In-Hospital Sodium Intake for Acute Decompensated Heart Failure

December 2023

U.S. Department of Veterans Affairs
Veterans Health Administration
Health Services Research & Development Service

Recommended citation: Mai HJ, Jutkowitz E, Kanaan G, et al. In-Hospital Sodium Intake for Acute Decompensated Heart Failure: A Systematic Review. Washington, DC: Evidence Synthesis Program, Health Services Research and Development Service, Office of Research and Development, Department of Veterans Affairs. VA ESP Project #22-116; 2023.

AUTHORS

Author roles, affiliations, and contributions to the present report (using the CRediT taxonomy) are summarized in the table below.

Author	Role and Affiliation	Report Contribution
Htun Ja Mai, MBBS, MPH	Co-Investigator, Providence Evidence Synthesis Program (ESP) Center Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Investigation, Writing – original draft, Writing – review & editing
Eric Jutkowitz, PhD	Director, Providence ESP Center Associate Professor, Brown University School of Public Health Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing, Project administration
Ghid Kanaan, MD	Research Associate, Providence ESP Center Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
Sebhat Erqou, MD, PhD	Co-Investigator, Providence ESP Center Physician, Providence VAMC Assistant Professor, Brown University School of Public Health Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
Vincent Salvador, MD, MPH	Research Associate, Providence ESP Center Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
Jacob Joseph, MD, MB	Co-Investigator, Providence ESP Center Chief of Cardiology, Providence VAMC Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
Wen-chih Wu, MD, MPH	Co-Investigator, Providence ESP Center Physician, Providence VAMC Professor, Brown University School of Medicine Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
James Rudolph, MD	Co-Director, Providence ESP Center Director, Long Term Services and Supports (LTSS) Center of Innovation (COIN) Professor of Medicine, Brown University School of Public Health Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Visualization, Writing – original draft, Writing – review & editing

Author	Role and Affiliation	Report Contribution
Eduardo Lucia Caputo, PhD	Research Associate, Providence ESP Center Providence, RI	Conceptualization, Methodology, Investigation, Data curation, Writing – review & editing
Taylor Rickard, MS	Program Manager, Providence ESP Center Providence, RI	Project administration, Visualization, Investigation, Data curation
Katherine Rieke, PhD, MPH	Research Associate, Providence ESP Center Providence, RI	Investigation, Data curation, Writing – original draft, Writing – review & editing
Ethan Balk, MD, MPH	Co-Investigator, Providence ESP Center Professor, Brown University School of Public Health Providence, RI	Conceptualization, Methodology, Investigation, Writing – review & editing, Visualization, Writing – original draft, Writing – review & editing

This report was prepared by the Evidence Synthesis Program Center located at the **VA Providence Health Care System,** directed by **Eric Jutkowitz, PhD and James Rudolph, MD** and funded by the Department of Veterans Affairs, Veterans Health Administration, Health Services Research and Development.

PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to conduct timely, rigorous, and independent systematic reviews to support VA clinicians, program leadership, and policymakers improve the health of Veterans. ESP reviews have been used to develop evidence-informed clinical policies, practice guidelines, and performance measures; to guide implementation of programs and services that improve Veterans' health and wellbeing; and to set the direction of research to close important evidence gaps. Four ESP Centers are located across the US. Centers are led by recognized experts in evidence synthesis, often with roles as practicing VA clinicians. The Coordinating Center, located in Portland, Oregon, manages program operations, ensures methodological consistency and quality of products, engages with stakeholders, and addresses urgent evidence synthesis needs.

Nominations of review topics are solicited several times each year and submitted via the ESP website. Topics are selected based on the availability of relevant evidence and the likelihood that a review on the topic would be feasible and have broad utility across the VA system. If selected, topics are refined with input from Operational Partners (below), ESP staff, and additional subject matter experts. Draft ESP reviews undergo external peer review to ensure they are methodologically sound, unbiased, and include all important evidence on the topic. Peer reviewers must disclose any relevant financial or non-financial conflicts of interest. In seeking broad expertise and perspectives during review development, conflicting viewpoints are common and often result in productive scientific discourse that improves the relevance and rigor of the review. The ESP works to balance divergent views and to manage or mitigate potential conflicts of interest.

ACKNOWLEDGMENTS

The authors are grateful to Gaelen Adam, MLIS for literature searching and the following individuals for their contributions to this project:

Operational Partners

Operational partners are system-level stakeholders who help ensure relevance of the review topic to the VA, contribute to the development of and approve final project scope and timeframe for completion, provide feedback on the draft report, and provide consultation on strategies for dissemination of the report to the field and relevant groups.

Mel L. Anderson, MD, MACP
National Program Executive Director
VHA Hospital Medicine

Anthony Breu, MD
Physician
VA Boston Healthcare System

Technical Expert Panel

To ensure robust, scientifically relevant work, the TEP guides topic refinement; provides input on key questions and eligibility criteria, advising on substantive issues or possibly overlooked

areas of research; assures VA relevance; and provides feedback on work in progress. TEP members are listed below:

Dr. Paul Heidenreich
Cardiologist and Chief of Medicine
Palo Alto VAMC

Dr. Nikhil Sikand, MD, FACC
Cardiologist, Assistant Professor of Medicine
Yale School of Medicine

Dr. Jeffrey Testani
Associate Professor of Medicine; Director of Heart Failure Research, Cardiovascular Medicine; Co-Director Heart & Vascular Center Clinical Research, Heart & Vascular Center
Yale School of Medicine

Peer Reviewers

The Coordinating Center sought input from external peer reviewers to review the draft report and provide feedback on the objectives, scope, methods used, perception of bias, and omitted evidence (see Appendix I for disposition of comments). Peer reviewers must disclose any relevant financial or non-financial conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The Coordinating Center works to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

ABBREVIATIONS TABLE

ACC	American College of Cardiology
ADHF	Acute decompensated heart failure
BNP	Brain (or B-type) natriuretic peptide
BUN	Blood urea nitrogen
CI	Confidence interval
eGFR	Estimated glomerular filtration rate
ESC	European Society of Cardiology
ESP	Evidence Synthesis Program
GRADE	Grading of Recommendations Assessment, Development and Evaluation
HF	Heart failure
HSS	Hypertonic saline solution
ICU	Intensive care unit
IQR	Interquartile range
IV	Intravenous
KQ	Key Questions
LVEDD	Left ventricle end-diastolic diameter
LVEF	Left ventricular ejection fraction
MD	Mean difference
NMD	Net mean difference
NR	Not reported
NRCS	Nonrandomized comparative study
NS	Not significant
NT-proBNP	N-terminal pro-brain (or B-type) natriuretic peptide
NYHA	New York Heart Association
PRA	Plasma renin activity
RCT	Randomized controlled trials
RD	Risk difference
RoB	Risk of bias
RR	Relative risk
SD	Standard deviation
TDS-HF	Thirst Distress Scale for Heart Failure
VAS	Visual analogue scale

EXECUTIVE SUMMARY

Key Findings

Five studies compared a lower sodium diet to a higher sodium diet (unrestricted in 4 studies); 15 studies compared supplemental sodium chloride (NaCl) with furosemide to furosemide alone in patients hospitalized with acute decompensated heart failure (ADHF). Of the 15 supplemental NaCl studies, 14 evaluated hypertonic saline solution (HSS) and 1 evaluated oral NaCl tablets.

- Adults hospitalized with ADHF consumed fewer calories on a restricted sodium diet compared to higher sodium diet. Sodium restriction did not differentially affect other intermediate, clinical, or health service use outcomes. Studies provided insufficient evidence for N-terminal pro-brain natriuretic protein (NT-proBNP), weight, and mortality. No study reported data on estimated glomerular filtration rate (eGFR) or serum cystatin C.
- Supplemental NaCl (mostly given as HSS) with furosemide significantly decreased serum creatinine, blood urea nitrogen (BUN), BNP, and weight and increased eGFR, urine output, and serum sodium. There were no significant differences in NT-proBNP, serum aldosterone, plasma renin activity (PRA), or cystatin C. Supplemental NaCl improved some clinical outcomes (New York Heart Association [NYHA] functional class and thirst symptoms) and reduced hospital length of stay, but did not affect intensive care unit admissions. No study reported data on clinical congestion score. Studies provided insufficient evidence on mortality and readmission outcomes.

INTRODUCTION

ADHF is a leading cause of hospitalization and rehospitalization in the United States (US). The goal of treatment for people hospitalized with ADHF is to reverse acute hemodynamic abnormalities and improve symptoms. In addition to pharmacological therapies (*eg,* diuretics and vasodilators), standard inpatient management of ADHF includes restricting dietary sodium. However, sodium restriction can negatively affect patients by activating antidiuretic and anti-natriuretic systems and reducing blood pressure, which can increase heart rate. There is also concern that patients find low-sodium food less flavorful, which could negatively affect nutrition intake and lead to poor adherence to a low-sodium diet.

Supplemental sodium (given as either HSS infusion or oral NaCl tablets) is proposed as an adjuvant therapy to loop diuretics in patients hospitalized with ADHF. This therapeutic approach is motivated by the observation that HSS causes volume expansion and mobilization of fluid to the intravascular compartment, which improves kidney function, urine output, and weight loss. Despite the potential clinical benefits, inpatient providers may be hesitant to adopt supplemental sodium given conceptual concerns that increased sodium intake may exacerbate HF symptoms.

The VA ESP was asked by the VA Office of Hospital Medicine for an evidence review on interventions affecting sodium intake patients hospitalized for ADHF. In collaboration with VA stakeholders, we developed the following Key Questions (KQs):

KQ1: Among adults hospitalized for decompensated heart failure, what is the comparative effectiveness of different prescribed sodium intake interventions?

KQ1a: Does effectiveness differ as a function of patient characteristics, including by age, comorbid conditions (kidney function, hypertension, diabetes, stroke, body mass index), existing versus new onset heart failure, preserved versus reduced ejection fraction or pre-hospitalization dietary sodium intake, sex, and race/ethnicity?

METHODS

We searched for peer-reviewed articles in Medline (via PubMed), Embase, ClinicalTrials.gov, CINAHL, and the Cochrane Database of Systematic Reviews from inception to February 13, 2023. Eligible studies evaluated the effect of prescribed sodium intake interventions (*eg*, restricted dietary intake, intravenous HSS, oral NaCl supplementation) for people ≥18 years of age hospitalized and treated for ADHF. We excluded studies that evaluated sodium intake as a continuous exposure (*ie*, not prescribed), that were conducted in the emergency department (without an inpatient component) or in an outpatient setting, that did not report patient-level interventions (*eg*, if they compared hospital policies that were not explicitly uniformly applied), or that did not include a comparison group. We included randomized controlled trials (RCT) and nonrandomized (observational) comparative studies (NRCS), whether prospective or retrospective and regardless of whether they were adjusted for potential confounders. Prioritized outcomes included intermediate (serum creatinine, brain [or B-type] natriuretic peptide [BNP], N terminal-proBNP [NT-proBNP], and caloric intake), clinical (clinical congestion score, weight loss, and 30-day all-cause mortality), and health service use measures (length of hospital stay and 30-day readmission). We analyzed all outcomes (except post-hospitalization outcomes) from the first in-hospital measurement to the end of the intervention or discharge. Where there were at least 3 studies reporting results from sufficiently similar analyses (based on population, interventions, comparators, and outcomes), we conducted meta-analyses using random-effects models. Using GRADE (Grading of Recommendations Assessment, Development and Evaluation) methodology, we determined certainty of evidence for each prioritized outcome (but not other outcomes). The review protocol was registered in PROSPERO (CRD42023410146).

RESULTS

Twenty studies reported the effectiveness of prescribed sodium for patients hospitalized with ADHF. Five studies (4 RCTs and 1 NRCS) evaluated the effectiveness of restricted dietary sodium intake interventions (with 381 analyzed patients), and 15 studies (13 RCTs and 2 NRCSs) evaluated the effectiveness of HSS with furosemide (14 studies) or oral NaCl with furosemide (1 study) (with 3,483 analyzed patients). The majority of the studies were conducted in Europe ($N = 9$), followed by South America ($N = 5$), Asia ($N = 3$), the Middle East ($N = 2$), and US ($N = 1$). ES Table shows the summary results for prioritized outcomes.

ES Table. Summary of Findings for Prioritized Outcomes

	Dietary Sodium Interventions			Supplemental Sodium Interventions*		
Outcome	**Studies (Patients); Design**	**Overall Confidence**	**Summary of Findings**	**Studies (Patients); Design**	**Overall Confidence**	**Summary of Findings**
Creatinine	3 (159); RCT	Moderate	Pooled NMD = 0.08 mg/dL, 95% CI (−0.08, 0.23)	11 (2,766); RCT	Moderate	**Pooled NMD = −0.38 mg/dL, 95% CI (−0.54, −0.22)**
BNP	2 (128); RCT	Low	Net *median* difference = 525 and −13 pg/mL	7 (2,848); 6 RCT and 1 NRCS	Low	**Pooled NMD = −62.84 pg/mL, 95% CI (−103.61, −22.08)**
NT-pro BNP	1 (31); RCT	Insufficient	No conclusion	3 (235); RCT	Low	Pooled NMD = −1614.17 pg/mL, 95% CI (−3581.66, 353.31)
Caloric Intake	2 (243); RCT, NCRS	Low	**Consume <20 kcal/kg/day RR = 3.4, 95% CI [1.70, 6.86])** **MD = −4.4 kcal/kg/day, 95% CI (−7.26, −1.53)** **MD in percent estimate of daily requirement: −16, 95% CI (−6.6, −25.4)**	0	NA	No evidence
Clinical Congestion Score	2 (128); RCT	Moderate	NMD = −0.5, 95% CI (−1.76, 0.76) and 0.4, 95% CI (−1.6, 2.4)	0	NA	No evidence
Weight Change	4 (191); RCT	Insufficient	No conclusion	14 (3,333); 13 RCTs and 1 NCRS	Moderate	**Pooled NMD = −2.66 kg, 95% CI (−4.70, −0.62)**
Mortality (All Cause)	4 (191); RCT	Insufficient	No conclusion	4 (2,317); RCT	Insufficient	No conclusion
Readmission	3 (159); RCT	Low	Pooled RR = 1.07, 95% CI (0.68, 1.69)	2 (159); RCT	Insufficient	No conclusion
Length of Hospital Stay	3 (159); RCT	Low	Pooled NMD = 3.1 days, 95% CI (−0.6, 6.7)	11 (3,243); 9 RCTs and 2 NRCS	Moderate	**Pooled NMD = −2.90 days, 95% CI (−4.02, −1.79)**

Notes. Statistically significant summary findings are in bold font.
*14 studies evaluated HSS and 1 study evaluated oral NaCl.
Abbreviations. BNP=brain (or B-type) natriuretic peptide; CI=confidence interval; MD=mean difference; NA=not applicable; NMD=net mean difference; NRCS=non-randomized controlled study; NT-proBNP=N-terminal pro-brain (or B-type) natriuretic peptide; RCT=randomized controlled trial; RR=relative risk.

Effect of Dietary Sodium Intake Restriction

Five studies conducted between 2008 and 2016 (that analyzed 381 participants) compared a low sodium diet to a higher sodium diet (unrestricted in 4 studies). Four RCTs were conducted in Brazil and 1 NRCS was conducted in Japan. Two RCTs had methodological concerns due to missing outcome data, not following intent-to-treat principles, or randomized patients based on medical record number and not concealing allocation. The NRCS was presented in a conference abstract and reported minimal methodological details. Prescribed sodium intake in the intervention groups ranged from 0.8 g/day (in 3 RCTs) to 2.4 g/day (in the NRCS). Sodium intake in the control groups ranged from 2.8 g/day to 3-5 g/day. Four studies also restricted fluid in the intervention group (800 to 1000 mL/day), 2 studies restricted fluid intake in the higher sodium diet groups (800 mL/day and 1000 mL/day), and 2 did not indicate any fluid restriction in the higher sodium diet groups. Three studies restricted diet until discharge, hospital day 7, or if there was a clinical indication to end it early (whichever came first). The other 2 studies did not report the duration of the intervention.

Intermediate Measures

In summary, there were no significant differences in serum creatinine (in 3 studies) and BNP (2 studies) between a low sodium diet and higher sodium diet (ES Table). Fewer calories were consumed by patients on a low sodium diet compared with a higher sodium diet (2 studies). There is insufficient evidence for the effect of dietary intervention on NT-proBNP or weight loss (due to imprecise estimates and methodological limitations).

Other specific findings included no significant difference in BUN (3 studies), urine output (1 study), proportion of patients prescribed diuretics or dose of diuretics (3 studies), serum sodium (3 studies), aldosterone (1 study), or plasma renin activity (PRA;1 study). Certainty of evidence was not assessed for these outcomes. No study reported eGFR or serum cystatin C.

Clinical Measures

There was no significant difference in clinical congestion score (ES Table). Studies provided insufficient evidence for mortality (no conclusion).

A low sodium diet combined with fluid intake restrictions significantly increased thirst (2 studies) but there was no significant difference in shortness of breath (1 study), well-being (1 study), or days to compensation (1 study). Certainty of evidence was not assessed for these outcomes.

Health Service Use

There was no difference in 30-day readmission or length of stay between a low sodium diet and higher sodium diet (ES Table). Patients consumed significantly less sodium (*ie*, were adherent to their prescribed diet) on a low sodium diet compared to higher sodium diet (2 studies).

Effect of Supplemental Sodium (and Diuretics)

Fifteen studies conducted between 1996 and 2022 analyzed 3,483 participants and evaluated the effectiveness of HSS ($N = 14$) or oral NaCl ($N = 1$) with diuretics in patients hospitalized with ADHF. Nine studies were conducted in Europe, 2 in Asia, 2 in the Middle East, 1 in the US, and

1 in South America. In 1 RCT, an independent physician assigned patients to treatment groups, and 1 RCT had major discrepancies within the text and poor methodological reporting of outcome definitions (therefore, high risk of bias). Three RCTs had methodological concerns related to allocation concealment and blinding (*ie*, moderate risk of bias). Two NRCSs either conducted crude unadjusted analyses or did not report a method to address confounding (therefore, high risk of bias). Seven studies described tailoring the concentration of HSS (between 1.4% and 4.6% NaCl) based on the patients' serum sodium levels, 6 studies evaluated a fixed HSS concentration (between 1.7% and 7.5% NaCl), and 1 study did not report concentration of HSS. Total sodium intake (calculated from both HSS and dietary intake) ranged from 0.7 to 8.1 g/day. One study used oral NaCl formulation to replicate neurohormonal effects of HSS intervention and for easy administration. Fourteen studies combined HSS or oral NaCl with intravenous furosemide, and 1 NRCS did not report information on diuretics usage in the conference abstract.

Intermediate Measures

The studies found statistically significant net decreases in serum creatinine (11 studies), BNP (7 studies), and weight (14 studies) from admission to last in-hospital measurement for patients administered sodium supplementation with furosemide compared to furosemide alone (ES Table). There was no significant difference in NT-proBNP (3 studies) or serum aldosterone (3 studies).

Other specific findings included significant net decreases in BUN (12 studies) and significant net increases in eGFR (6 studies), urine output (12 studies), and serum sodium (13 studies); and PRA (1 study) or cystatin C (2 studies). Certainty of evidence was not assessed for these outcomes. No study reported caloric intake.

Clinical Measures

There is insufficient evidence for the effect of sodium supplementation with furosemide on mortality (ES Table). No study reported clinical congestion score. Other nonprioritized outcomes for which certainty of evidence was not assessed included an increased likelihood of improving 2 NYHA functional classes for HSS with furosemide (3 studies). There is a reduction of thirst symptoms (1 study) but no evidence of a difference in a composite measure of HF symptoms (2 studies) or other symptoms of HF including shortness of breath (2 studies).

Health Service Use Measures

Hospital length of stay was shorter for patients who received sodium supplementation with furosemide compared to furosemide alone (ES Table). There was no significant difference in intensive care unit admissions (1 study). There is insufficient evidence on readmission (2 studies; 1 small study with serious methodological limitations, and conflicting results among 2 studies).

DISCUSSION

ADHF is a leading cause of hospitalization, rehospitalization, and morbidity in the US and in the VA system. Although a restricted sodium diet with diuretic therapy is standard practice for patients hospitalized with ADHF, we identified only 5 relatively small studies (total $N = 381$) that have evaluated this strategy. Restricting sodium in ADHF patients is hypothesized to reduce fluid retention and congestion. However, the evidence does not support that weight change, urine

output, and clinical congestion score differed between patients who received restricted or higher sodium diets. Importantly, about 16% fewer calories were consumed by patients who received a restricted diet (in 2 studies), and 2 studies reported increased thirst for patients who received a restricted sodium diet combined with fluid restriction. While the clinical implications of short-term reduced caloric intake and thirst are unclear, it may lead to poor experience of care and create unnecessary friction with clinical staff. No study reported data on quality of life or patient experience of care.

A larger evidence base evaluated the effect of combining HSS (or oral sodium supplementation) with furosemide (15 studies, total $N = 3,483$), which is hypothesized to reduce hyperactivation of the renin-aldosterone-angiotensin pathway and reduce the sodium-avid state of the kidneys. Consistent with this hypothesis, we found that sodium supplementation with furosemide compared to furosemide alone significantly improved kidney function, increased urine output, and reduced weight. No sodium supplementation study evaluated caloric intake, but there is no reason to believe this strategy would affect food consumption. Sodium supplementation with furosemide also reduced hospital length of stay by 3 days, which is large and meaningful for patients and health systems; although the 1 study conducted in US found no significant difference in hospital length of stay between oral NaCl with furosemide and furosemide alone. Therefore, the magnitude of any reduction in length of stay in the VA is unclear. Variation across studies in the duration of intervention and diuretic dose makes it challenging to identify the best sodium supplementation with diuretic strategy. Despite the apparent beneficial effect of this intervention, providers may still have concerns about administering sodium to people with ADHF, which is counter to conventional practice.

No study reported differences in effectiveness by patient characteristics (age, sex, or race/ethnicity), comorbid conditions, community dietary sodium intake, existing versus new onset heart failure, or preserved versus reduced ejection fraction. Finally, no study compared a dietary sodium restriction to sodium supplementation with furosemide.

Implications for VA Policy

All dietary sodium RCTs were conducted in Brazil and most HSS studies were conducted in Europe. The majority of European studies were conducted by 3 different author groups. Despite this, the overall findings (particularly for intermediate and clinical outcomes) likely translate to the VA, since the underlying biology and mechanisms are not likely different by country. As noted, the magnitude of changes in length of stay found in studies conducted in mostly Europe may not apply to the VA, and the 1 study conducted in the US (oral NaCl) found no significant difference in length of stay. Any potential effect on length of stay is dependent on typical length of stay for ADHF admissions at individual institutions and health care systems. Our findings call for VA Medical Centers to review the routine practice of severely restricting sodium intake for patients admitted with ADHF. However, sodium supplementation with loop diuretics to augment diuresis shows promise as a strategy to improve inpatient management of ADHF. In addition to evaluating the clinical data, VA decision makers will need to consider implementation needs and barriers. Providers and systems may be reluctant to change practice since the use of sodium in HF is counterintuitive and discussed in medical curricula as something to be avoided. Sodium supplementation and intravenous diuretic protocols may require additional resources for patient monitoring and safety protocols. Lastly, training medical staff will be critical to promote the safe use of HSS in selected patients with ADHF. To evaluate needs and barriers, VA can apply

implementation science methods. This can include interviews with Veterans, providers, and Medical Center leadership and using the VA medical record to monitor safety of patients who receive sodium supplementation.

Research Gaps/Future Research

The evidence base on restricting dietary sodium was small and had several addressable limitations: missing outcome data, failure to follow intent-to-treat analysis, or randomizing patients based on medical record number. Thus, there is a need for a well-designed, adequately powered RCT of pragmatic design to assess the effectiveness of HSS infusion for patients admitted with ADHF. The absence of adequately powered RCT data from North America presents an opportunity for the VA to conduct its own effectiveness and implementation study of this strategy. For sodium supplementation, comparative effectiveness studies of different dosing strategies (durations and concentrations) are needed to identify the optimal approach. The effect of sodium supplementation on length of stay in the US also needs to be addressed. Studies need to examine differences in effectiveness by patient demographics, heart failure phenotypes, chronicity of heart failure, and comorbid conditions. It is likely feasible to evaluate differences in effectiveness using robust quasi-experimental methods or conducting *post hoc* analyses of existing RCTs. No study evaluated patient quality of life or satisfaction with care, which may be especially important for interventions that restrict dietary sodium.

Limitations

This evidence review has several limitations. We were unable to compare effects by intervention dosing or duration. Outcomes of 30-day mortality and 30-day readmission may be affected by care after discharge, and we did not evaluate corresponding outpatient care protocols. Studies examining dietary interventions in outpatient settings can be difficult to conduct since patients often self-report sodium consumption and adherence is more challenging. We focused on studies conducted in an inpatient setting where diet can be controlled by providers and patients are likely to be more compliant with treatment.

Conclusions

Although restricting dietary sodium is standard practice for patients admitted with ADHF, only a few small studies have examined this approach. There is no difference in BNP, clinical congestion score, 30-day readmission, and length of stay between low sodium and higher sodium diets. Importantly, fewer calories are consumed by patients on low sodium diets compared to higher sodium diets. Studies provide insufficient evidence for the effect of dietary sodium interventions on NT-pro BNP and weight loss. In contrast, serum creatinine, BNP, and weight, but not mortality, decreased for patients administered sodium supplementation with furosemide compared to furosemide alone. Importantly, length of hospital stay was shorter for patients who received sodium supplementation with furosemide. Sodium supplementation studies provide insufficient evidence for mortality and 30-day readmission. There is a need for well-designed RCTs to assess the effectiveness of sodium restriction for the inpatient management of ADHF and for more US-based RCTs of HSS (or oral sodium) with furosemide.