The Impact of Sodium Reduction on Cardiovascular Disease (CVD) Primary and Secondary Prevention: An Umbrella Review

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Abstract

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Background: The impact of dietary interventions in primary and secondary prevention of cardiovascular diseases is not well synthesized. **Specific aim:** To determine the health benefits of sodium reduction interventions by comparing primary prevention versus secondary prevention. **Data source:** PubMed from January 1, 2010, to January 21, 2025. **Study selection:** Systematic reviews and meta-analyses (SRMAs) of randomized controlled trials (RCTs) and cohort studies that explored the impact of sodium reduction interventions on our targeted outcomes: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart failure (HF), cardiovascular diseases (CVD) incidence, and CVD mortality. **Data Management:** COVIDENCE. **Data Synthesis:** We screened 425 titles and abstracts and included 10 SRMAs in our umbrella review. In primary prevention, we found that the dietary approaches to stop hypertension (DASH), Sodium-reduced Diet, Sodium Substitution by potassium, and Mediterranean Diet reduce SBP and DBP among normotensive and hypertensive populations. Similarly, the Japanese Diet and DASH were found to be effective in reducing the risk of CVD in general and stroke. In secondary prevention, despite the low quality of the SRMAs assessed by the Modified AMSTAR-2 tool, our review reported a significant impact of the Mediterranean Diet on risk reduction among populations with existing cardiovascular disease conditions and CVD mortality. **Conclusion:** Sodium reduction interventions could contribute to reducing the global burden of cardiovascular diseases. Besides the Sodium-reduced Diet and Sodium Substitution interventions, food-related interventions can contribute to preventing cardiovascular diseases through both primary and secondary strategies.

Introduction

Every year, cardiovascular diseases (CVDs) claim the lives of 17.9 million people, making them the main drivers of death worldwide (World Health Organization, 2025). To date, the leading CVDs-related deaths are ischemic heart disease (185,000,000 DALYs) and strokes (intracerebral hemorrhage (78,6000,000 DALYs), ischemic stroke (70,200,000 DALYs), subarachnoid hemorrhage (10,400,000 DALYs)), which occur prematurely among people under age 70 (World Health Organization, 2025; Vaduganathan et al., 2022). Additionally, heart failure, the severe and end clinical stage of most CVDs, has emerged as a significant global health issue and the leading cause of admission among patients aged 65 and above, with an estimate of 83% for a minimum of one time, and an estimate of 43% -at least four times among patients with a chronic heart failure, which has a significant economic impact on countries worldwide (Liu et al., 2025; Savarese et al., 2022; Mozaffarian et al., 2016).

CVDs encompass a group of diseases that arise from the intricate interplay of various risk factors (Hobbs, 2004), the exploration of which has laid the foundation of prevention strategies. The modifiable risk factors for CVDs are classified into three categories: environmental, behavioral, and metabolic risk factors (Vaduganathan et al., 2022). To mitigate the impact of CVDs, several preventive strategies targeting risk factors have been identified. Among them are the primary and the secondary prevention. While primary prevention consists of implementing interventional schemes to alleviate risk in high-risk individuals who have not yet developed the disease, secondary prevention focuses on lowering the risk in patients with existing CVDs (Hobbs, 2004). Essentially, CVDs prevention strategies focus on metabolic and behavioral risk factors throughout a person's lifespan, with specificities unique to secondary prevention. The approach for preventing behavioral risk factors consists of smoking cessation, regular physical exercise, weight control, and a healthy diet (rich in fruits, fish, nuts, whole grains, vegetables, legumes, and vegetables decreased in sodium, alcohol, and fat) (Thakkar et al., 2021; Mozaffarian et al., 2016; Hobbs, 2004). On the other hand, the control of metabolic factors involves managing high blood pressure (HBP) (BP < 130/80 mmHg), cholesterol management (with a focus on LDL-C), and diabetes management (HbA1c < 7%). While controlling behavioral and metabolic risk factors is common in both primary and secondary prevention, the additional layer typical of secondary prevention involves treating existing cardiovascular diseases (CVDs). Hence, evidence-based strategies recommend the association of Beta Blockers in people with myocardial infarction, Angiotensin-converting enzyme (ACE) inhibitors in CVDs patients in post-myocardial infarction with a dysfunction of the left ventricle, and the introduction of antiplatelet therapy in older patients with atrial fibrillation and all coronary artery disease (CAD).

Among the risk factors, HBP (209,000,000 DALYs) is the leading risk factor and the main cause of premature deaths (Vaduganathan et al., 2022). In 2021, the number of CVDs and HBP-related deaths amounted to 10.8 million, with an overall death estimated at 11.3 million. The exploration of the factors influencing HBP pointed to excessive sodium intake, a diet component of behavioral risk factors, as the significant driver of hypertension in many countries, centering the preventive strategies of CVDs around the reduction of sodium intake.

Excessive sodium intake-related deaths are estimated to be 1.89 million annually in adults; the World Health Organization (WHO) recommends a daily dietary sodium intake of below 2 g (World Health Organization, 2023; Powles et al., 2013). Worldwide, the average sodium intake is estimated at 4g/day, which is twice the international standard (Powles et al., 2013). The WHO recommends a set of best-buy policies to achieve this target. They include product reformulation, labeling front of packs, mass media campaigns, and public food procurement and service policies (World Health Organization, 2023). Several systematic reviews and meta-analyses (SRMAs) of randomized controlled trials (RCTs) or cohort studies have evaluated the impact of sodium consumption reduction on the primary and secondary prevention of CVDs. To the best of our knowledge, no study compares the effects of sodium reduction interventions in primary and secondary prevention. The current research is an umbrella review of SRMAs that compares the impact of sodium reduction interventions in primary and secondary prevention of CVDs.

Methods

Literature Search

We searched systematic reviews and meta-analyses (SRMAs) of randomized control trials (RCTs) and cohort studies with no geographical limitation, focusing on the impact of sodium-related diet improvement (dietary sodium, Dietary Approach to Stop Hypertension (DASH)) or salt substitutes on blood pressure (Systolic and diastolic blood pressure), CVDs, including ischemic heart disease, strokes (ischemic stroke, intracerebral hemorrhage, subarachnoid hemorrhage), and hypertensive heart disease, in PubMed from January 1, 2010, through January 21, 2025. With a language restriction to English and French, we utilized MeSH terms to combine keywords that can help explore the review question. We combined the terms "sodium," "salt," "diet," "hypertension," and "cardiovascular diseases" and their synonyms to identify relevant articles (**complete search strategy in Appendix Table 1).** We managed the literature retrieved from PubMed using COVIDENCE, a web-based software, where we conducted title and abstract reviews, full-text reviews, and data extraction. The title and abstract review, as well as the full-text review, were performed independently by three reviewers (K.T.T., N.J., Q.L.). All conflicts were resolved via consensus.

Study Selection

We used the PICOS (Population, Intervention/Exposure, Comparator, Outcome, and Study Characteristics) framework to identify eligible studies. Hence, we considered as 1) **Population**, participants from 18 years and older in studies focusing on people without CVDs in the primary prevention and people with CVDs in secondary prevention; 2) **Intervention/exposure**, studies that assess the effects of sodium reduction interventions, including structured dietary regimens like DASH Diet, the use of salt substitutes, and general dietary improvements aimed at lowering overall sodium intake; 3) **Comparator**, control group maintaining usual dietary sodium intake; and 4) **Outcome**, Systolic Blood Pressure (SBP), Diastolic Blood pressure (DBP), or both, cardiovascular diseases (CVDs) and CVD mortality. As **Study Characteristics**, we included meta-analyses and systematic reviews of randomized controlled trials (RCTs) and prospective cohort studies. Only papers published over the past 15 years were included. We included papers with a minimum follow-up period of 4 weeks for randomized controlled trials (RCTs) and 1 year for cohort studies. Additionally, we reported studies that measured 24-hour urine sodium (24H UNa) excretion, which assesses sodium intake, and 24-hour urine potassium (24H UK) excretion for studies focusing on the sodium substitute potassium.

Data Extraction and Quality Assessment

Two reviewers (K.T., N.J.) extracted data for all studies that adhered to the inclusion criteria and performed the quality assessment using COVIDENCE.

Data Extraction

The data to extract from each study included the study characteristics (first Author's name, publication year, country, number of studies included, follow-up time, type of study: SRMA RCT, SRMA/Cohort studies), the population (number of participants, health condition: normotensive, hypertensive, CVDs, CVD Mortality, Comorbidity, Age), type of prevention (primary prevention, secondary prevention), Intervention (type of intervention: Sodium-reduced Diet, sodium substitution, food-based interventions (DASH, Mediterranean Diet, Japanese Diet), the follow-up time, outcomes (SBP, DBP, CVDs, CVD mortality), the comparison type (regular diet), Effect size (pooled mean difference, odds ratio (OR)/ relative risk (RR)/ Hazard Ratio (HR), 95% confidence interval (CI)), and the comorbidities.

Quality Assessment

We evaluated the methodological quality of the SRMAs included in the study using the Modified AMSTAR-2 (Shea et al., 2017; Swierz et al., 2021; Talukdar et al., 2023; Yang et al., 2024). Our Modified AMSTAR-2 considered a total of 17 criteria. Among them are 9 non-critical criteria and 8 critical criteria. Among the critical criteria are 1) the protocol registration, 2) the appropriateness of the literature review, 3) Rationalization of the excluded studies in the study, 4) Report of the assessment Risk of bias for studies included in the review, 5) appropriateness of the meta-analyses methods, 6) consideration of the risk of bias during results report, 7) Publication bias assessment and potential impact 8) Report of the effect size. After the assessment, we rated the included paper in 4 categories: high, moderate, low, and critically low.

Data Analysis

We organize the data extracted by prevention categories, primary and secondary prevention, and outcome groups, such as SBP and DBP for primary prevention and CVDs for secondary prevention. To display the impact of the different sodium reduction interventions on these outcomes, we opted for a Forest plot to visually represent the magnitude of the effect sizes across the studies using the Metaphor package in R version 4.5.0. For studies reporting effect measures in OR or HR, we conducted a random-effects model analysis to calculate the RR using the original data (number of events and non-exposed) if available.

Results

Study selection and study characteristics

The initial search in PubMed database yielded 425 studies. The removal of duplicates reduced the number of screened studies to 422, of which we excluded 350 and identified 72 SRMAs that adhered to the inclusion criteria. After the full-text review, we included 10 eligible studies for our umbrella review (**Figure 1**)

Appendix Tables 2, 3, and 4 report the characteristics of the included studies. Among the studies categorized in primary prevention, the DASH intervention was the most frequently reported (n = 5), followed by the Sodium-reduced Diet (n = 2) and

Sodium Substitution (mixing potassium and minerals), as well as the Mediterranean Diet and the Japanese Diet, which were each reported once. In secondary prevention, a Sodium-reduced Diet (n = 1) and a Mediterranean Diet (n = 1) were the main interventions.

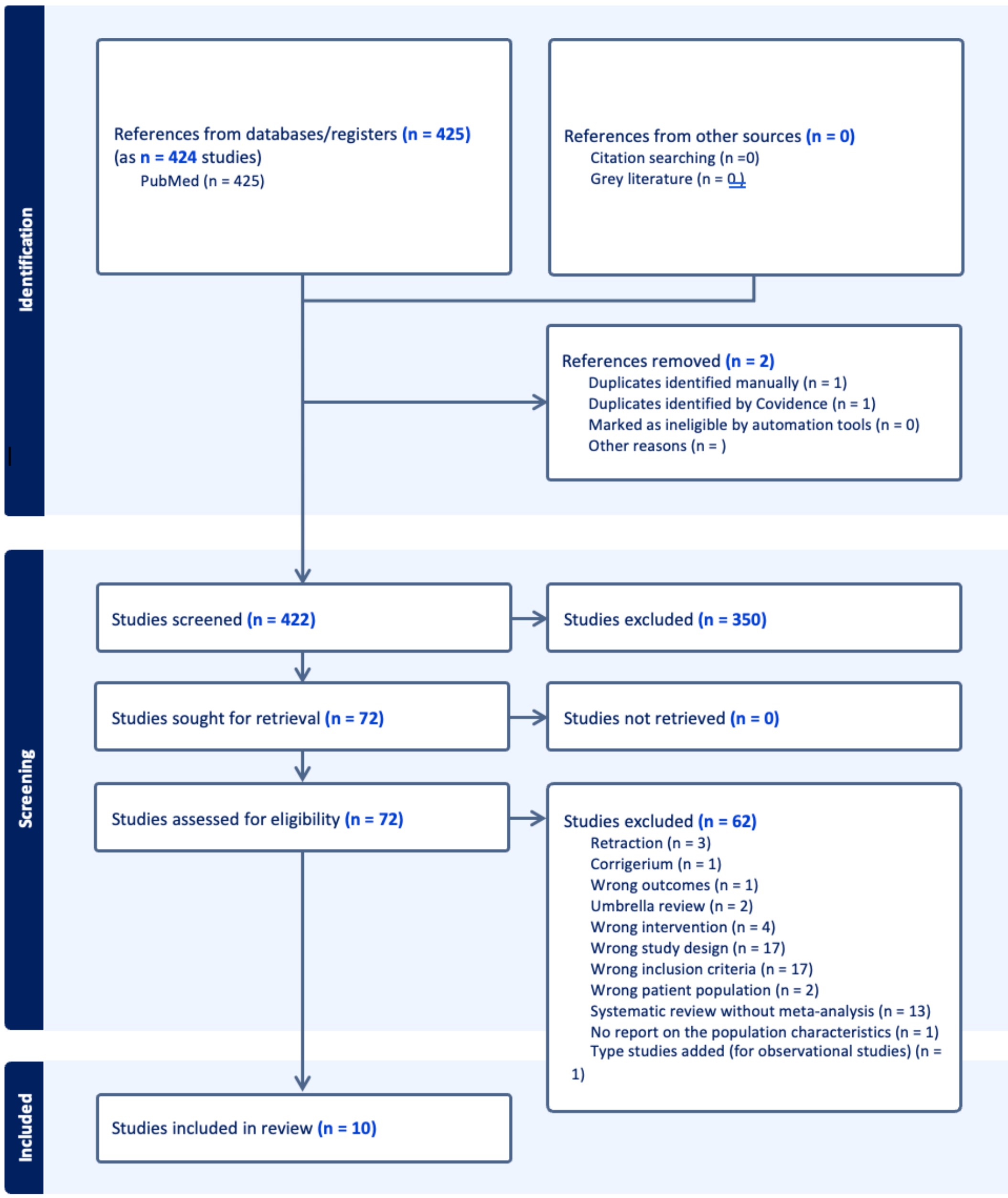

Figure 1: Flow Diagram of Selection Process

Regarding outcomes, we reported SBP (n= 5) and DBP (n= 5), CVD (n= 2), stroke (n=2), ischemic heart disease (n= 1), heart failure (n= 1), CVD mortality (n= 1), stroke mortality (n= 1), and ischemic heart disease mortality (n= 1) in primary prevention. In secondary prevention, we included studies on stroke (n = 1), Ischemic Heart Disease (n = 1), heart failure hospitalization (n = 1), and CVD Mortality (n = 1).

Methodological Quality

Based on the Modified AMSTAR-2 instrument used to assess the quality of the papers included, the quality of the papers was high for 2 reviews, moderate for 1 review, low for 1 review, and critically low for 3 reviews. We primarily observed limitations, including the lack of registration, the absence of a rationale to substantiate the exclusion of studies, the failure to investigate publication bias and its potential impact on the SRMAs' results, and the non-reporting of the source of funding for the included studies. **Appendix Table 5** summarizes the Modified AMSTAR-2 assessment for each study.

Primary prevention

In primary prevention, seven (7) studies evaluated the impact of sodium reduction interventions on SBP, DBP, and CVDs. According to the Modified AMSTAR-2, we rated two (2) SRMAs high, two (2) as Low and Critically Low, and one (1) as Moderate **(Appendix Table 2 and Table 3).** Studies included were SRMAs of RCTs and SRMAs of cohort studies, most of which enrolled normotensive and hypertensive patients as well as the general population with multiple cardiovascular risk factors.

Systolic Blood Pressure

Figure 2 summarizes SRMAs exploring the primary prevention outcome, Systolic Blood Pressure.

Three (3) studies using DASH intervention reported its impact on SBP. A high-quality review by Filippou et al. (2020), including 30 RCTs, reported a decrease of -3.2 mm Hg (95% CI: -4.2, -2.3). The SRMA with low quality, Guo et al. (2021), focusing on hypertensive participants, found that DASH intervention induced a reduction of SBP of –3.26 mmHg (95% CI: -5.58, -0.94), while the critically low review, Gay et al. (2016) reported a decrease of -7.62 mmHg (95% CI: -9.95, -5.29).

A Sodium-reduced Diet intervention was reported in 2 reviews with different quality scores. The moderate quality SRMA, He et al. (2013), reported a decrease of SBP of -4.18 mmHg (95% CI: -5.18, -3.18). Meanwhile, in the second review, which scored critically low quality, Gay et al. (2016) observed a reduction of -2.06 mmHg (95% CI: -3.50, -0.63). Two (2) SRMAs reported respectively on sodium substitution and the Mediterranean diet. The review on the sodium substitution intervention Greenwood et al. (2024), using potassium as a substitute for sodium, a high-quality SRMA, reported a significant decrease in SBP of 5.12 mmHg (95% CI: -6.72, -3.52). An intervention that explored the impact of the Mediterranean diet on SBP, as observed by Gay et al. (2016), showed a slight reduction in SBP, estimated at -1.17 mmHg (95% CI: -2.28, -0.46).

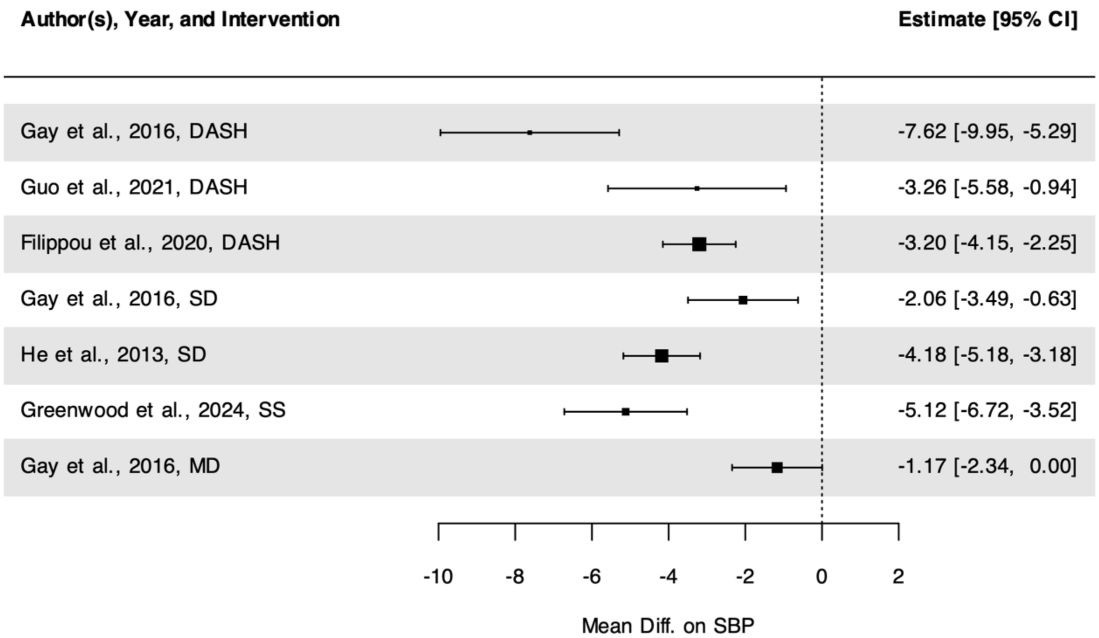

Figure 2: Forest Plot of the Primary Prevention Outcome: Systolic Blood Pressure. DASH: Dietary Approaches to Reducing Hypertension, MD: Mediterranean Diet, SD: Sodium-reduced Diet, SS: Sodium Substitution with Potassium.

Diastolic Blood Pressure

Figure 3 summarizes SRMAs exploring the primary prevention outcome, Diastolic Blood Pressure.

Similar to the SBP outcome, three (3) studies explored the impact of DASH on the DBP. Gay et al. (2016), a critically low SMRA, reported a decrease in DBP of -4.22 mmHg (95% CI: -5.87, -2.57). Guo et al. (2021), a low-quality review, on the other hand, found that DASH intervention induced a lessening of DBP of -3.20 mmHg (95% CI: -4.81, -1.59), while Filippou et al. (2020), a high-quality study estimated a drop of DBP of -2.50 mmHg (95% CI:-3.50, -1.50).

Two (2) studies explored the impact of the Sodium-reduced Diet on DBP. The SRMA of RCTs conducted by Gay et al. (2016) observed a slight decrease in DBP of -1.30 mmHg (95% CI: -2.37, -0.23), whereas He et al. (2013), a moderate-quality study, reported a decline in DBP of -2.06 mmHg (95% CI: -2.67, -1.45).

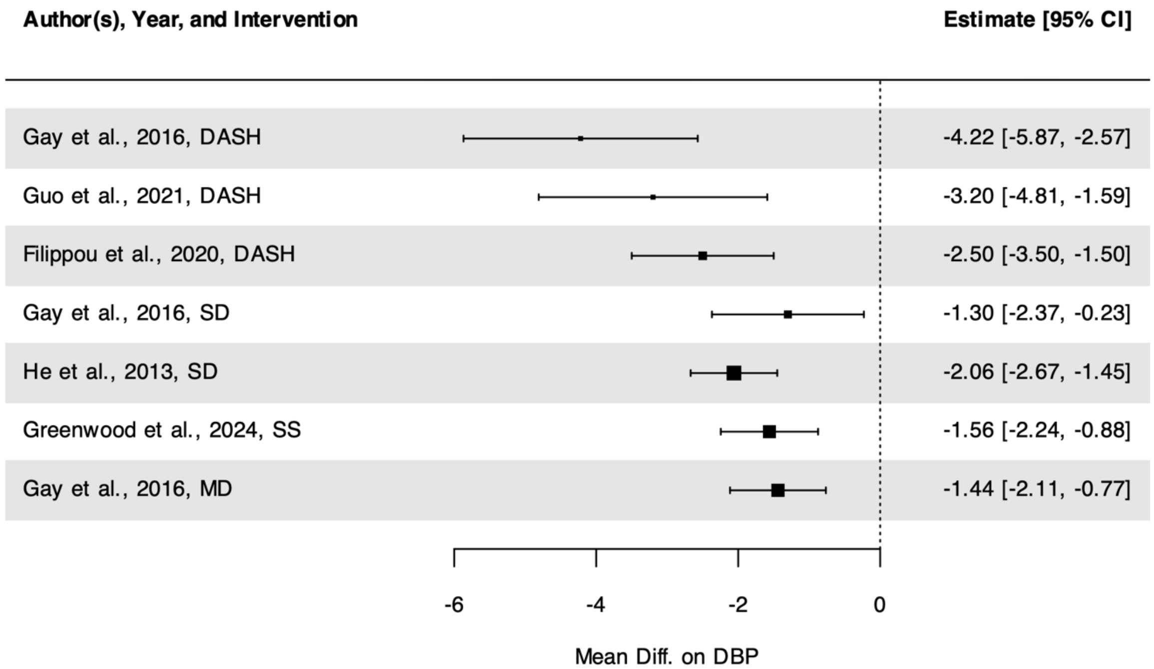

Figure 3: Forest Plot of the Primary Prevention Outcome: Diastolic Blood Pressure. DASH: Dietary Approaches to Reducing Hypertension, MD: Mediterranean Diet, SD: Sodium-reduced Diet, SS: Sodium Substitution with Potassium.

Among the strategies for reducing excessive oral sodium ingestion, two studies reported the impact of additional interventions on DBP. In 2024, Greenwood et al. reported in the SMRA of RCTs that they estimated a reduction of -1.56 mmHg (95% CI: -2.24, -0.88) in DBP following exposure to potassium. Moreover, Gay et al. (2016) observed a lowering of -1.44 mmHg (95% CI: -2.11, -0.77) in an SMRA of RCTs that explored the impact of the Mediterranean Diet on DBP.

Cardiovascular Diseases

Regarding cardiovascular disease, we included two studies. Shirota et al. (2022) investigated the effect of the Japanese Diet on cardiovascular disease (CVD) in the general population. Their review, an SRMA of cohort studies, has a critically low Modified AMSTAR-2 score, with an RR of 0.83 (95% CI: 0.77, 0.89) among people who have high adherence to the Japanese Diet compared to those with low adherence. Salehi-Abargouei et al. (2013), on the other hand, focused on the effect of DASH on cardiovascular disease. Their study, which scored critically low on the Modified AMSTAR-2 scale, reported an RR of 0.8 (95% CI: 0.74-0.86) among participants exposed to the DASH intervention compared to those on a regular diet (**Figure 4).**

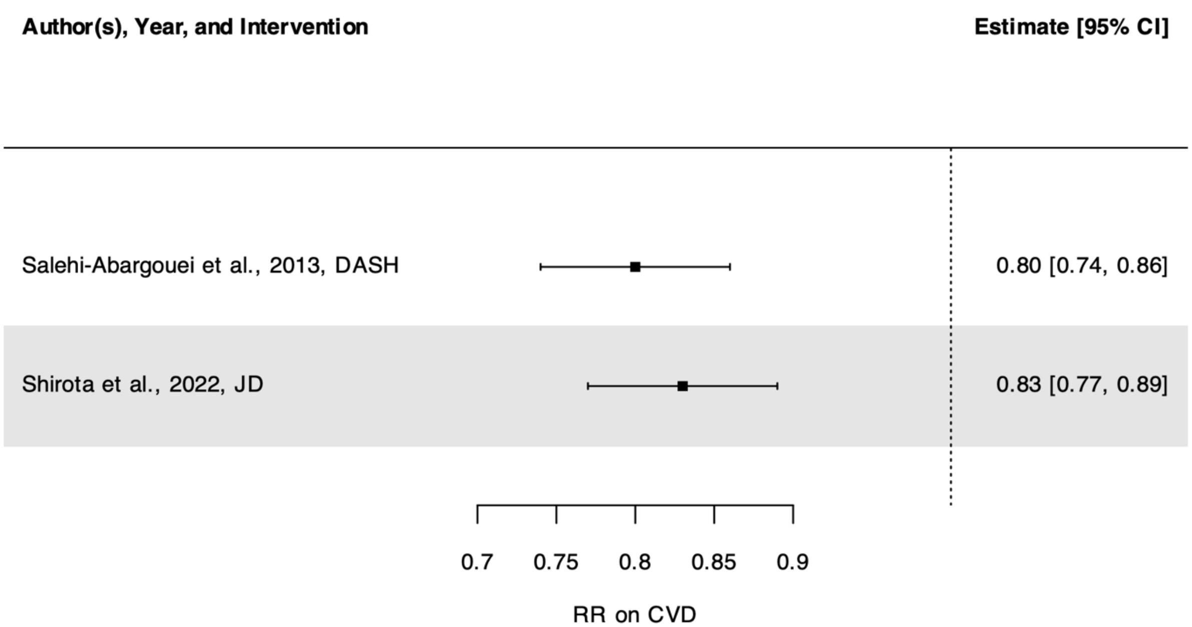

Figure 4: Forest Plot of the Primary Prevention Outcome: Cardiovascular Diseases. DASH: Dietary Approaches to Reducing Hypertension, JD: Japanese Diet.

Stroke

While Salehi-Abargouei et al. (2013) focused on the DASH intervention, Shirota et al.(2022) reviewed the impact of the Japanese Diet on Stroke. In both studies, the reported Relative Risks were quite similar. The former, an SRMA of cohort studies with a critically low Modified AMSTAR-2 score, included participants with CVD risk factors and reported an RR of 0.81 (95% CI: 0.72, 0.92). The latter, a review conducted in the general population, also scored low with Modified AMSTAR-2, observing an RR of 0.8 (0.69–0.93) among the population with high adherence to the Japanese Diet.

Ischemic Heart Disease

In one study, Salehi-Abargouei et al. (2013) examined the effect of the DASH intervention on ischemic heart disease. They reported an RR of 0.79 (95% CI: 0.71, 0.88) among those in the intervention group compared to the control group.

Heart Failure

The Heart Failure outcome was reported by Salehi-Abargouei et al. (2013). Their review reported an RR of 0.71 (95% CI: 0.58, 0.88) among patients with CVD who used the DASH diet compared to those on a normal Diet.

CVD Mortality and Stroke Mortality

In the SRMA of cohort studies conducted by Soltani et al. (2020), exploring the impact of DASH intervention on CVD and stroke mortality in the general population not at significant risk of mortality, they reported an RR of 0.96 (95% CI: 0.95, 0.98) and 0.97 (95% CI: 0.96, 0.98) respectively for CVD Mortality and Stroke Mortality among the participants with high adherence to DASH.

Ischemic Heart Disease Mortality

An RR of 0.81 (95% CI: 0.75, 0.88) was reported in the review conducted by Shirota et al.(2022), measuring the impact of the Japanese Diet on Ischemic Heart Disease among the general population with high adherence to the intervention.

Secondary Prevention

Our review yielded two (2) studies in the secondary prevention. The reviews examined the effects of the Mediterranean Diet and the Sodium-reduced Diet on cardiovascular diseases (CVDs), Heart Failure Hospitalization, and cardiovascular disease mortality **(Table 4)**. All reviews are conducted in populations with pre-existing cardiovascular conditions and are either SRMAs of RCTs or SRMAs of cohort studies. Additionally, the Modified AMSTAR-2 score of these SRMAs is low.

Stroke and Ischemic Heart Disease

One SRMA assessed the impact of sodium reduction intervention on stroke and ischemic heart disease. Karam et al. (2023) explored in their review the effect of the Mediterranean Diet on both outcomes. For stroke, they reported an OR of 0.65 (95% CI: 0.46, 0.93). For Ischemic Heart Disease, the OR of the outcome among participants who adhered to the Mediterranean Diet was 0.48 (95% CI: 0.36, 0.65).

Heart Failure Hospitalization

The SRMAs of Urban et al. (2023) exploring the impact of a Sodium-reduced Diet on the occurrence of hospitalization among patients with heart failure reported an RR of 1.53 (95% CI: 0.84, 2.79).

CVD Mortality

In 2023, Karam et al. SRMA reported an OR of 0.48 (95% CI: 0.36, 0.65) for CVD mortality among participants who adhered to the Mediterranean Diet compared to those who received minimal intervention.

Discussion

Our umbrella review examined 10 systematic reviews and meta-analyses of cohort studies and randomized controlled trials on sodium reduction interventions in the primary and secondary prevention of Cardiovascular diseases, revealing a series of significant findings. Firstly, in addition to the Sodium-reduced Diet, which involves reducing daily sodium intake, various means exist to lower sodium consumption, including the Dietary Approaches to Stop Hypertension (DASH), the Mediterranean Diet, the Japanese Diet, and Sodium Substitution with potassium. Secondly, adherence to sodium reduction interventions could reduce the risk of CVD emergence in primary prevention or CVD complications in secondary prevention.

Before interpreting the results further, we must highlight several significant limitations. Firstly, we circumcribed our review to one database, PubMed. This might have induced a potential selection bias. Secondly, we limited our search strategies to English and French, which yielded more SRMAs in the US and other developed countries and a few in low and middle-income countries but were later excluded due to non-adherence to inclusion criteria. This could limit the generalizability of our findings to other socio-cultural contexts. Thirdly, we observed a few SRMAs focusing on secondary prevention. The limited availability of primary studies in secondary prevention could explain this. Additionally, the differences in study design among SRMAs included in our review, as well as the duplication of some RCTs in SRMAs, impeded the possibility of performing a meta-analysis. Finally, we did not evaluate the quality of evidence using tools like NutriGrade.

Some limitations arose from the SRMAs of RCTs and Cohort studies included in our review. We observed that many studies exploring the impact of the Sodium-reduced Diet intervention on CVD outcomes fall short in assessing sodium intake without using the gold standard method, 24-hour sodium urine collection. Three (3) SMRAs on DASH reported a lessened SBP and DBP in normotensive and hypertensive populations. Among these reviews, the effect sizes reported in SBP and DBP were quite large in the Gay et al. (2016) review, -7.62 mmHg (95% CI: -9.95, -5.29) versus -3.26 mmHg (95% CI: -5.58, -0.94) and - 3.2 mmHg (95% CI: -4.2, -2.3) in the two other studies for SBP (Filippou et al., 2020; Guo et al., 2021), and -4.22 mmHg (95% CI: -5.87, -2.57) versus -2.5 mmHg (95% CI:-3.50, -1.50) and -3.2 mmHg (95% CI: -4.81, -1.59) in the two other studies for DBP (Filippou et al., 2020; Guo et al., 2021). These differences may be explained by the fact that Gay et al. (2016) applied specific inclusion and exclusion criteria, which could have contributed to a larger effect size. The study includes RCTs published between January 1990 and March 2015, with a minimum follow-up period of 6 months. This temporal and follow-up threshold may have influenced the type of DASH studies included in Gay et al. (2016) SRMAs, as opposed to the studies by Filippou et al. (2020) and Guo et al. (2021), which had a minimum follow-up period of 15.3 weeks and 4 weeks, respectively. The meta-regression conducted by Gay et al. (2016) revealed an association between a reduction in BMI in the intervention group and a decrease in blood pressure. Consequently, the DASH trials included in their analysis may have achieved greater weight loss outcomes, which could have amplified the observed blood pressure benefits. Additionally, the study reported that trials with more extended follow-up periods (>24 months) display smaller effect sizes than trials with shorter follow-up periods (<12 months). The latter might indicate the influence of temporal factors in the included DASH trials.

Despite these limitations, our umbrella review offers a valuable snapshot of the impact of sodium reduction interventions in both primary and secondary prevention. To the best of our knowledge, this is the first umbrella review to weigh the impact of all possible interventions in the primary and secondary prevention of CVDs. Our methodological rigor led to the exclusion of most studies based on the follow-up time, which was set as a minimum of 4 weeks for SRMAs of RCTs and 1 year for cohort studies. This might suggest the significance of a period-related adherence to the reported interventions to achieve a positive impact on CVD prevention.

Across the food-based interventions (Mediterranean Diet, Japanese Diet, DASH) included in our study, the main features are vegetables, fruits, whole grains, sources of protein, and sources of unsaturated fat. These features are similar to the Planetary Health Diet, which is rich in unsaturated fats, vegetables, whole grains, nuts, and legumes and reduced in seafood and protein from poultry while also restricting sweets and red meat (Sawicki et al., 2024). Consistent with our findings, which reported the effectiveness of primary and secondary prevention strategies for cardiovascular diseases, the Planetary Health Diet was also found to be effective in reducing the incidence of cardiovascular disease (Muszalska et al., 2025; Sawicki et al., 2024).

Furthermore, high adherence to the Mediterranean Diet and the Planetary Health Diet was associated with a reduction in mortality risk (Aznar de la Riera et al., 2025).

Our umbrella review suggests various avenues for future research and practice. There is a need to conduct more primary studies assessing the impact of dietary interventions on cardiovascular disease (CVD) in secondary prevention. This will contribute to strengthening the existing body of literature with additional evidence to inform policies and prevention strategies more effectively. More research is needed in low- and middle-income countries for generalizability purposes in future umbrella reviews and the establishment of a universal diet guideline. Furthermore, since food-related interventions such as the Mediterranean Diet and the Japanese Diet have geographic limitations, more research comparing their effects with a universal diet, like the Planetary Health Diet, could contribute to better adaptation in various cultural settings. For practice, food-based or potassium-substitute interventions are valid alternatives to the Sodium-reduced Diet. They can inform national primary and secondary prevention strategies to mitigate the burden of cardiovascular disease.

Conclusion

In summary, our research has revealed that sodium reduction interventions can contribute to reducing the global burden of cardiovascular diseases through primary and secondary prevention strategies. Besides the Sodium-reduced Diet and Sodium Substitution interventions, food-related interventions have contributed significantly to the prevention efforts. However, their global implementation may be limited, as some compositions are more closely tied to a specific geographic context. The latter would require an adaptation to account for socio-cultural and economic realities. Doing so might increase the impact of food-related interventions, which would require more research.

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Appendix

Table 1: Full Search Strategy for online database

Electronic Database	Search Strategy
PubMed	("Diet, Sodium-Restricted"[Mesh] OR "Sodium Chloride, Dietary"[Mesh] OR ("Sodium"[Mesh] AND (diet* OR nutrition* OR food*)) OR ((salt[tiab] OR “sodium chloride”[tiab] OR NaCl[tiab]) AND (limit*[tiab] OR reduc*[tiab] OR restrict*[tiab] OR lower[tiab] OR decline[tiab] OR decreas*[tiab] OR content[tiab] OR recipe*[tiab] OR amount*[tiab] OR intake[tiab] OR consumption[tiab])) OR “salt content”[tiab] OR “sodium content”[tiab] OR "dietary sodium"[tiab] OR "dietary salt"[tiab] OR “salt intake”[tiab] OR “sodium intake”[tiab:~3] OR “low salt”[tiab] OR “low sodium”[tiab] OR “salt free”[tiab] OR “sodium free”[tiab] OR “salt substitut*”[tiab] OR “sodium substitute*”[tiab] OR “salt substitute”[tiab:~2] OR “Salt substitutes”[tiab:~2] OR “sodium substitute”[tiab:~2] OR “sodium substitutes”[tiab:~2] OR “Dietary Approaches to Stop Hypertension”[tiab] OR “DASH diet”[tiab:~3] OR “DASH diets”[tiab:~3]) AND ("Hypertension"[Mesh] OR "Blood Pressure"[Mesh] OR “Cardiovascular Diseases"[Mesh] OR “Heart Diseases”[Mesh] OR "Heart Failure"[Mesh] OR "Myocardial Ischemia"[Mesh] OR "Stroke"[Mesh] OR "Ischemic Stroke"[Mesh] OR "Intracranial Hemorrhages"[Mesh] OR "Cerebral Hemorrhage"[Mesh] OR "Subarachnoid Hemorrhage"[Mesh] OR normotens*[tiab] OR hypertens*[tiab] OR “blood pressure”[tiab] OR “cardiovascular disease*”[tiab] OR “heart disease*”[tiab] OR “heart failure”[tiab] OR “myocardial infarct*”[tiab] OR “heart attack*”[tiab] OR “ischemic heart”[tiab] OR “ischaemic heart”[tiab] OR stroke[tiab] OR “intracerebral hemorrhag*”[tiab] OR “intracerebral haemorrhag*”[tiab] OR “cerebral hemorrhag*”[tiab] OR “cerebral haemorrhag*”[tiab] OR “intracranial hemorrhag*”[tiab] OR “intracranial haemorrhag*”[tiab] OR “cranial hemorrhag*”[tiab] OR “cranial haemorrhag*”[tiab] OR “subarachnoid hemorrhag*”[tiab] OR “subarachnoid haemorrhag*”[tiab] OR “brain infarct*”[tiab] OR “cerebral infarct*”[tiab] OR “cerebrovascular accident*”[tiab]) AND ("meta analysis" [Publication Type] OR "systematic review" [Publication Type] OR meta analysis as topic[MeSH Terms]

	OR "systematic reviews as topic" [MeSH Terms] OR systematic[sb] OR "systematic review" [tiab:~2] OR "systematically reviewed "[tiab:~2] OR "meta analysis" OR "meta analyses" OR metaanaly* OR "cochrane review" OR "critical review" OR "evidence gap map" OR "integrative review" OR "mapping review" OR "mixed studies review" OR "mixed methods review" OR "evidence synthesis" OR "research synthesis" OR "rapid review" OR "realist review" OR "scoping review" [tiab:~2] OR "state-of-the-art review" OR "systematized review" OR "umbrella review" OR "review of reviews" OR "The Cochrane database of systematic reviews" [Journal]) AND ("english"[Language] OR “French”[Language])

Table 2: Primary Prevention Interventions – Systolic Blood Pressure and Diastolic Blood Pressure

First author	Publication year	Country	Number of Studies included (N* of studies focusing on a specific intervention / Total number of studies inclued in the review)	Study follow-up	Participants condition	Number of participants	Age/Age range	Comparator	Study Characteristics	Mean Difference	95% CI	Comorbidities	Intervention	Modified AMSTAR - 2
Outcome: Systolic Blood Pressure														
Gay et al.	2016	USA and other countries	4/24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	-7.62	−9.95 to −5.29	Diabetes Mellitus, Obesity and Use of Antihypertensive	DASH	Critically Low
Guo et al.	2021	USA, China, South Korea, Canada, Pakistan, and Brazil.	10	4-48 weeks	Hypertensive	2416	45.10 to 62.20 years	Normal diet	SRMA RCTs	-3.26	-5.58 to -0.94		DASH	Low
Filippou et al.	2020	NR	30	15.3 weeks	Normotensive and hypertensive	5545	Average 51 years	Other: Control Diet	SRMA of RCTs	-3.2	-4.2 to -2.3	Metabolic Syndrome, Type 2 Diabetes Mellitus	DASH	High
Gay et al.	2016	USA and other countries	24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	-2.06	- 3.50 to - 0.63	Diabetes Mellitus, Obesity and Use of Antihypertensive	Sodium-reduced Diet	Critically Low
He et al.	2013	NR	34	4 weeks to 3 years	Normotensive and hypertensive	3230	22 to 73 years old	Normal diet	SRMA RCTs	-4.18	-5.18 to -3.18		Sodium-reduced Diet	Moderate
Greenwood et al.	2024	Peru, Taiwan, China	16	6 months	Higher than average risk of CVD	35, 251	21 to 75	Normal diet; Other: No intervention	SRMA RCTs	-5.12	- 6.72 to -3.52		Sodium Substitution with	High
Gay et al.	2016	USA and other countries	4/24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	-1.17	-2.81 to -0.46	Diabetes Mellitus, Obesity and Use of Antihypertensive	Mediterranean Diet	Critically Low
Outcome: Diastolic Blood Pressure														
Gay et al.	2016	USA and other countries	4/24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	−4.22	-5.87 to -2.57	Diabetes Mellitus, Obesity and Use of Antihypertensive	DASH	Critically Low
Guo et al.	2021	USA, China, South Korea, Canada, Pakistan, and Brazil.	10	4-48 weeks	Hypertensive	2416	45.10 to 62.20 years	Normal diet	SRMA RCTs	-3.2	-3.68 to -0.46		DASH	Low
Filippou et al.	2020	NR	30	15.3 weeks	Normotensive and hypertensive	5545	Average 51 years	Other: Control Diet	SRMA of RCTs	-2.5	-3.5 to -1.5	Metabolic Syndrome, Type 2 Diabetes Mellitus	DASH	High
Gay et al.	2016	USA and other countries	24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	-1.3	-2.37 to - 0.23	Diabetes Mellitus, Obesity and Use of Antihypertensive	Sodium-reduced Diet	Critically Low
He et al.	2013	NR	34	4 weeks to 3 years	Normotensive and hypertensive	3230	22 to 73 years old	Normal diet	SRMA RCTs	-2.06	- 2.67 to -1.45		Sodium-reduced Diet	Moderate
Greenwood et al.	2024	Peru, Taiwan, China	16	6 months	Higher than average risk of CVD	35, 251	21 to 75	Normal diet; Other: No intervention	SRMA RCTs	-1.56	2.25 to -0.88		Sodium Substitution with potassium	High
Gay et al.	2016	USA and other countries	4/24	6-48 months	Normotensive and hypertensive	23858	19 years or older	Control diet, advice only, or standard follow-up	SRMA RCTs	-1.44	-2.11 to -0.76	Diabetes Mellitus, Obesity and Use of Antihypertensive	Mediterranean Diet	Critically Low

CVD: Cardiovascular Disease, DASH: Dietary Approaches to Reducing Hypertension, NR: Not Reported, RCT: Randomized Controlled Trial, USA: United States of America.

Table 3: Primary Prevention Interventions – CVDs

First author	Publication year	Country	Number of Studies included (N* of studies focusing on a specific intervention / Total number of studies inclued in the review)	Study follow-up	Participants condition	Number of participants	Age/Age range	Comparator	Study Characteristics	Effect Measure	95% CI	Comorbidities	Intervention	Modified AMSTAR - 2
Outcome: CVD														
Salehi-Abargouei et al.	2013	USA, Sweden and Italy	6	7 to 24 years	Participants with CVD Risk factors	259,984	30-83 years	Normal diet	SRMA Cohort studies	0.8	0.74 -0.86		DASH	Critically Low
Shirota et al.	2022	Japan	58	7 to 19 years	General population	3,137,428.00	40 to 78 years	Lowest adherence to the diet	SRMA Cohort studies	0.83	0.77 - 0.89		Japanese Diet	Critically Low
Outcome:Stroke														
Salehi-Abargouei et al.	2013	USA, Sweden and Italy	6	7 to 24 years	CVDs	150,191	30-83 years	Normal diet	SRMA Cohort studies	0.81	0.72 - 0.92		DASH	Critically Low
Shirota et al.	2022	Japan	58	7 to 19 years	General population	3,137,428.00	40 to 78 years	Lowest adherence to the diet	SRMA Cohort studies	0.8	0.69 - 0.93		Japanese Diet	Critically Low
Outcome: Ischemic Heart Disease														
Salehi-Abargouei et al.	2013	USA, Sweden and Italy	6	7 to 24 years	Participants with CVD Risk factors		30-83 years	Normal diet	SRMA Cohort studies	0.79	0.71 - 0.88		DASH	Critically Low
Outcome: Heart Failure														
Salehi-Abargouei et al.	2013	USA, Sweden and Italy	6	7 to 24 years	Participants with CVD Risk factors	74,966	30-83 years	Normal diet	SRMA Cohort studies	0.71	0.58 - 0.88		DASH	Critically Low
Outcome: CVD Mortality														
Soltani et al.	2020	China, USA, Europe, UK	17	12.4 - 19.2 years	General population not at great risk of mortality	10,169		Low adherence to DASH	SRMA Cohort studies	0.96	0.95 - 0.98		DASH	Low
Outcome: Stroke Mortality														
Soltani et al.	2020	China, USA, Europe, UK	17	12.4 - 19.2 years	General population not at great risk of mortality	3,784		Low adherence to DASH	SRMA Cohort studies	0.97	0.96 - 0.98		DASH	Low
Outcome: Heart Disease / Ischemic Heart Disease Mortality														
Shirota et al.	2022	Japan	58	7 to 19 years	General population	3,137,428.00	40 to 78 years	Lowest adherence to the diet	SRMA Cohort studies	0.81	0.75 - 0.88		Japanese Diet	Critically Low

CVD: Cardiovascular Disease, DASH: Dietary Approaches to Reducing Hypertension, NR: Not Reported, RCT: Randomized Controlled Trial, USA: United States of America, UK: United Kingdom. *All the Effect Measures are Relative Risks.*

Table 4: Secondary Prevention

First author	Publication year	Country	Number of Studies included	Study follow-up	Participants condition	Number of participants	Age/Age range	Comparator	Study Characteristics	Effect Measure	95% CI	Comorbidities	Intervention	Modified AMSTAR - 2
			Outcome:Stroke											
Karam et al.	2023	NR	12/40	1-9.6 years follow-up time	Participants with cardiovascular risk factors (High blood pressure, diabetes mellitus, obesity, etc.) and CVDs	35,548 (17916 Secondary prevention)		Minimal intervention	SRMA RCTs	0.65 (OR)	0.46 - 0.93	Hypertension, Dyslepidemia, Obesity, Diabetes Mellitus	Mediterranean Diet	Low
			Outcome: Ischemic Heart Disease											
Karam et al.	2023	NR	12/40	0.75-9.6 years follow-up time	Participants with cardiovascular risk factors (High blood pressure, diabetes mellitus, obesity, etc.) and CVDs	35,548 (17916 Secondary prevention)		Minimal intervention	SRMA RCTs	0.48 (OR)	0.36 - 0.65	Hypertension, Dyslepidemia, Obesity, Diabetes Mellitus	Mediterranean Diet	Low
			Outcome: Heart Failure Hospitalization											
Urban et al.	2023		9	12 weeks to 3 years	Heart Failure	1,211	18 year and older	Normal diet	SRMA Cohort Studies and RCTs	1.53	0.84 - 2.79		Sodium-reduced Diet	Low
			Outcome: CVD Mortality											
Karam et al.	2023	NR	12/40	0.75-9.6 years follow-up time	Participants with cardiovascular risk factors (High blood pressure, diabetes mellitus, obesity, etc.) and CVDs	35,548 (17916 Secondary prevention)		Minimal intervention	SRMA RCTs	0.48 (OR)	0.36 - 0.65	Hypertension, Dyslepidemia, Obesity, Diabetes Mellitus	Mediterranean Diet	Low

CVD: Cardiovascular Disease, DASH: Dietary Approaches to Reducing Hypertension, NR: Not Reported, OR: Odds Ratio, RCT: Randomized Controlled Trial, SMRA: Systematic Review and Meta-Analysis, USA: United States of America, UK: United Kingdom. *All the effect measures without OR label are Relative Risk.*

Table 5: Modified AMSTAR-2 Scores

First Author	Modified AMSTAR-2 Score			
	High	Moderate	Low	Critically Low
Gay et al.				
Guo et al.				
Filippou et al.				
He et al.				
Greenwood et al.				
Salehi-Abargouei et al.				
Shirota et al.				
Soltani et al.				
Karam et al.				
Urban et al.				