leisure Activity in Youth)	Ov PA pol par imp larg bet sch sch wh bei imp dur stu opp sch
Schetzina *et al.*[62] 2009 US (Tennessee)	Author reported Appalachia	Prevention (qualitative)	Policy	Not applicable	Not applicable	60–90 minute focus groups with adults (23 teachers, 12 parents), and 30–40 minute focus groups with students (19 4th grade students)	Community-needs assessment; qualitative outcomes from focus groups using open-ended questions about school nutrition and PA practices and resources, perceptions of student overweight/ obesity; outcomes analyzed using the Coordinated School Health Program model as an analysis framework	Co con obe sup doi tho a n eat par abo and of BM par mo sch sch env aca pre of sup bar

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
Smith and Holloman[91] 2014 US (Ohio)	Author reported a rural Appalachian county	Prevention (pre-post design)	Policy (and nutrition)[b]	30-day	Teen advisory council (teachers and students from 9th-12th grades)	N = 186 high school students 9th-12th grades from 2 schools (mean age 15.85 years)	Sugar-sweetened beverage consumption and water consumption pre, post, and 30-day follow-up	Sug bev cor dec sig wa cor inc fro pos
Other (n = 8)								
Askelson *et al.*[109] 2019 US (Iowa)	Author reported 5 schools located in rural areas	Prevention (pre-post design)	other	1 school year	Nutrition researchers	6 middle schools: 5 rural schools and 1 non-rural school; food service director and staff and student group	Lunchroom perception assessment completed by students, online survey (student, parents, and food service staff), production records (fruit, vegetable, and milk) and telephone interviews with food service directors	5 o imp lun ass of inc of of ser veg mil ser des trea suc imp cor wit an out
Gabriele *et al.*[63] 2010 US (Louisiana)	Author reported rural school	Prevention (RCT, secondary)	Other (program evaluation)	Weekly for 2.5 school- year period (32 lessons, 5 were repeated = total of 37 lessons); new lesson every 2 weeks	Internet counselor (had bachelor's degree or higher degree in nutrition, health behavior, psychology, or exercise and sport science); teachers did classroom activities	N = 773 students in 4th-6th grades from 14 schools (mean age 10.5 years)	Treatment implementation information presented; BMI not reported	12 par stu site tim 117 int cov imp
Muzaffar *et al.*[105] 2018 Multiple countries (US, Australia, England)	Definition not included	Combined prevention and intervention (RCT and quasi-experimental)	Other (systematic review)	3–5 sessions	Registered dietitian, trained staff, teachers, parents, volunteers, chefs, and undetermined	6 intervention studies; included children and early adolescents	Food prep, cooking confidence, trying new foods, cooking attitudes, behaviors, behavioral intentions, fruit and vegetable preference, theoretical constructs (perceptions), anthropometrics (BMI), BP, diet intake, visual estimate intake whole grains and vegetables	Imp coo hea coo eff beh int pre kno hea int
Ning *et al.*[88] 2014 China (Qingdao)	Not defined	Prevention (RCT)	Other	Information not provided	Information not provided	15,095 primary and secondary	Prevalence of overweight/	No ove obe

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
						school children/ adolescents	obesity, PA, sedentary time	pre bet edu cor we tim sig low edu (*P* inc aw 2 d me fac edu
Sanigorski *et al.*[56] 2008 Australia (Colac, Victoria)	Author reported town of about 11,000 inhabitants in rural area	Prevention (quasi-experimental)	Other (Community Capacity Building)	3 years	Colac Area Health, Colac Otway Shire and Colac Neighborhood Renewal; Deakin University provided support	4 preschools and 6 primary schools at baseline (2003, N = 1001) and follow-up (2006, N = 839) Controls: 4 preschools and 12 primary schools baseline (N = 1183) and follow-up in (2006, N = 979)	Differences in the increases in anthropometry (weight, waist, waist-to-height ratio and BMI z-score) over time and the relationship between baseline indicators of children's household socioeconomic status	Int sig low boc wa sco
Schiller *et al.*[51] 2007 US (Colorado)	Author reported, Fort Collins, CO	Prevention (pre-post design [abstract])	Other (body science focus)	8-week program	Not determined	Teachers and 6th grade students from 1 school; specifics not included	Knowledge, attitudes, body acceptance, interest in science-health careers	Be sci kn sci (m beh (se phy inc acc inc in rel
Slaney *et al.*[73] 2012 Australia (Mansfield in NE Victoria)	Author reported rural campus near Mansfield in NE Victoria, Australia	Prevention (pre-post design)	Other (residential school program)	10 months (Feb-Nov)	Not specified	N = 1021 year 9 students (mean age 14.9 years)	BMI pre and post	Par pro BM we obe not
Whelan *et al.*[112] 2019 Australia (Victoria)	Author reported rural and remote	Prevention (pre-post design)	Other (communityled local determinants)	3.5 years	Communityled	Community; workplaces and children in kindergarten	Community readiness assessments, community-based systems dynamics, workforce audit, policy audit and changes in kindergartens, workplaces, schools, food supply audit,	Lo 3.5 a l pre ove obe to s (11 Dis foo kin lun sig red

Study, year, location	Method of rural designation	Study type (design)	Intervention components	Intervention frequency/ length	Provider	Sample	Type of outcomes	Ke
							preexisting anthropometric data analysis, sales data, lunchbox audits and key informant interviews	Wo rev tim ava obe (70

%ile, percentile; BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; K, kindergarten; LDL, low-density lipoprotein; PA, physical activity; PE, physical education; RCT, randomized controlled trial; SNAP-Ed, Supplemental Nutrition Assistance Program Education; Tx, treatment; US, United States

[a] The prevention program also included behavioral components.

[b] The prevention program is listed in the table under more than one component.

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Appendix II: Studies ineligible following full-text review

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3. Hosseini H, Yilmaz A. Using telehealth to address pediatric obesity in rural Pennsylvania. Hosp Top. 2019;97(3):107–18. [PubMed: 31244391] *Reason for exclusion*: ineligible concept – no outcomes reported
4. Lyders S Evaluation of a daily activity program for early school-age children in a rural setting. 2019.*Reason for exclusion*: ineligible population – adults
5. Marchetti D, Fraticelli F, Polcini F, Fulcheri M, Mohn AA, Vitacolonna E. A school educational intervention based on a serious game to promote a healthy lifestyle. Mediterranean J Clin Psychol. 2018;6(3):1–16.*Reason for exclusion*: ineligible context – both rural and urban settings

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8. ClinicalTrials.gov. Families and schools for health [internet]. 2016 [cited 2019 Jul 22]. Available from: https://clinicaltrialsgov/show/nct02659319.*Reason for exclusion*: ineligible concept – no outcomes reported
9. ClinicalTrials.gov. Rural disparities in pediatric obesity: the iAmHealthy Intervention [internet]. 2017 [cited 2019 Jul 22]. Available from: https://clinicaltrialsgov/show/nct03304249.*Reason for exclusion*: ineligible concept – no outcomes reported
10. ClinicalTrials.gov. Systems-oriented school healthy weight promotion based on NASA Mission X Campaign [internet]. 2017 [cited 2019 Jul 22]. Available from: https://clinicaltrialsgov/show/nct03355131.*Reason for exclusion*: ineligible concept – no outcomes reported
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12. Richards K, Slawson DL, Johns-Wommack R, Smith S. Identifying demographic risk factors for pediatric obesity: a multitvariate analysis of Tennessee coordinated school health BMI reports for 2007–2008. Obesity. 2011;19:S127–S8.*Reason for exclusion*: ineligible concept – not program/intervention
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16. Samuels CA. Studies evaluate school wellness policies. Education Week. 2009;28(23):4.*Reason for exclusion*: ineligible concept – not program/intervention
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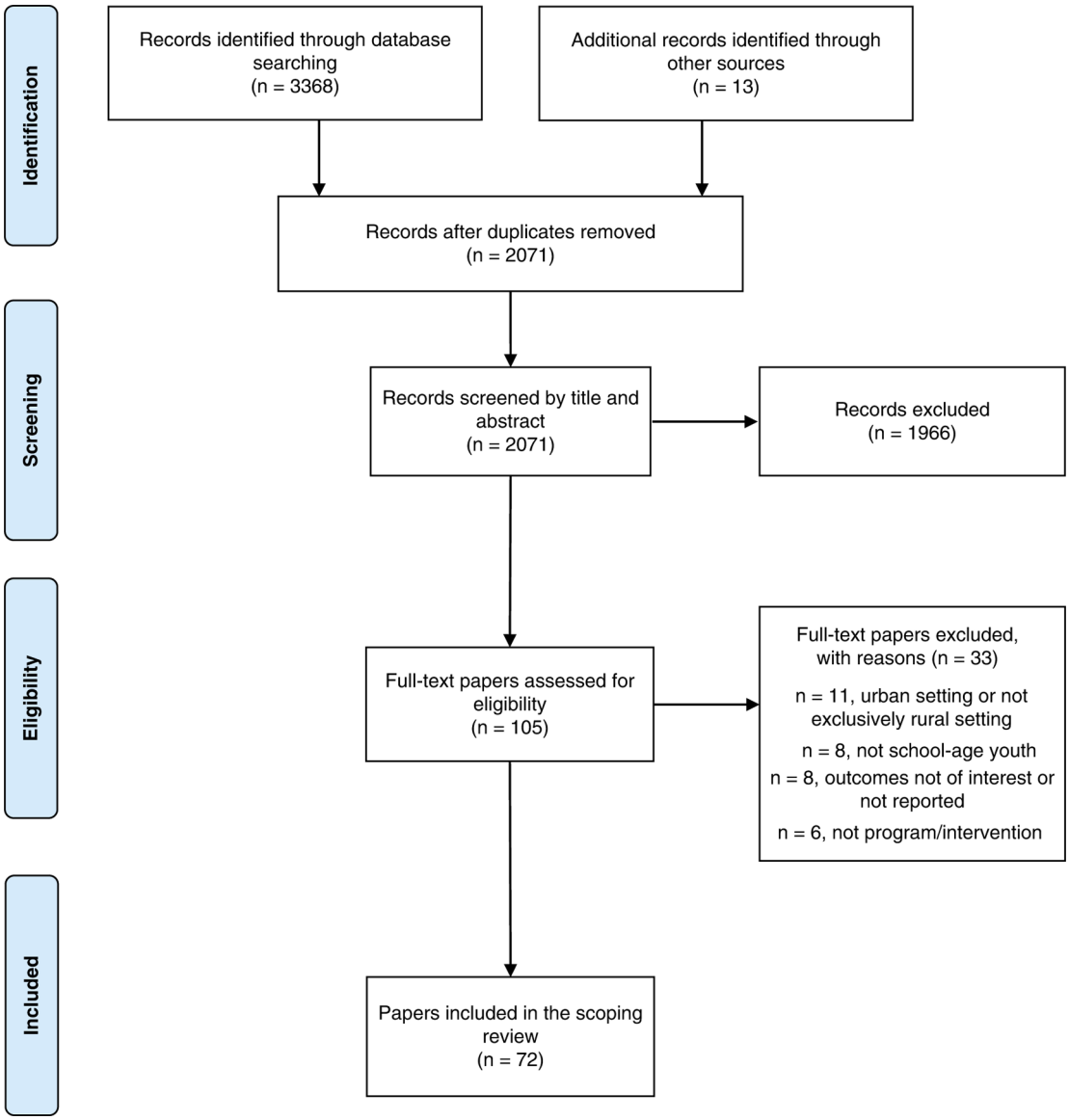

Figure 1:
Search results and source selection and inclusion process[41]