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Integrating Food Security Interventions in Cardiometabolic Prevention Programs: A Systematic
Review of the Literature

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2017

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in the Hubert Department of Global Health
2022

Abstract

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By Nana Esi Acquah

Food insecurity which is estimated to affect over 10% of households in the U.S. continues to be a major factor resulting in the development of cardiometabolic diseases (CMD) such as diabetes and cardiovascular disease. To prevent a further rise in CMDs, disease prevention programs recommend lifestyle and behavior modifications such as increased exercise and improved eating habits through the intake of healthier food items such as fruits, vegetables, and legumes as one of the primary ways to reduce disease risk. These changes prove to be difficult for individuals facing food insecurity due to limitations in the accessibility and affordability of healthy food options. This review examines current cardiometabolic prevention program efforts to address challenges among food-insecure participants and identifies gaps and limitations of current interventions. The electronic database PubMed was searched for published papers after 2000 to identify cardiometabolic prevention programs addressing food insecurity. Handsearching was also performed to find additional publications that met criteria for inclusion. Data abstracted included changes in baseline/endline health and behavior outcomes and program and participant characteristics (e.g., age). Three articles satisfied the inclusion criteria. One was a randomized control trial, one a cluster-randomized design, and the last was a longitudinal study. Reports of improvements in BMI levels, weight loss, and reduced obesity risk with extended program participation were reported in study 1 which was focused on a retail intervention on tribal reservations. Study 2, another retail intervention on Native American reservations reported marginal improvements in fruit and vegetable intake. In study 3, a Diabetes Prevention Program in 2 clinics, there were reports of improvements in food security, weight loss, and increased consumption of healthier foods. There is a lack of evidence documenting improvements in health outcomes based on current program efforts. Future research should involve the collection of health data (weight changes, BMI, HbA1c levels) to increase evidence-based findings, facilitate community engagement, pass policies that connect food insecure clients to nutrition assistance, and adapt existing nutrition programs (medically tailored meals, food incentive programs (vouchers), and digital services) to address the needs of food insecure program participants.

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Acknowledgements

I would like to express my sincere gratitude to my wonderful advisor, Dr. Mary Beth Weber for mentoring me, for her patience, and continuous support. Her guidance, detailed feedback, and wealth of knowledge on the topic helped me immensely throughout the writing process. I could not have imagined a better mentor and advisor to guide me during this experience.

Thank you to the research librarian Hannah Rogers for her kindness and helping explain the systematic review process to me, providing me with a list of resources and databases to use, and walking me through the search term process to help me easily identify which articles to use.

Finally, thank you to my family-my parents Irene and Alex, my siblings Aba, Sam, and Ekow, and my uncle Kobe-for always supporting me and checking on me throughout this process. You all kept me grounded and focused, and I am so fortunate to have each of you to rely on not only for encouragement but for a laugh or phone call when I was feeling overwhelmed.

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Abbreviations

AHA	American Heart Association
BMI	Body Mass Index
BP	Blood Pressure
CBPAR	Community-Based Participatory Research
CHD	Coronary Heart Disease
CKD	Chronic Kidney Disease
CVD	Cardiovascular Disease
DASH	Dietary Approaches to stop Hypertension
DPP	Diabetes Prevention Program
HbA1C	Hemoglobin A1C
HEI	Healthy Eating Index
FI	Food Insecurity
MTM	Medically Tailored Meals
RCT	Randomized control trial
SES	Socioeconomic status
T2DM	Diabetes Mellitus Type II
WW	Weight Watchers

Chapter 1: Introduction & Rationale

Cardiometabolic diseases (CMDs) including cardiovascular disease (CVD), diabetes mellitus, and kidney disease are the main causes of morbidity and mortality in the United States (Berkowitz et al., 2017). Improvements in dietary patterns such as increased consumption of whole grains, healthy proteins such as seafood, beans, legumes, white meat poultry, unsaturated fat, and fiber are critical in the prevention of CMDs, however, adherence to a healthy diet can pose challenges for many individuals especially when access to food is an issue (Berkowitz et al., 2017). Food insecurity (FI) is defined by the United States Department of Agriculture (USDA) as the inconsistent access to wholesome nutritious foods to maintain a healthy life. FI is said to be strongly associated with CMDs. Common risk factors for food insecurity include residing in rural areas, having low socioeconomic status, and identifying as African-American or Hispanic. Consequently, certain populations are known to have both higher rates of CMD's and food insecurity (Castillo et al., 2012).

In 2014, food insecurity was estimated to affect 14% of the U.S. population or 49 million Americans and these numbers have only been exacerbated by the recent COVID-19 pandemic with prevalence of food insecurity among low-income adults reaching up to 44% (Berkowitz et al., 2018; Liu & Eicher-Miller, 2021). Poor diets resulting from food insecurity are reported to be correlated with increased incidences of negative health outcomes such as increased risk of being diagnosed with obesity, hypertension, diabetes, heart disease, stroke, or kidney disease (Te Vazquez et al., 2021). Furthermore, increased healthcare expenditures are another risk factor associated with food insecurity with experts estimating an additional US \$77 billion dollars spent annually in healthcare costs related to limited food access (Berkowitz et al., 2018).

Food insecurity can create challenges that prevent the ability to adhere to recommended guidelines of CMD prevention programs, by making it difficult to adopt healthy lifestyle (Darnell et al., 2019). There are both social implications and economic costs associated with food insecurity when not adequately managed. Inability to comply with program guidelines creates an unhealthy sequence of events in which poor diet quality leads to poor health, poor health then leads to challenges with working, which results in reduced income and further exacerbates the risk of being food insecure, and this would in turn prolongs the consumption of unhealthy highly processed foods (Berkowitz et al., 2018). Therefore, addressing these challenges would help to reduce the growing issue of food insecurity among program participants and help provide long-term sustainable solutions and reduce healthcare related costs.

CMD prevention programs have an essential role in helping to stop the development of metabolic diseases. The objective of this review will be to understand if and how CMD programs and interventions in the U.S. are addressing the nutritional needs of their food insecure populations and discuss the necessary steps that need to be implemented to improve the health status of these populations.

1.1 Statement of the Problem

CMD programs have operated for years, however, to date there is little evidence about how effective these programs are for their food-insecure participants. There are no comprehensive reviews that have been published that examine what is known about past or current interventions efforts. Therefore, systematically identifying these gaps in knowledge can help to address these limitations that negatively impact these vulnerable populations.

1.2 Purpose statement

This systematic review will examine and evaluate current efforts by CMD programs including diabetes, obesity, heart disease, and hypertension prevention programs to address and support the needs of food insecure program participants. By systematically identifying limitations and gaps in current practices, it will help to facilitate discussion about future efforts that can be made to implement a more inclusive program and increase research practices focused on finding innovative solutions to provide the resources needed for program success.

1.3 Research questions

This review will ask the following questions:

- I. How have cardiometabolic prevention programs in the U.S. addressed issues of food insecurity among underserved populations?
- II. Do cardiometabolic prevention programs that address food insecurity results in positive health outcomes among participants?
- III. What are the gaps in current prevention programs' efforts to effectively address food-insecure populations?

1.4 Significance statement

Food insecurity continues to be a public health threat and research shows numbers are on the rise. Limited access to food is linked to several chronic diseases including hypertension, diabetes, obesity, and heart disease and disease prevalence is more common among food-insecure populations compared to food-secure (Venci & Lee, 2018). Therefore, identifying any gaps in current CMD prevention programs can be used to improve/alter current and future program guidelines to address the needs of a growing food-insecure population in the US. Evidence found in this systematic literature review can be used to advocate for more funding for programs that allow for resource allocation to address the needs of food insecure participants.

Chapter 2: Review of the Literature

2.1 Burden of Cardiometabolic Disease

Cardiometabolic diseases are a group of diseases classified as type 2 diabetes mellitus (T2DM), cardiovascular diseases (CVDs), and chronic kidney disease (CKD). T2DM, CVD, and CKD share common risk factors leading to disease development including hypertension, obesity, and dyslipidemia (Stol et al., 2020). Approximately 34.1 million adults in the US 18 or older have been diagnosed with diabetes and another 88 million or 1 in 3 adults have pre-diabetes. Left untreated, it is estimated that individuals diagnosed as prediabetic will develop type 2 diabetes within five years (*National Diabetes Statistics Report 2020. Estimates of Diabetes and Its Burden in the United States.*, 2020) *About Prediabetes and Type 2 Diabetes | National Diabetes Prevention Program | Diabetes | CDC*, 2020).

Furthermore, an estimated 18.2 million Americans ages 20 and up (7% of the population) have coronary heart disease (CHD) and in 2020, it was estimated that roughly 655,000 Americans die yearly from heart disease (Te Vazquez et al., 2021). Additionally, approximately 42.4% percent of adults in the United States have been diagnosed as overweight or obese, 47% or 116 million adults are said to have hypertension, and 1 in 5 adults or 15% of the population has CKD (CDC, 2021a, 2021b; *Chronic Kidney Disease in the United States, 2021*, 2021). CMD risk differs across population subgroups. For example, socioeconomic status (SES) is highly attributable to both diabetes and CVD (Kanjilal et al., 2006). SES can result in differences in education and lead to income-related disparities that can create barriers such as food insecurity, create health challenges, lead to housing insecurity, and reduced access to healthcare (Stotz et al., 2021). Similarly, race is a major risk factor for disease development with certain racial/ethnic groups being affected more than others. For example, in 2010, non-Hispanic Blacks had the

highest prevalence of diabetes at 12.6% compared with non-Hispanic Whites at 7.1% (Gaskin et al., 2014)

Finally, CMD risk also changes based on regional differences where the Southeastern region of the US known to experience higher disease prevalence. These impacted areas are commonly referred to as the Diabetes Belt and the Stroke Belt. The Diabetes Belt consists of 15 states is it is reported that prevalence of diabetes over 11%. Characteristics of these populations include identifying as a non-Hispanic African American, living an inactive lifestyle, and being overweight or obese (Barker et al., 2011). In the Stroke Belt, stroke risk is 27% higher than the general population (Howard & Howard, 2020). These rates are attributed to lower SES in this region of the country as well the large proportion of African Americans living in this region and poor health status including higher incidences of obesity and smoking (Liao et al., 2009).

2.1.1 Role of a healthy diet in disease prevention

According to the Center for Disease Control and Prevention, consumption of a healthy diet can reduce risk of chronic diseases such as obesity, CVD, and T2DM. Approximately 70% of Americans are said have high intakes of processed foods leading to increases incidences of heart disease and stroke. Similarly high intakes of sodium over the recommended <2300 mg a day leads to higher rates of obesity and consequently results in increased prevalence of diabetes. Consumption of foods with low levels of sodium and saturated fats and high levels of fiber is reported to lead to lower BP and cholesterol levels (*Poor Nutrition / CDC*, 2021). Dietary strategies that promote the uptake of macronutrients and low-fat foods such as the DASH diet are also shown to have positive outcomes in the prevention of metabolic diseases. Such diets are said to result in decreased BP, BMI, weight loss, improvements in cholesterol, decrease in T2DM prevalence, and reduced CVD risk (Castro-Barquero et al., 2020).

Diet quality is therefore essential to ensuring that individuals are consuming a healthy, balanced diet. Indices of diet quality can be used as way to measure the relationship between diet and disease by providing information on whether individuals are adhering to dietary recommendations. Different components to measure include adequate consumption of fruits, vegetables, dairy products, whole grains, and fats (Harrison et al., 2020). Healthy Eating Index (HEI) scores can then be calculated to evaluate dietary patterns. The ideal score of 100 is reflective of an individual that is compliant with dietary guidelines, however in 2015, total HEI for Americans was 59 indicating the need to improve diet quality to reduce the risk of being diagnosed with diet-based CMD such as T2DM and CVD (*Healthy Eating Index (HEI) | Food and Nutrition Service*, n.d.)

2.2 Burden of Food Insecurity

Food insecurity is associated with a poor diet quality that consists of a reliance on cheap high-fat, high-sugar based meals. Consequently, poor diet quality significantly reduces intake of sufficient levels of fruits, vegetables (Te Vazquez et al., 2021). In turn, food insecure individuals are reported to have lower serum concentrations of vitamins such as vitamin A, vitamin B, magnesium, iron, zinc compared to food sufficient households (Dixon et al., 2001).

Consequently, food insecurity can lead to worse health outcomes such as stroke, elevated blood sugar levels, increased hospitalization rates, higher body mass index (BMI) levels, and hypoglycemic episodes which increases risk of CMD (Laraia, 2013). T2DM, CVD, hypertension, and obesity are all diet-sensitive diseases therefore following a healthy diet is an essential tool for the prevention of disease development. Consequently, food insecurity introduces the unique challenge of being able to consistently consume a diet rich in nutrients and serves as a precursor to CMD (Berkowitz et al., 2017).

2.2.1 Risk factors linked with being food insecure

The Department of Health and Human Services defines underserved populations as communities who experience health disparities or face barriers in accessing services. Key characteristics of underserved and vulnerable populations include being at high-risk for health problems, encountering challenges and barriers when trying to access services, and having financial, educational, or housing challenges (Serving Vulnerable and Underserved Populations, n.d.).

Unemployment, low-income, single-parent households, households with children 6 years and under, and identification as a minority including African American or Hispanic are all risk factors that increase chances of food insecurity (Castillo et al., 2012). High rates of unemployment in low-income populations can create challenges that make it difficult to provide meals for the entire household. Similarly, in households of children with unemployed parents, higher rates of food insecurity are expected compared with food-secure households. Race and ethnicity also play a critical role in food insecurity where some races such as African Americans are reported to have food insecurity rates that are higher than the national average. Disability is another risk factor that can increase food security due to reduced work opportunities and additional healthcare expenditures that could lead to reduced income. Environmental factors including living in a “food desert” where supermarkets are located several miles from residential neighborhoods, the abundance of fast-food restaurants and corner markets with unhealthy food options all increases risk of food insecurity. Consequently, these circumstances also increase CMD risk (Office of Disease Prevention and Health Promotion, 2021).

2.2.2 Uniquely at risk: More detailed examples

When it comes to food insecurity, there are certain populations or groups that are impacted more than others. In 2016, black non-Hispanic populations were estimated to be twice as likely to be food insecure compared to the general population (22.5% versus 12.3%) and Hispanic populations had a food insecurity prevalence of 18.5% (Office of Disease Prevention and Health Promotion, 2021). Similarly, from 2000 to 2010, Native Americans were twice as likely to be food insecure compared to white Americans, who are predominantly food secure. Disparities are also found within Native American populations living in rural versus urban areas where populations living in urban regions such as inner cities were 1.4 times more likely to be food insecure compared to those living on reservations or nonmetropolitan regions. Living on reservations provides social benefits such as food sharing which leads to a higher prevalence of food security compared to urban regions (Jernigan et al., 2017). Similar findings are seen among Hispanic immigrants in rural versus urban regions. Hispanic immigrants in rural areas are said to face greater levels of food insecurity due to additional challenges and barriers including the lack of funds for healthy food options and having other responsibilities that limit time needed to prepare healthy foods. Consequently, this population consumes more low-cost, highly-processed meals (Haldeman et al., 2008).

2.2.3 Linkages between food insecurity and cardiometabolic disease in the US

Poor diets are responsible for approximately 45% of CMD related deaths and poor diet is also said to be responsible for 18% of all heart disease and type II diabetes costs (Jardim et al., 2019). These issues are all exacerbated in food insecure populations who have an even greater risks of CMD development (Liu & Eicher-Miller, 2021). For example, risk of diabetes is also said to be 2.5 times higher in food-insecure households compared with households that are food

secure (Seligman & Schillinger, n.d.). Similarly, CVD risk is said to be twice as high among food insecure adults. Furthermore, risk of coronary heart disease, heart attack, and hypertension is 1.4 times higher than food secure individuals (Liu & Eicher-Miller, 2021). Food insecurity is highly associated with risk factors of CMD including obesity, hypertension, hyperglycemia, and dyslipidemia (Castillo et al., 2012). The two share a cyclical relationship in which food insecurity leads to consumption of smaller food portions, cardiometabolic-related medical costs lead to consumption of less healthy food options which in turn further increases risk of food insecurity when access to food is limited. Furthermore, the lack of healthy food options leads to increased cortisol levels as stress rises, leading to an increase in the consumption energy-dense foods which results in high adiposity levels, which in turn increases risk of obesity and hypertension (Miguel et al., n.d.).

2.3 Cardiometabolic Prevention and Program Examples

2.3.1 Diabetes Prevention Program

The National Diabetes Prevention Program (DPP) targets two main risk factors of diabetes including (1) being overweight and (2) living a sedentary lifestyle. The program has a goal-based intervention style that aims to achieve a 7% weight-loss among participants and has requirements of at least 150 minutes of high intensity physical activity per week (T. D. P. P. R. Group, 2004). Research has shown that participants enrolled in the DPP can lower chances of developing diabetes by approximately 58%. Furthermore, among subgroups in the program, effects of the intervention did not show any significant difference between sex, race, or ethnic group (*Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin / NEJM*, n.d.). Additional outcomes associated with the DPP include reduced risk of high blood

pressure and cholesterol (*Diabetes Prevention Program (DPP) / NIDDK, n.d.*). In year one of the program, fasting blood sugar levels decreased in intervention groups while values rose in placebo groups (*Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin / NEJM, n.d.*). Regression analysis conducted has demonstrated adverse outcomes where prediabetic participants practicing lifestyle modifications had a higher risk of developing diabetes. Experts attribute these outcomes to reduced adherence to program sessions and environmental factors not accounted for (Perreault et al., 2012).

The DPP intervention has several critical components that guide the program, the major ones being (1) personalization of the program by using individual coaches, (2) on-going development, and (3) the incorporation of curriculum about healthy eating habits. Unlike other diabetes interventions, the DPP incorporated an individual-based method of treatment to adapt the program to the unique backgrounds of enrolled participants. Each enrollee was assigned to a “lifestyle” coach who worked to provide support and ensure that goals were being achieved. Regarding on-going development, the program provided a core curriculum at the beginning of the intervention and made modifications as time went on to make the program less rigid and more flexible. This included the incorporation of group classes in addition to individual sessions as well opportunities to restart the program if needed. Finally, the curriculum provided by the DPP consisted of 16 sessions focused on better nutrition practices, physical activity, and behavioral training focused on self-efficacy. The first 8 weeks were geared towards helping participants monitor their food intake and physical activity and the remaining 8 weeks focused on environment factors and social influences that could impede success as well as any other barriers or challenges that could impact the maintenance of newly learned lifestyle behaviors (T. D. P. P. (DPP) R. Group, 2002).

2.3.2 Dietary Approaches to Stop Hypertension (DASH)

As the leading cause of CVDs, several hypertension programs have been implemented to provide strategies to lower blood pressure (BP) levels (Carey et al., 2018). Since 1973, The National High Blood Pressure Education Program, an educational program created by the National Institute of Health (NIH) to reduce prevalence of high BP, has been leading efforts that combine a targeted and community-based approach to help with of lowering BP levels among high-risk populations (Whelton et al., 2002). Their research and guidelines set the precedence for current recommendations which are focused on incorporating a combination of lifestyle modifications including reducing sodium intake, increasing potassium intake, reducing weight, and increasing physical activity. The final modification includes the consumption of healthier foods and specific dietary recommendations have been created for prehypertensive individuals to follow and they are referred to as The Dietary Approaches to Stop Hypertension (DASH) (Carey et al., 2018). The DASH diet is reported to help lower blood sugar levels, cholesterol, and insulin resistance. Furthermore, it is known to help with weight management and reduce obesity as well as incidence of heart failure (Challa et al., 2021).

The DASH diet is composed of a balanced nutrition plan that promotes the consumption of 4-5 servings of fruits and vegetables, 6-8 servings of whole grains, 2-3 servings of oils, 2-3 servings of low-fat dairy products, 6 or less servings of lean proteins such poultry or seafood, and 2300 mg of sodium daily. 4-5 servings of legumes and nuts are also recommended on a weekly basis. Additionally, recommendations include selecting foods high in potassium magnesium, fiber, calcium, and protein. Consequently, the diet excludes foods with high levels of trans fat or saturated fats such as sweets, sugar-sweetened drinks, or fatty meats. Following the DASH is said to have significant improvements on blood pressure and low-density lipoprotein (LDL) cholesterol. It is important to note, that the DASH should not be the sole

lifestyle modification used to reduce BP. Instead, the combination of the DASH diet in addition to reduced sodium intake results in significant improvements in BP (Carey et al., 2018; *DASH Eating Plan* / NHLBI, NIH, n.d.).

2.3.3 American Heart Association

Multiple cardiovascular prevention programs have also been established and they often focus on controlling risk factors such as limited physical activity, high BP, poor diet high in saturated fat, stress, smoking, obesity, and having a high blood cholesterol (Shea & Basch, 1990). The Center for Disease Control and Prevention Division for Heart Disease and Stroke Prevention (DHDSPP) also provides funding and local support for statewide community-based lifestyle interventions focused on reducing BP and cholesterol levels, and providing nutritional education (*About State, Local, and Tribal Programs* / Cdc.Gov, 2020). For example, in 2017, blood pressure control rates were said to increase from 63% to 73% in Montana. Similarly, in 2014, health care systems in South Carolina were able to increase patient awareness of blood pressure conditions 69% to 94% (*Division for Heart Disease and Stroke Prevention At A Glance* / CDC, 2020).

Additionally, for over a century, the American Heart Association (AHA) has been conducting research on cardiovascular health and has provided guidelines and recommendations on methods to prevent CVD (*About Us*, n.d.). The AHA plays a critical role in CVD prevention. In 2020, the planning task force developed what was known as the 2020 Impact Goals. These goals proposed 7 optimal health choices to improve cardiovascular health and they were (1) maintaining a regular body weight, (2) increasing levels of physical activity, (3) consuming a healthy diet based on recommended dietary guidelines, (4) maintaining normal cholesterol or blood lipid levels, (5) maintaining normal blood pressure levels, (6) having a normal fasting glucose, and (7) not smoking. By implementing these goals, the AHA hoped to see an

improvement in cardiovascular health with a 20% and a reduction in CVD related deaths and stroke by 20% by the year 2020 (Yeboah, 2018).

2.3.4 Obesity Prevention Programs

Efforts have also been made to assist with prevention of obesity. The United States Department of Agriculture (USDA), National Institute of Food and Nutrition (NIFA), and Food and Nutrition Service (FNS) collaborated in 2014 to create the Regional Nutrition Education and Obesity Prevention Centers of Excellence (RNECE) initiative which promotes nutrition-based educational courses, weight loss, and increased physical activity to prevent obesity (*Regional Nutrition Education and Obesity Prevention Centers of Excellence (RNECE) | National Institute of Food and Agriculture, n.d.*). To date, there is not much published information indicating the benefits of the RNECE initiative except for the its assistance in increasing resources for SNAP-ed programs and policies (*Regional Nutrition Education and Obesity Prevention Centers of Excellence (RNECE) | National Institute of Food and Agriculture, n.d.*).

In addition to the RNECE, several commercial weight loss programs exist that people can use. For example, Weight Watchers (now WW) has published literature highlighting the success of its weight management program that combines dietary counseling with exercise guidance (Cobiac et al., 2010). Furthermore, studies show comparable weight loss outcomes between WW and the DPP and given the reach of WW, with over 25,000 meetings sessions held each week across the US, WW has proven to be a method that can result in considerable health improvements for individual especially individuals that are prediabetic (Marrero et al., 2016).

2.4 Concluding Remarks: Aim of Review

We have seen that CMD programs are focused on promoting healthy eating behaviors, however, to date, it is not clear how these programs have specifically addressed issues of food security among program participants. To provide clarity on this issue, this systematic review

aims to (1) identify current intervention/outreach efforts being made to address food insecurity amongst underserved populations, (2), determine whether current programs are effectively addressing the health outcomes of food-insecure populations, and (3) examine whether gaps, if any, exists in current program efforts and provide recommendations for program improvement.

Chapter 3: Methods

3.1 Literature Search Strategy (see table in Appendix C)

This review included literature from articles published in the PubMed database that addressed how CMD programs are addressing their food insecure participants. Our literature search strategy included a combination of Medical Subject Headings (MeSH) terms and key words related to cardiometabolic diseases, prevention programs and interventions, and food insecurity. PRISMA guidelines were used to report the systematic review. Figure 1 below provides a summary of the search strategy described above.

Search	Actions	Details	Query	Results	Time
#6	...	>	Search: #1 AND #2 AND #5	1,413	13:12:24
#5	...	>	Search: food insecurity[MeSH Terms] OR food insecurity[tw] OR food supply[tw] OR food desert OR food access[tw]	23,449	13:11:56
#4	...	>	Search: #1 AND #2 AND #3	1,335	13:10:49
#3	...	>	Search: food insecurity[MeSH Terms] OR food insecurity[tw] OR food supply[tw] OR food desert	22,833	13:10:24
#2	...	>	Search: prevention program[tw] OR preventative measures[tw] OR intervention OR lifestyle	9,501,701	13:09:08
#1	...	>	Search: (diabetes mellitus[MeSH Terms] OR diabetes mellitus[tw] blood sugar OR hypertension[tw] OR cardiovascular disease[tw] OR heart disease OR obesity[MeSH Terms] OR obesity[tw])	2,325,839	13:07:59

Figure 1. Data Search Strategy Table

3.1.1 Selection Strategy: Inclusion and Exclusion Criteria used general Cochrane methods that incorporated the PICO (Participants, Interventions, Comparisons, and Outcomes) framework were used for this review where defined research questions were developed, a target population was specified, interventions of interest were identified, and an outcome of interest was specified. Comparison groups were not applicable to the research questions. Specific inclusion and exclusion criteria was developed to determine which studies to include in the review (*5 Defining the Review Question and Developing Inclusion Criteria*, n.d.).

The eligibility criteria for this review looked at four key factors, type of participants, types of interventions, types of outcome measures, and finally the type of study. The inclusion and exclusion criteria are summarized in table 1 below.

We chose not to specify specific outcomes data in our inclusion and exclusion criteria to prevent any limitations in findings. Consequently, outcomes provided included information such as HbA1C levels, body mass index (BMI), fasting blood glucose levels, glucose tolerance, low density lipoprotein, high density lipoprotein, and total cholesterol, improved physical fitness, improved diabetes management, reduced diabetes risks, improved blood pressure, as well as improved food security outcomes.

Parameter	Inclusion Criteria	Exclusion Criteria
Population	<ul style="list-style-type: none"> • Low-income populations • Food-insecure • Any gender • Adults ages 18+ 	<ul style="list-style-type: none"> • Food-secure • Socially and financially advantaged communities
Intervention	<ul style="list-style-type: none"> • Diet programs • Weight-loss programs • Exercise programs • In-Person/ Remote 	<ul style="list-style-type: none"> • None
Comparison	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • None
Outcomes	<ul style="list-style-type: none"> • Any health outcomes 	<ul style="list-style-type: none"> • None
Study Design	<ul style="list-style-type: none"> • English Language • Conducted in the U.S. • Focused on any diabetes, hypertension, CVD, obesity prevention study • Studies conducted since <u>2000</u> • Randomized Control Trials (RCT) • Longitudinal studies (evaluating intervention efforts) • Qualitative studies 	<ul style="list-style-type: none"> • Cross sectional study • Case study

Table 1. Summary of PICOS Inclusion and Exclusion Criteria

The review process started with a literature search. Afterwards, articles were then screened and selected by title and abstracts to identify any relevant studies. Articles that were unrelated to the topic (CMD interventions) or target population or were not written in English were excluded. Handsearching was also performed to identify additional publications that met pre-determined inclusion and exclusion criteria. All selected articles then went through a full-text evaluation to determine eligibility. A flow diagram of the literature search process can be seen in the results chapter in figure 2.

3.2 Data Extraction

Full texts that met inclusion criteria were included in the review. Key information was selected and managed using a Microsoft Excel spreadsheet. Information abstracted included type of study, participant demographics (i.e., SES), intervention (program characteristics - i.e., program type, remote, in-person), methods targeting food insecure populations, outcomes with a focus on underserved populations. For outcomes, we extracted information about pre/post intervention changes in participant characteristics (i.e., baseline BMI, weight, fruit, and vegetable intake, and improved diet). The primary outcomes measured was the mean difference in these health and behavioral outcomes from baseline to endline.

3.3. Quality / Risk-of-Bias Assessment (See tables in Appendix A and B)

In this systematic review, risk of bias and the quality of each article was assessed using some of the indicators provided in the Joanne Briggs Critical Appraisal tool for both qualitative and quantitative studies. Quality of quantitative studies was assessed based on whether the study was a cohort study (longitudinal) or a randomized control trial (RCT). For RCT's, three indicators, were used and these included (1) if randomization was used for treatment assignment, (2) whether outcomes measured in a reliable way, and (3) statistical analysis methods used. Indicators for cohort studies included (1) if the follow-up time reported and long enough to see

outcomes, (2) if groups control and intervention groups were from the same population, and (3) statistical analysis used (Appendix A). Qualitative studies were assessed with the following three indicators, (1) ethics of study, (2) agreement between methodology and research questions and objectives, and (3) the representation of study participants (Appendix B) (*Critical-Appraisal-Tools - Critical Appraisal Tools / Joanna Briggs Institute, n.d.*). Reporting bias assessments and certainty assessment was not calculated.

3.4 Ethical considerations

IRB approval was not needed for this project given human research was not conducted

Chapter 4: Results

4.1 Article Search Findings

The PubMed database search identified 1,425 articles as seen in figure 2 below that included the search terms. Filtering the results to articles in English and published after 2000 reduced the number of relevant articles to 1,364. Hand searching added 3 articles totaling the number of articles to 1,367. Based on titles, 1,328 articles were excluded and of the remaining 39 articles, 25 were excluded after abstracts were reviewed and 3 duplicated were removed. Articles removed based on abstracts failed to include relevant information addressing low-income food insecure populations. Remaining articles were reviewed and studies that were cross-sectional or case studies (n=4), included participants 18 years of age or younger (n=3), or were conducted outside the U.S. (n=1) were removed from further consideration. Three articles met the inclusion criteria for the systematic review.

Key information from each article was abstracted into an Excel database. Study details, participant and intervention demographics, outcomes, and quality assessments across the three studies are presented in Table 2. Two articles are focused on intervention methods that address obesity, diabetes, hypertension, and CVD prevention among Native American populations and one article describes intervention methods involving CDC Diabetes Prevention Programs among low-income, uninsured food-insecure participants in two-free clinics.

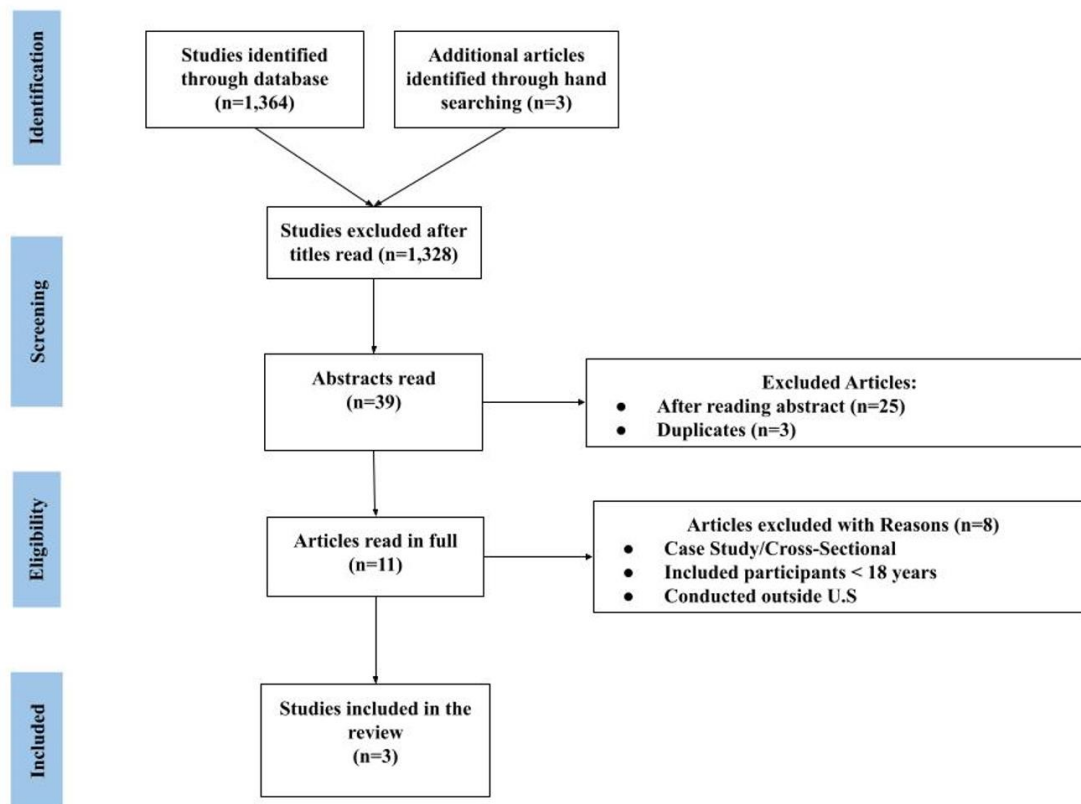


Figure 2. Flow Diagram of the Literature Search Process. This diagram is based on the PRISMA example.

Articles one and two were retail-based interventions (Gittelsohn et al., 2013; *A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.). The first article had a baseline sample size of 276 participants and 145 post-intervention. Participants were predominantly female (~73%) and the mean age was from 46 years (Gittelsohn et al., 2013). The second article conducted interventions

for two Native American Nations (referred to as Nation A and Nation B). The reported baseline sample size for both nations was 1637 and 1204 post-intervention. For both nations, females were the primary participants. In Nation A, 62% of participants were female and in Nation B 70% were female. The median age in Nation A was 40.1 and 42.2 for Nation B (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.) . The third article was a DPP intervention that gathered data on 74 participants (Darnell et al., 2019).

Article one was a randomized- controlled community-based intervention (Gittelsohn et al., 2013). Article two used a two-step implementation process. Step one involved community-based participatory methods and part two involved the use of a clustered-randomized design (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.). Article three was a longitudinal study conducted over a 12-month period (Darnell et al., 2019). Control groups in articles one and two received no intervention, visual aids, or communication material (Gittelsohn et al., 2013; *A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.). Additionally, all interventions were implemented in-person in community-based settings (Gittelsohn et al., 2013; *A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.; Darnell et al., 2019). The three studies fell into one or both of following intervention strategies: (1) Use of communication materials (i.e., visual aids) in grocery stores and (2) improved access to healthier food options. The most common outcomes assessed were changes in consumer purchases, healthy food intake, and weight-loss. Participant demographic data and study-level characteristics are detailed in Table 2 below.

Table 2 – Participant demographics and study characteristics

	Participant Demographics			Study-Level Details		
	Sample Size	Age, years	Sex, % (female)	Study Design	Intervention Strategy	Delivery Settings
Study 1: A Food Store–Based Environmental Intervention Is Associated with Reduced BMI and Improved Psychosocial Factors and Food-Related Behaviors on the Navajo Nation	145	46 ± 16.1	73	Randomized-controlled community-based intervention	Community-based distribution of communication materials Community-based focus on increased accessibility of healthy food options	In-Person
Study 2: A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study	1204	Nation A: 40.1 ± 14.9 Nation B: 42.2 ± 14.6	Nation A: 62 Nation B: 70	Clustered-randomized Control	Community-based distribution of communication materials Community-based focus on increased accessibility of healthy food options	In- Person
Study 3: Addressing food insecurity to support patient success in diabetes prevention programs	74	Not Listed	Not Listed	Longitudinal	Community-based focus on increased accessibility of healthy food options	In-Person

=

4.1.1 How have cardiometabolic prevention programs in the U.S. addressed issues of food insecurity among underserved populations?

One food insecurity intervention discussed in studies one and two was the use of retail-based methods. Study one incorporated a store-region randomized community-intervention in which participants were divided into control and intervention groups. Healthy food items were promoted in stores and intervention groups were exposed to these options. Methods to promote items included cooking demonstrations, food tasting, distributing promotional items, and answering customized questions (Gittelsohn et al., 2013).

The food-insecurity intervention used in study two is a two-step process. The first step used community-based participatory research methods by recruiting Native American residents in each nation to provide a list of potential healthy foods to place in tribal convenience stores. Native American shoppers then participated in food tastings and focus groups to get a better understanding of the types of foods shoppers would prefer. These findings were then used influence pricing and promotion of food items in stores. In step two stores were assigned the intervention, Native American shopper were recruited, and shopping behaviors and eating habits were observed (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.).

The use of food boxes containing diabetes appropriate meals was the food-insecurity intervention used in study three. The article focused on adults enrolled in a DPP adapted program implemented in in two free clinics that incorporated food boxes which were distributed routinely (weekly, bi-weekly, or monthly) to participants during their classes (Darnell et al., 2019).

4.1.2 Different outcomes of cardiometabolic prevention programs.

Study 1, was a 14-month intervention trial called Navajo Healthy Store, involving the inclusions of healthy food options placed and promoted in local grocery stores on reservations (Gittelsohn et al., 2013). Study 2 is an intervention involving two tribal nations (Nation A and Nation B), known as The Tribal Health and Resilience in Vulnerable Environments (THRIVE) study, where a retail intervention in corner stores was used to market healthy food options A *Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d. Study 3 is a longitudinal study measuring outcomes of a CDC National Diabetes Prevention Program adapted program incorporating food boxes conducted at two free clinics (Darnell et al., 2019).

4.1.2.a. Diet Outcomes. We observed dietary changes in each of the three articles. Daily fruit and vegetable intake was recorded and reported as low in both intervention and control groups for both nations A and B from pre to post intervention for study 2. Additionally, in Nation A, pre-post results for the intervention participants showed a small increase in the purchasing of healthy food items. The mean impact was reported as 0.21 [95% CI-1.48-16.99]. In Nation B, there were reports of a small increase in the purchasing of healthy food items. (A *Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.) In study 3, a food recall survey showed additional changes from baseline to programs end for consumption of fruit, salad, and fried potatoes. The survey results are as follows from baseline to 12 months: no fruit (18% vs. 0%), no salad (28% vs. 8%), and no fried potatoes (34% vs. 62%, $p=0.04$) (Darnell et al., 2019).

4.1.2.b. Weight Outcomes. In study 1, for program participants utilizing the Navajo Healthy Stores, there were reports of being overweight at baseline and improvements by endline

where some reported seeing reduction in weight by 0.5%. Furthermore, as exposure to the intervention increase, there were improved odds of reducing overweight or obesity status. The odds of improving obesity status were 5.02 [95% CI-1.48-16.99] (Gittelsohn et al., 2013). Weight loss was also reported in study 3 where the average weight-loss reported for food insecure patients was 4% compared to 2.7% for food-secure patients after 6 months ($p=0.23$) and 5.2% compared to 2.4% at 12 months ($p=0.20$) (Darnell et al., 2019).

4.1.2.c. Other Outcomes. Additional outcomes reported included changes in behavioral practices, BMI levels, and food security status. Exposure to healthy food options promoted in local grocery stores was associated with improved healthy food intentions ($P \leq 0.01$), healthy cooking methods ($P \leq 0.05$) and the procurement of healthier foods ($P \leq 0.01$) in study 1. Furthermore, pre/post BMI changes of -0.4 ($P=0.06$) were reported among intervention participants compared to control groups and increased exposure to the intervention was correlated with significant changes in pre/post BMI levels ($P \leq 0.05$) (Gittelsohn et al., 2013). Other positive outcomes noted were changes in food security status. 55% of participants were reported food insecure at baseline compared to 52.5% at the 6-month follow-up ($p=0.38$) and 46% at 12 months ($p=0.05$) in study 3 (Darnell et al., 2019).

Chapter 5: Discussion

5.1 How Food Insecurity is being addressed among underserved populations

The studies identified demonstrate that current intervention efforts targeting food insecure populations are focused at the community level. Methods such as community workshop discussions that identify healthy food options and explore pathways to promote consumption provided promising ways to use local environmental assets and resources for obesity prevention strategies (Gittelsohn et al., 2013). Additionally, current data shows that tailoring the DPP program to provide diabetes-appropriate healthy food boxes to patients in free clinics can result in health improvements such as weight loss and improved food security status (Darnell et al., 2019). However, given that the study is ongoing, it cannot be said definitively that this intervention can improve diabetes prevention.

Despite the inconclusive evidence described above, other studies investigating diabetes wellness programs including provision of diabetes food boxes to help food insecure patients control hemoglobin A1c levels have shown success (*Healthy Food Box Programs*, n.d.)). One intervention demonstrated both health improvements such as reductions in hemoglobin A1c levels from 8.11% to 7.96% and improvements in self-management practices including increases in healthy food options, specifically fruit and vegetable consumption, improved self-efficacy, improved glycemic control, fewer reporting's of patients having to choose between food or medicine, and higher rates of adherence to medications (Seligman et al., 2015).

5.1.1 Health Outcomes of Prevention Programs

Available evidence shows prevention strategies implemented among underserved populations, specifically Native Americans, can help lower obesity risk and promote weight loss (Gittelsohn et al., 2013; *A Healthy Retail Intervention in Native American Convenience Stores:*

The THRIVE Community-Based Participatory Research Study, n.d.). We also found improvements in dietary behaviors among participants receiving the intervention. Specifically, there were reports of increases in fruit and vegetable purchases compared to participants not receiving the intervention, however consumption remained low among the population from pre to post intervention. Promotional signs and healthy food displays were also associated with an increase in the purchasing of healthy food items (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.). The distribution of food boxes to food insecure DPP program participants was also associated with increases in the consumption of healthy food items (e.g., salads, fruit) (Darnell et al., 2019). Although, the study results shown are promising, either marginal improvements were reported or there was limited outcome data provided underscoring the need to dedicate more efforts to understanding how to best improve behavioral practices that can impact dietary patterns of food insecure clients.

5.1.2 Gaps in current program efforts.

Recent efforts by cardiometabolic prevention programs fail to provide long-term sustainable ways to effectively address food-insecure populations. Therefore, more research needs to be conducted on ways to improve methods addressing food-insecurity to determine how to make programs last long-term. The study of the DPP program is an example of a program that takes a more traditional approach of a food assistance model by simply offering meals to participants (Darnell et al., 2019). Recent studies have shown that recipients of food assistance services often feel disempowered when they receive help in this manner. Example models for how to address and improve this issue include incorporating methods like meal vouchers or medically tailored groceries as this provides the recipient with a sense of autonomy over their food choices (Booth et al., 2018).

Although the provision of meal kits appears to be a successful intervention to combat food insecurity, it is a short-sighted approach to addressing the issue. An alternative, more feasible option could be a method where the DPP study provides meal kits during the first part of the program while using training sessions with clients to provide cooking demonstrations, recipes, meal preparation tutorials, and nutrition education courses so they can practice meal prepping on their own. Furthermore, clinics could form partnerships with local food organizations (local food pantries, local grocery stores, farmers markets) to provide on-site services to connect individuals to food resources and therefore increase access to affordable food options (American Hospital Association, 2017). These options could reduce reliance on meal kits and promote self-efficacy.

Studies 1 and 2 are great examples of feasible, long-term solutions of how future interventions could be implemented. Both utilize the community environment to determine the best way to assist the target population instead of relying on outside sources. In doing so, researchers were able to discover that convenience stores in tribal nations were a great way to not only reach food-insecure Native American populations but findings also allowed researchers to tailor the meals offered to the traditional foods sold in these stores Gittelsohn et al., 2013; *A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d. Despite the feasibility of these studies, it is important to note that additional research must be conducted to better understand how to adapt these interventions in a way that can lead to behavioral changes or modification that result in improved health outcomes.

Another major gap in current program efforts is the limited amount of information provided in studies on health outcomes before information is disseminated. Studies are

incomplete because they fail to use data collected to assess a program's impact on the health status of food insecure populations. Therefore, we are unable to make conclusive arguments of long-term implications of these programs. Furthermore, it makes it challenging to use the methods employed by these programs in future interventions designs due to the limited amount of information provided on health and behavioral outcomes as well inconsistencies across studies in terms of outcomes metrics selected. Thus, there needs to be more detailed data analysis that provides statistics and figures detailing the outcomes of program efforts that target food-insecure clients.

5.2 How Findings Differ from other Literature

The findings observed align with other retail-based interventions (Albert et al., 2017; Ayala et al., 2013) targeting chronic disease, specifically the limited impact on fruit and vegetable intake. However, there are key differences that should be accounted for. Article 1, The Navajo Healthy Store intervention, adapted healthy traditional food options based on the community food environment using community-based participatory research (CBPAR) methods. CBPAR allowed researchers to better understand the needs of the populations and provide the best food options by conducting taste tests and focus groups to identify food preference. Additionally, instead of using the standard approach of recruiting supermarkets to relocate to these communities, the intervention utilized what was considered by program implementers to be a more viable option of using existing corner stores to increase access to healthy food options. Convenience stores received “makeovers” where healthier foods were placed in stores and promotional signs were utilized. Despite the use of CBPAR methods, limited effects in health outcomes were observed. (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d.).

The marginal changes in health behaviors seen should not dismiss the benefits or value that CBPAR methods have but instead highlights the need to incorporate a more inclusive intervention that involves other actors such as local retailers or large chain supermarkets that have the capital and purchasing power to increase access to nutrient-rich foods to food-insecure communities. This addition can help complement foods provided in corner stores (Brown & Sanders, 2007; Albert et al., 2017). Food retailers are said to play a significant role in meeting household food-related needs and help reduce the chances of being food insecure by increasing both the accessibility and affordability of healthy food options. Partnerships with food retailers both small and large-scale, can increase healthy food habits, improve diet quality, and lead to increases of fruit and vegetable purchases (Sneed et al., n.d.). Therefore, retail-based interventions involving partnerships with supermarkets could prove to be a sustainable solution. Local governments can take action to incentivize supermarket development in food-insecure areas using financial incentives such as tax breaks to encourage the construction of these retail stores (USDA, n.d.).

When it comes to interventions targeting diabetes prevention and food insecurity there is limited literature. We only managed to find one article demonstrating the effectiveness of a DPP programs delivery of food boxes to food insecure populations and the health improvements that resulted (Darnell et al., 2019). Consequently, there is limited data with conclusive evidence of successful ways programs have targeted their food insecure participants. Instead, most studies (Torrence et al., 2018; Torres & Schmidt, 2022) are focused on disease management once diagnosed. Practices that diabetes managements programs have adopted include (1) screening for food insecurity, (2) providing nutrition counseling services, (3) assisting with modifications of medications, (4) referring clients to food resources, (5) connecting clients to physicians, (6)

helping clients develop coping mechanisms, (7) and reducing smoking. Patients' assessments and screenings were said to be helpful for tailoring dietary needs and providing appropriate medications to patients. Additionally, there are reports of considerable decreases in hemoglobin A1c levels (18% reduction in patients with hemoglobin A1c above 7%) (Gucciardi et al., 2019).

5.3 Other Findings in the Literature

Other interventions (*Medically Tailored Meals*, n.d.; "Open Hand Atlanta," n.d.; Rising et al., 2021) targeting food insecurity include diet programs that incorporate medically tailored meal delivery (MTM) services. Interventions like this have been developed for food insecure individuals with diabetes. Under this intervention meals are prepared following the guidance of a registered dietician (*Food Is Medicine Coalition*, n.d.). In one such clinical trial called "The Community Servings: Food as Medicine for Diabetes" meals were tailored to address adults 18 and older in the Boston metropolitan area. Recruits had to be diagnosed with type 2 diabetes, have a hemoglobin A1c level greater than 8.0, and be food insecure. Patients received pre-packaged meals weekly meals which including 5 lunches and 5 dinners. The findings demonstrated improved dietary quality among participants, lower food insecurity rates, reduced hyperglycemia levels compared with baselines, and improved mental health status (Berkowitz, Delahanty, et al., 2019).

Food banks are identified as one potential method to address self-management for diabetes, and pilot interventions (Ferrer et al., 2019) have been created to support low-income food insecure populations. The Feeding America network, a non-profit hunger relief organization, has successfully partnered with food pantries in Texas, California, and Ohio to provide diabetes support by providing diabetes screening services, preparing, and distributing pre-packaged diabetes food boxes to households bi-monthly supplies and recipes to last one to

two weeks, providing educational courses, and referring participants to primary care providers (Seligman et al., 2015).

In 2020, Feeding America used these food bank-based intervention methods to improve community food distribution to both English speaking and Spanish speaking clients with high risk for diabetes in Oakland California. By the middle of the program, participants reported considerable improvements in food security status, dietary habits, exercise, mental health status (depression scores), and overall health. The proportion of households reporting skipping meals decreased from 43.6% at baseline to 29.3% by the program's midpoint. Participants reported increases in physical activity from 95.6 to 145.1 minutes. Additionally, those who reported physical activity once a week or more increased from 62.5% to 80.7%. The proportion of individuals reporting poor to fair health was also reduced from 73.9% to 60.1%. Finally, participants reported increased intake of salads, legumes, whole grains, fruits and vegetables and the decreased consumption of oily foods, sugary drinks and desserts (Cheyne et al., 2020).

Similar to food banks, food pantries are also used as a way to overcome food insecurity in studies (Bertmann et al., 2021; Seligman et al., 2022). The key difference between the two is that food banks are organizations that collect and store large amounts of food from food industries and distribute it to different entities like soup kitchens or food pantries which are “self-governing” agencies that distribute food directly to the community (*Food Bank vs. Food Pantry* « *Food Bank*, n.d.). In a study reporting on sodium content in food pantries, 7 of the 11 pantries reported practices to improve visibility of healthy food options (i.e., new lighting over food options), 11 improved convenience of food arrangement (i.e., offered proper spacing of foods for easy access), 6 changed placement, ordering, and priming (i.e., offered healthy foods at multiple points in stores), 5 used signage (i.e., used banners and posters to showcase fresh produce), 3

provided recipes, and 3 held cooking demonstrations. Additionally, 12 of the pantries adopted food pantry nutrition policies to promote health and nutrition. Policy implementation included emphasizing healthy foods (n=9), increasing variety of health food options (n=7), having minimum requirements for the amounts fruits and vegetables in pantries (n=7), and ensuring a proper budget was in place for purchasing healthy foods (n=7). Pantries reported offering a greater proportion of low sodium options, however these options were said to be distributed to recipients in small amounts. The study provided a general overview of the methods that would be used to improve access to healthy food options, however, the study did not report any findings of its impact on health outcomes for food insecure individuals that utilize pantries (*Healthy Food Environments in Food Pantries: Lessons Learned from a Sodium Reduction Intervention*, n.d.).

Despite the lack of health outcomes in this study, there are several ongoing studies using food pantries to address food insecurity that show promising results. There is evidence demonstrating that food pantries that apply healthy food initiatives like the one mentioned above help increase fruit and vegetable consumption, improve food security, and lead to improved diet quality (*Healthy Food Initiatives in Food Pantries*, n.d.). A pantry-based study was conducted in Illinois to evaluate outcomes of two food pantries, one using traditional methods and one arranging items to showcase healthier food options. Behavioral outcomes reported included an increased uptake of fruits, vegetables, nuts, and dairy products. The positive outcomes demonstrated highlight the potential benefits that could result food pantry-based interventions food insecure populations (Grabow et al., 2020).

Healthy food incentive programs that utilize produce vouchers are another potential method or intervention to address food insecurity (Cavanagh et al., 2017; *Keiki Produce Prescription (KPRx) Program Feasibility Study to Reduce Food Insecurity and Obesity Risk*,

n.d.) The Brighter Bites Produce Voucher Program was created during the COVID-19 pandemic as a collaboration between retail stores and non-profit organizations to assist food-insecure low-income families in five cities across the U.S. Produce coupons were sent bi-weekly to homes of program participants. Similar programs have been implemented across the U.S. including the Utah Double Up Food Bucks Program or DC Greens grocery retail produce prescription program (where partnerships have been made with local farmers markets (Durward et al., 2019; *Produce Rx*, n.d.).

Food incentive programs like these are known to result in positive behavioral outcomes such as an increased consumption of fruits and vegetables, healthier eating habits, and reduced food insecurity. Despite the promising outlook of the Brighter Bites Produce Voucher Program, the study lacked sufficient evidence demonstrating improvements or changes in health outcomes of program participants. However, a strength of the program is its ability to involve multiple stakeholders and form partnerships with both local and nationwide supermarket chains. Consequently, this can allow for the program to be easily expanded, possibly making this a feasible and sustainable intervention (Haidar et al., 2021).

Digital-based intervention are another method that has been used to address food insecurity (Gomes et al., 2021). A recent study was conducted to create and design a “user-centered” digital intervention to address binge eating and weight-management among food insecure individuals. Program participants were over 18 years old, reported 12 or more episodes of binge eating over a 3-month period, and had a high BMI index that categorized them as obese ($\geq 30 \text{ kg/m}^2$). Semi-structured interviews were conducted among selected participants and findings revealed that a successful digital intervention would provide customized options to

accommodate user's lifestyle, budget, dietary needs and preferences, and schedules (Venkatesh et al., 2021).

Other preferences included accessibility of the program by offering it on multiple types of devices (e.g., computer, cell phone). In addition, participants requested the inclusion of recipes that had ingredients that could be used to make multiple meals as well as providing a list of food options that would allow them to purchase healthy foods with food stamps and having grocery-delivery services options. The final feature that participants requested was the incorporation of educational sessions on healthy lifestyle choices including ways to manage and avoid binge eating. The needs-based assessment conducted in the study provided great insight into ways to develop and design a digital-based solution to best accommodate the needs of the community. Although it can serve as a model for future programs, similar to other studies the study lacked evidence documenting of how program implementation impacted health outcomes and behaviors (Venkatesh et al., 2021). Therefore, there is an urgent need for more studies to be conducted that provide health outcomes data on technology-based interventions.

5.4 Strengths and Weaknesses of the Analysis

There are several limitations to this systematic literature review. First, the number of articles included in the analysis is small (N=3), suggesting a need for more research in this area and making it difficult to describe patterns, successes, and challenges in this body of work. Secondly, regarding article selection, the systematic review only used peer reviewed articles and did not incorporate information existing in grey literature or reports. An alternative search strategy could have accounted for these sources. In addition, articles were only searched for in one scientific database, which may have limited access to articles related to the research questions. Generalization or transferability of the articles is another limitation of this review. The

sample sizes of the studies included were relatively small, outcomes were measured using different metrics, and studies lacked participant diversity, therefore generalization to a large population is not feasible (Sulaiman et al., 2021). Additionally, the populations in each study were highly tailored to specific groups (i.e., Native Americans), therefore, we can only understand how interventions can be adjusted to better help these specific populations and results cannot be applied to a nationally representative sample. Despite these limitations, the findings included in this systematic review provided possible ways for cardiometabolic prevention programs to address food insecure clients: encouraging community engagement/involvement, utilizing available community assets for interventions, and facilitating collaboration between food bank networks and prevention programs.

5.5 Public Health Implications

Lifestyle changes, promoting healthy eating and physical activity, are the recommended clinical guidelines for cardiometabolic disease prevention (CDC, 2021). Our analysis demonstrates that multicomponent interventions that acknowledge community food environments and supplement high-risk groups with healthy food options result in marginally improved health outcomes, specifically reduced BMI, and weight loss, thereby lowering the risk of chronic diseases such as obesity and diabetes (Gittelsohn et al., 2013). The Diabetes Prevention Program tailored program also demonstrated that improved dietary intake also showed reduced risk of disease progression. Food insecurity rates declined 2.5% and weight-loss among food-insecure clients went up 1.2% from baseline to post-intervention. These positive outcomes, although marginal, can be used as a guide to implement future interventions on a wider scale.

5.6 Recommendations

The studies included in this review provide evidence for potential ways to address food insecurity among food insecure clients participating in cardiometabolic prevention programs. There is not one single solution that is sufficient to solve the issue, but instead the use of multiple methods is critical to improving the health outcomes of this target group. Firstly, community-based participatory methods that involve multiple actors within the community environment (e.g., local residents, supermarkets, corner stores, churches) could be a promising way to improve health behaviors based on evidence showing its usefulness in increasing fruit and vegetable intake, and supporting healthy diets and weight management for food-insecure program participants (Coughlin & Smith, 2017; Sneed et. al).

Secondly, increasing research efforts around chronic disease prevention among food insecure populations could help identify additional methods that could be used to improve the health status of food insecure clients while also increasing knowledge about this unique topic. Some popular interventions that could be beneficial include the use of medically tailored meals or food incentive programs, establishing proper infrastructure in communities, and using digital or virtual options. A final method that is commonly cited for disease management but could be tailored to disease prevention, are efforts focused on implementing policies that connect clients with nutrition assistance specifically food pantries (Berkowitz et al., 2017).

The following sections expand on the methods found in the literature discussed above. The sections provide additional examples of how the previously listed interventions could be incorporated into prevention programs to potentially help address the challenges faced by food insecure clients.

5.6.1 Implementing a Community-Based Approach

The involvement of community members in program interventions has been shown as a successful way to develop policy-level solutions that are sustainable. There are research articles documenting the benefits of community-based participatory research (CBPAR) methods to address food insecurity (Jarrott et al., 2019). Additionally, CBPAR methods are said to incorporate community assets and knowledge while also empowering community members by treating them as equals in the planning process (Holkup et al., 2004).

One Study called the Healthy Options intervention used CBPAR methods to increase access to healthy food options by providing community members with vouchers to farmer's markets and having them participate in community activities including community gardening, cooking classes, farm tours, health fairs, classes geared towards starting food-based business, and specified days with activities for children. The program resulted in improved eating habits in households. Results at the programs end reported an increase in fruit and vegetable consumption by 55% compared to baseline (Dailey et al., 2015).

5.6.2 Standardizing Future Research Efforts

More research efforts and activities pertaining to cardiometabolic prevention programs and food insecure clients should be encouraged to improve current efforts in programs. The systematic literature review addressed the gaps in literature that exist around this issue. Data is missing for many low-income underserved food-insecure communities. Additionally, there is limited data showcasing ways to adapt current efforts into long-term sustainable practices. Researchers must be mindful of this limited evidence when planning and implementing future studies to address these gaps in knowledge

It is also important to note the need to increase the number of studies demonstrating improvements in health outcomes given the limited data we have on this information before

information is disseminated. Article 2 mentions slight changes in health behaviors among program participants, however it did not mention how these changes could be translated to reductions in disease or improvements in health outcomes (*A Healthy Retail Intervention in Native American Convenience Stores: The THRIVE Community-Based Participatory Research Study*, n.d). Articles 1 and 3 discuss only marginal improvements in health outcomes, with article 1 stating that extended participation in the program being necessary to see any significant reductions in obesity risk (Gittelsohn et al., 2013; Darnell et al., 2019). Therefore, it would be beneficial to have a greater number of articles documenting how behavioral modifications and changes could result in improved health outcomes as it could make the study more reliable.

5.6.3 Medically Tailored Meals

Experts have noted that medically tailored meals (MTMs) have been helpful for decreasing food insecurity and improving overall health. For 50 years Meals on Wheels has provided MTMs to seniors that are homebound. As a result, there has been improvements in diets and a higher reported quality of life (*Meals on Wheels Health*, n.d.) Based on this success, medical experts encourage the use of these meal services to patients with chronic diseases (*Improving Health Outcomes While Curbing Costs with Medically Tailored Meals*, n.d.). A 2017 study in San Francisco provided MTMs according to American Diabetes Association recommendations over a 6-month period to food-insecure or “nutritionally at-risk” patients. Findings demonstrated improvements in diets where patients reported increased intake of fruits and vegetables and decreased consumption of foods with high fat and sugar content. Patients also reported improved mental health status, decreased BMI and hemoglobin A1c levels, fewer visits to the emergency room, and less hospitalizations (Rabaut, 2019).

5.6.4 Food Incentive Programs (Vouchers)

Food vouchers are another potential intervention to improve food insecurity and increase access to healthy food options. In a recent study, participants were given monthly vouchers to spend at their local farmers markets. Findings revealed increases in fruit and vegetable intake. (Dailey et al., 2015) Similarly, in 2015, Vouchers 4 Veggies (V4V), the largest produce prescription program in the US, was launched in San Francisco to address low-income, food-insecure black indigenous and people of color (BIPOC). Participants were given \$20-\$40 a month based on the size of their household for 6 months. Results showed improvements in food insecurity, participants having better eating habits and better health, and increases in stores produce sales. Bases on the program's success, V4V has been copied and implemented in multiple cities across the country (*Healthy Food Vouchers - San Francisco, CA, n.d.*)

5.6.5 Addressing Infrastructure Challenges

Implementing programs that address flaws in local food systems could be a great way to ensure an adequate food supply for food insecure individuals. In Massachusetts, a collaborative effort was made among several stakeholders including the Department of Agricultural Resources and the Department of Fish and the Department of Public Health to create a program called the Food Insecurity Infrastructure Grant Program. The program helps connect farmers with local food producers to create sustainable food systems to ensure that community members have access to food options that are locally produced. The program incorporates urban farms, community and food organizations, community gardens, fisheries, corner stores, and other local food system businesses. These partnerships help provide a way to maximize the production and distribution of food in an equitable manner in the community. Given that this is a new program, no evidence has been provided demonstrating the programs impact on individual food consumption (Theoharides, 2021). There is literature advocating for similar food systems

interventions where there would be a collaboration between producers, retailers, and the government to improve food access for food insecure residents but due to the lack of outcomes listed, further research is needed to examine how improvements in infrastructure addresses the health needs of food insecure populations (Mui et al., n.d.).

5.6.7 Digital Interventions

Technology based methods could overcome some food insecurity challenges, especially in modern times where internet and smartphone access has increased. The Pew Research Center reports that many adults in low-income households own a smartphone (NW et al., n.d.). Consequently, experts note that there has been an increase in “health-technology partnerships” to increase access to food for food-insecure families (Phan et al., 2018). With the growing number of adults in the US with smartphones (85%), digital interventions appear to be a feasible option to address food insecurity (Venkatesh et al., 2021). We see one example with the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) where program participants can use applications (apps) on their smartphones to see if food items can be purchased using WIC benefits. Additionally, they can enroll in and complete nutritional education courses online. The US Department of Agriculture (USDA) has a similar program for SNAP recipients where it implemented a 2-year pilot program in 7 states allowing SNAP recipients to buy groceries online. The tool is said to be beneficial for individuals living in rural communities where access to healthy food options is poor. The program has partnered with retail stores including ShopRite Supermarkets, Safeway Inc. and Amazon. SNAP clients are also eligible for a 45% discount on Prime memberships to ensure free shipping of food items. (Phan et al., 2018). No health outcomes were provided for the studies listed. Instead, there was a focus on online purchases and ways to make improvements to increase use of apps (*USDA ERS - SNAP Online*, n.d.; Zimmer et al., 2021) Other food interventions that utilize technology include the

non-profit organization known as Food Connect. Since 2015, the organization has provided hunger relief solutions to address food insecurity in underserved communities and in 2020, they have begun at home delivery services to address food insecurity challenges associated with the COVID-19 pandemic. The Food Connect mobile application helps organizations schedule food donations by helping coordinate hunger relief efforts so that individuals in need of food can be matched and food can be distributed to them quickly. For example, they aggregate food shelter data onto maps so that they can organize requests for food pick-ups and deliveries. In 2020, Food Connect partnered with the Children’s Hospital of Philadelphia and food organization Common Market to deliver produce to households that are food insecure. 389 families were provided fresh produce including fruits and vegetables for 16 weeks. With Food Connects technology, 4,770 food boxes were delivered to homes. Participants ranked services highly, with 81% reporting satisfaction with food quality, however, there was no documentation of improvements or changes in health outcomes or health behaviors (Garcia et al., 2021) Despite the improvements in food access shown with these digital interventions, future research needs to be conducted to address how technology-based methods can improve health outcomes to make this a more feasible option.

5.6.8 Upscaling Food Pantry Efforts

Recently there has been increasing recognition in the role that food pantries play in addressing food insecurity. Food pantries have greater food access and distribution capacities (reach nearly every US county, especially underserved communities) making them a potential way to address the challenges faced by food-insecure clients (Seligman et al., 2015). Food pantries have a history of distributing donated foods and groceries to food insecure populations (Bazerghi et al., 2016). For example, food pantries have provided “diabetes appropriate” meals to households when food is scarce (Seligman et al., 2015). Therefore, prevention programs could

potentially partner with these local food pantries and have a budget allocated to food banks for the preparation and distribution of healthy meals on a routine basis for this high-risk population. The collaborative effort could maximize efforts and lead to improved health outcomes and as well as program adherence.

It is important to note that access to food pantries alone may not result in positive health outcomes. Some studies (Eicher-Miller, 2020; *Food Insecurity, Poor Diet Quality, and Obesity among Food Pantry Participants in Hartford, CT* | Elsevier Enhanced Reader, n.d.) reported high prevalence of chronic diseases among food pantry clients. However, a food pantry intervention that incorporates or combines nutrition education, supplemental foods and recipes, glucose monitoring for diabetics, and patient referrals could lead to improved health outcomes such weight loss among food pantry clients (Eicher-Miller, 2020).

5.7 Conclusions

Cardiometabolic disease continues to be the leading cause of morbidity in the U.S and researchers suggest that controlling risk factors, specifically food insecurity can reduce morbidity rates (Berkowitz, Basu, et al., 2019). The findings in this systematic review highlight the need for further exploration for how cardiometabolic prevention programs address food insecure participants. Further, there is insufficient data to say definitively that the interventions found are the best ways to address this growing issue. Additional longitudinal studies are needed to help determine the long-term effects of interventions. The findings revealed that community-based interventions at convenience stores might be the best method to address food insecurity for Native American populations. However, it is important to be mindful that this solution may not be applicable or effective for other underserved populations previously mentioned (i.e., African

Americans and Hispanics). With the information found, more context-specific interventions need to be implemented to determine the best ways to help other populations.

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Appendix A

JBI Critical Appraisal Checklist for Cohort Studies and Randomized Control Trials	
Randomized Control Trial	
Questions	Response (Yes, No, Unclear)
(1) Was randomization used for treatment assignment?	
(2) Were outcomes measured in a reliable way?	
(3) Was correct statistical analysis used?	
Cohort (Longitudinal)	
(1) Were the two groups recruited (control and intervention groups) from the same population?	
(2) Was the follow-up time reported and long enough to see outcomes?	
(3) Was correct statistical analysis used?	

Checklist for Cohort Studies and Randomized Control Trials. Adapted from JBI by University of Alelaide. Retrieved March 15, 2022, from <https://jbi.global/critical-appraisal-tools>

Appendix B

JBI Critical Appraisal Checklist for Cohort Studies and Randomized Control Trials	
Questions	Response (Yes, No, Unclear)
(1) Is the research approved as an ethical study?	
(2) Is there agreement between methodology and research questions and objectives?	
(3) Is there adequate representation of study participants?	

Checklist for Qualitative Research. Adapted from JBI by University of Alelaide. Retrieved March 15, 2022, from <https://jbi.global/critical-appraisal-tools>

Appendix C

PRISMA 2020 Checklist

	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title Page
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract Page
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	1
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	16
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	15
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	15, Figure 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	15-16, Table 1 1
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	17
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	17
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	17
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	17-18
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	17
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	17
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	18
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	17
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence	17

	Item #	Checklist item	Location where item is reported
		and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	18
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	18
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	19-20, Figure 2
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	19
Study characteristics	17	Cite each included study and present its characteristics.	19-22, Table 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	N/A
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	24-25
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	N/A
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	24-25
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	26-31
	23b	Discuss any limitations of the evidence included in the review.	35-36
	23c	Discuss any limitations of the review processes used.	35
	23d	Discuss implications of the results for practice, policy, and future research.	36
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	N/A
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N/A

	Item #	Checklist item	Location where item is reported
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	N/A
Competing interests	26	Declare any competing interests of review authors.	N/A
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

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