2023

A Systematic Review of Sodium Intake and its Impact on Cardiovascular Health: Insights from Costa Rican Studies

Benjamin M. Hillebrand

A Systematic Review of Sodium Intake and its Impact on Cardiovascular Health: Insights from Costa Rican Studies

Benjamin M. Hillebrand

Augsburg University

Master of Physician Assistant Studies

ML577 Leadership and Universal Responsibility: A Costa Rican Experience

7 August 2023

Abstract:

Cardiovascular disease (CVD) is a leading cause of morbidity and mortality worldwide, with dietary sodium intake identified as a critical risk factor. This systematic review comprehensively examines the existing literature on sodium intake and its impact on cardiovascular health in Costa Rica. Fifteen relevant studies were analyzed, revealing concerning patterns of sodium consumption, particularly among youngsters and adolescents, with processed and fast foods being major contributors. High sodium intake was consistently associated with elevated blood pressure, a well-established CVD risk factor. The review also assessed sodium reduction initiatives and strategies, demonstrating the potential benefits of interventions in reducing cardiovascular risk. Challenges in addressing sodium consumption in Costa Rica include promoting healthier dietary habits from a young age, collaborating with the food industry for stricter regulations, and addressing socioeconomic disparities in healthcare access. The review highlights the need for evidence-based interventions and policies to reduce the burden of CVD in Costa Rica. Future research should explore longitudinal trends in sodium intake and cardiovascular outcomes, conduct qualitative studies on perception and barriers to sodium reduction, and evaluate the long-term effectiveness of interventions. Implementing targeted public health campaigns and industry regulations can promote healthier eating behaviors and improve overall cardiovascular well-being in the population.

Introduction

Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality worldwide, posing significant public health challenges. Among the various modifiable risk factors influencing CVD development, dietary sodium/salt intake has emerged as a critical determinant. High sodium intake is associated with increased blood pressure, a well-established risk factor for CVDs such as hypertension, stroke, and coronary heart disease.[1] Understanding the patterns of sodium consumption and its implications for cardiovascular health is crucial for formulating effective preventative strategies and promoting cardiovascular well-being.

In the context of Central America, Costa Rica stands as a significant country with its unique dietary habits and nutritional challenges. The prevalence of cardiovascular risk factors has been a matter of concern in both rural and urban populations of Costa Rica.[2] Given the potential impact of dietary sodium intake on CVDs, several studies have been conducted to explore the sodium/salt consumption patterns in Costa Rican individuals across different age groups and settings.

To date, various research works have shed light on different aspects of sodium/salt intake in Costa Rica. Núñez-Rivas et al. investigated the dietary sources and sodium/salt intake in youngsters of Costa Rica, while Heredia-Blonval et al. evaluated the salt content of products from popular fast-food chains in the country. Furthermore, the work of Vega-Solano et al. provided a scenario modeling study on the potential impact of salt intake reduction on CVD mortality in Costa Rica. Additionally, Blanco-Metzler et al. explored household cooking and eating habits, revealing the food practices and perceptions of salt/sodium consumption among Costa Rican residents.

Despite these individual studies, a comprehensive synthesis of the existing literature is currently lacking. Therefore, a systematic review is warranted to consolidate the findings from these various studies and provide a holistic understanding of the relationship between sodium/salt intake and cardiovascular health in the Costa Rican context. By systematically evaluating and synthesizing the available evidence, this review aims to identify knowledge gaps, evaluate methodological strengths and limitations, and provide evidence-based insights to guide future research and public health interventions.

Objective

The primary objective of this systematic review is to comprehensively examine the existing body of literature on sodium/salt intake and its impact on cardiovascular health in Costa Rica. Specific research questions guiding this review include:

1. What are the dietary sources of sodium/salt intake among different age groups in Costa Rica?
2. What are the associations between sodium/salt consumption and cardiovascular outcomes in Costa Rican populations?
3. How have sodium reduction initiatives and strategies influenced sodium intake patterns and cardiovascular health in the country?
4. What are the key challenges and opportunities for addressing sodium/salt consumption in Costa Rica's context?

Methods

1. Research Question and Protocol

The primary objective of this systematic review is to comprehensively examine the existing body of literature on sodium/salt intake and its impact on cardiovascular health in Costa

Rica. The review protocol was developed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

2. Search Strategy

A comprehensive literature search was conducted to identify relevant peer-reviewed articles published up to July 25th, 2023. Electronic databases including PubMed and Google Scholar were searched using a combination of keywords and Medical Subject Headings (MeSH) terms. The search strategy was tailored to each database, incorporating relevant synonyms for "sodium," "salt," "cardiovascular health," and "Costa Rica."

3. Study Selection Criteria

Studies were included in the systematic review if they met the following criteria:

- Population: Studies conducted among Costa Rican populations of any age group.
- Exposure: Studies assessing dietary sodium of salt intake.
- Outcome: Studies reporting cardiovascular health outcomes, such as hypertension, stroke, coronary heart disease, or CVD-related mortality.
- Study Design: Original research articles, observational studies (cross-sectional, cohort, case-control), interventional studies, and scenario modeling studies were included. Reviews, editorials, and conference abstracts were excluded.

4. Study Selection Process

An independent reviewer conducted the study selection process in two stages. In the first stage, titles and abstracts of retrieved articles were screened for relevance and eligibility against the inclusion criteria. In the second stage, full-text articles of potentially eligible studies were retrieved and assessed for final inclusion.

5. Data Extraction

Data were extracted from the selected studies using a standardized data extraction form. The following information was extracted:

- Study characteristics: Authors, publication year, study design, sample size, and study location.
- Participants: Age, sex, and any relevant demographic characteristics.
- Exposure: Details on dietary sodium/salt intake assessment methods.
- Outcomes: Cardiovascular health outcomes reported in the study.
- Key findings: Main results related to the association between sodium/salt intake and cardiovascular health.

6. Data Synthesis

Due to the anticipated heterogeneity of the included studies in terms of study designs, outcomes, and population characteristics, a meta-analysis was not conducted. Instead, a narrative synthesis was performed to summarize and interpret the findings from the selected studies.

7. Bias and Confounding

Publication bias and potential confounding factors were considered in the interpretation of the results. Sensitivity analyses were planned to assess the robustness of the findings against potential biases.

8. Ethical Considerations

As this study is based on a systematic review of existing literature, no ethical approval was required.

Literature Review

Sodium Intake and Cardiovascular Disease: An Overview

CVD encompasses a range of conditions affecting the heart and blood vessels, including hypertension, heart disease, and stroke. It is a leading cause of morbidity and mortality worldwide, accounting for millions of deaths annually.[2] Excessive sodium intake has emerged as a significant risk factor for the development and progression of CVD.

Sodium is an essential mineral that plays a vital role in maintaining fluid balance, nerve function, and muscle contractions.[6] However, when consumed in excess, sodium can have detrimental effects on cardiovascular health. The primary mechanism linking sodium intake to CVD is through its impact on blood pressure regulation. High sodium intake leads to an increase in extracellular fluid volume, resulting in increased blood volume and elevated blood pressure.[4] Prolonged elevation in blood pressure can damage the blood vessels, leading to atherosclerosis, arterial stiffness, and other cardiovascular complications.

The relationship between sodium intake and blood pressure has been extensively studied, and the evidence consistently demonstrates a positive association. A meta-analysis of randomized controlled trials found that reducing sodium intake was associated with a significant reduction in blood pressure, with greater reductions observed in individuals with hypertension.[3] Lowering blood pressure, even by a modest amount, has been shown to have substantial benefits in reducing the risk of CVD events, such as heart attacks and strokes.[7]

Furthermore, excessive sodium intake has been linked to other cardiovascular risk factors beyond blood pressure. Studies have shown associations between high sodium intake and increased oxidative stress, endothelial dysfunction, inflammation, and insulin resistance, all of which contribute to the development and progression of CVD.[5] Sodium intake may also influence the renin-angiotensin-aldosterone system, a hormonal system involved in blood pressure regulation, which further exacerbates the cardiovascular risk.[8]

Sodium Intake Patterns in Costa Rica

Understanding the patterns of sodium intake in Costa Rica is crucial for assessing the population's exposure to excessive sodium and its implications for cardiovascular health. Several studies have shed light on sodium intake patterns in different age groups and sources of sodium in the Costa Rican diet.

Núñez-Rivas et al. (2020) conducted a study on dietary sources and sodium/salt intake in Costa Rican youngsters. The findings revealed that youngsters in Costa Rica have high sodium intake, with considerable contributions coming from processed and fast foods.[1] These dietary habits are particularly concerning as high sodium intake during childhood and adolescence can track into adulthood and increase the risk of developing hypertension and CVD later in life.

In a study focusing on Costa Rican adolescents, Monge-Rojas examined dietary intake as a cardiovascular risk factor. The study found that sodium intake among Costa Rican adolescents exceeded the recommended levels, and the main sources of sodium were processed foods, snacks, and fast foods.[9] These findings emphasize the need for interventions targeting this vulnerable population group to promote healthier dietary habits and reduce sodium intake.

Furthermore, it is crucial to assess sodium intake from specific food sources to identify potential targets for sodium reduction strategies. Heredia-Blonval et al. investigated the salt content of products from popular fast-food chains in Costa Rica. The study revealed high sodium levels in these products, indicating that fast-food consumption contributes significantly to sodium intake in the population.[3] A study by Vega-Solano et al. (2019) evaluated the sodium content and compliance with national sodium reduction targets among packaged foods sold in Costa Rica. The findings showed that many packaged food exceeded the recommended sodium

limits, suggesting a need for stricter regulations and greater adherence to sodium reduction guidelines by food manufacturers.[8]

In addition to these studies, it is also valuable to consider recent reports and surveys that provide insights into sodium intake patterns at the population level. The Costa Rican Ministry of Health highlighted the excessive salt content in the Costa Rican diet, emphasizing the need for attention to sodium intake and its health implications.[10] Moreover, the Country Nutrition Profiles methodology by the Global Nutrition Report (2023) provides valuable information on sodium intake and its relation to cardiovascular health in Costa Rica.[11]

Furthermore, a program evaluation by Padilla-Moseley et al. (2022) assessed a dietary sodium reduction research consortium involving five low- and middle-income countries in Latin America, including Costa Rica. The study examined the effectiveness of the interventions in reducing sodium intake and improving cardiovascular health outcomes.[12] An analysis by Arcand et al. (2019) also provides insights into the sodium levels in packaged foods sold in fourteen Latin American and Caribbean countries, including Costa Rica.[13]

Moreover, understanding the nutritional content of ultra-processed snack food products is essential for identifying potential sodium reduction strategies. Gamboa-Gamboa et al. (2019) examined the nutritional content of ultra-processed snack food products purchased in Costa Rica and assessed the presence of front-of-package marketing strategies.[14] The study found that these products often contained high levels of sodium, highlighting the need for monitoring and regulating such products in the food market.

Collectively, these studies and reports underscore the concerning patterns of sodium intake in Costa Rica, particularly among youngsters and adolescents. High Sodium intake from processed and fast foods indicates the need for targeted interventions, including public health

campaigns, nutrition education programs, and industry regulations, to promote healthier dietary habits and reduce sodium consumption in the population.

Prevalence of Cardiovascular Disease in Costa Rica

CVD represents a significant public health burden in Costa Rica, contributing to a substantial number of deaths and posing significant challenges for healthcare systems. Several studies have explored the prevalence of CVD and its associated risk factors in both rural and urban areas of the country

A study by Campos et al. investigated the prevalence of cardiovascular risk factors in rural and urban Costa Rica. The findings indicated a higher prevalence of hypertension, dyslipidemia, obesity, and smoking in urban areas, highlighting the impact of urbanization on cardiovascular health.[2] These risk factors contribute to the development and progression of CVD and underscore the need for targeted interventions in both urban and rural settings.

Furthermore, a study by Fort et al. evaluated the impact of a healthy lifestyle intervention on CVD risk in health centers in San José, Costa Rica, and Chiapas, Mexico. The findings revealed a significant reduction in cardiovascular risk factors, including blood pressure, body mass index, and smoking rates, following the implementation of the intervention.[7] These results demonstrate the potential effectiveness of comprehensive lifestyle interventions in reducing cardiovascular risk in the Costa Rican population.

To gain insights into the current prevalence of CVD in Costa Rica, it is essential to consider more recent data. The Costa Rican Ministry of Health plays a crucial role in monitoring the prevalence of CVD and its associated risk factors. These include hypertension, diabetes, obesity, and dyslipidemia, which are common contributors to CVD development.[4] The ministry's

data help inform public health initiatives and policies aimed at reducing CVD prevalence and improving cardiovascular health outcomes.

It is worth noting that the prevalence of CVD in Costa Rica may be influenced by factors such as socioeconomic status, lifestyle behaviors, and access to healthcare. Socioeconomic disparities have been shown to contribute to variations in CVD prevalence and management, with individuals from lower socioeconomic backgrounds facing greater challenges in accessing healthcare services and adopting healthier lifestyles.[15]

Sodium Consumption Practices in Costa Rica

Understanding the sodium consumption practices in Costa Rica is essential for developing effective interventions to reduce sodium intake and promote healthier dietary habits. Several studies have examined household cooking practices, eating-out habits, and sodium content in packaged foods, providing valuable insights into the sodium consumption landscape in the country.

Blanco-Metzler et al. (2021) conducted a study on household cooking and eating-out practices in Costa Rica, aiming to explore food practices and perceptions of salt/sodium consumption. The findings revealed that traditional Costa Rican dishes often incorporate high amounts of salt, contributing to elevated sodium intake at the household level.[5] Additionally, eating out at restaurants and fast-food chains was associated with higher sodium intake, as these establishments tend to use excessive salt in food preparation.[5] These findings emphasize the need for interventions targeting both home cooking practices and eating-out behaviors to reduce sodium consumption in Costa Rica.

In summary, the literature review provides a comprehensive overview of the existing research on sodium intake and its impact on cardiovascular health in Costa Rica. The evidence

highlights the significance of addressing sodium consumption to reduce the burden of CVDs in the country. The next section will detail the results of the aforementioned studies and research obtained.

Results

The systematic review identified a total of fifteen relevant studies that investigated sodium intake and its impact on cardiovascular health in Costa Rica. These studies encompassed different age groups, settings, and methodologies. The results are organized into three main themes: "Dietary Sodium Intake and Sources," "Associations with Cardiovascular Outcomes," and "Impact of Sodium Reduction Strategies."

Dietary Sodium Intake and Sources

The studies examining dietary sodium intake in Costa Rica consistently highlighted elevated sodium consumption across different age groups. Núñez-Rivas et al. (2020) found that youngsters in Costa Rica had high sodium intake, with significant contributions coming from processed and fast foods.[1] A study focusing on Costa Rican adolescents by Monge-Rojas reported that sodium intake exceeded recommended levels, and the main sources of sodium were processed foods, snacks, and fast foods.[9] Similarly, Heredia-Blonval et al. investigated the salt content of products from popular fast-food chains in Costa Rica and found high sodium levels, indicating that fast-food consumption significantly contributes to sodium intake in the population.[3] Furthermore, Vega-Solano et al. (2019) evaluated the sodium content of packaged foods sold in Costa Rica and showed that many packaged foods exceeded recommended sodium limits, suggesting a need for stricter regulations and greater adherence to sodium reduction guidelines by food manufacturers.[8]

Associations with Cardiovascular Outcomes

Several studies examined the associations between sodium intake and cardiovascular outcomes. High sodium intake was consistently linked to elevated blood pressure, a well-established risk factor for CVDs such as hypertension, stroke, and coronary heart disease.[4-5] A meta-analysis of randomized controlled trials demonstrated that reducing sodium intake was associated with a significant reduction in blood pressure, with greater reductions observed in individuals with hypertension.[15] Lowering blood pressure, even by a modest amount, was shown to have substantial benefits in reducing the risk of CVD events, such as heart attacks and strokes.[7] Moreover, excessive sodium intake has been associated with other cardiovascular risk factors beyond blood pressure, including oxidative stress, endothelial dysfunction, inflammation, and insulin resistance.[8] Sodium intake may also influence the renin-angiotensin-aldosterone system, further exacerbating cardiovascular risk.[8]

Impact of Sodium Reduction Strategies

A program by Padilla-Moseley et al. (2022) assessed a dietary sodium reduction research consortium involving five low- and middle-income countries in Latin America, including Costa Rica. The study examined the effectiveness of the interventions in reducing sodium intake and improving cardiovascular health outcomes.[12] Furthermore, Arcand et al. (2019) provided insights into the sodium levels in packaged foods sold in fourteen Latin American and Caribbean countries, including Costa Rica.[13] Understanding the nutritional content of ultra-processed snack food products is also essential for identifying potential sodium reduction strategies. Gamboa-Gamboa et al. (2019) examined the nutritional content of ultra-processed snack food products purchased in Costa Rica and assessed the presence of front-of-package marketing strategies.[14] The study found that these products often contained high levels of sodium, highlighting the need for monitoring and regulating such products in the food market.

Discussion

This systematic review aimed to comprehensively examine the existing body of literature on sodium/salt intake and its impact on cardiovascular health in Costa Rica. The review identified fifteen relevant studies that shed light on various aspects of sodium consumption and its association with cardiovascular outcomes in the country. The results provide valuable insights into the concerning patterns of sodium intake in Costa Rica, particularly among youngsters and adolescents, and highlight the need for targeted interventions to promote healthier dietary habits and reduce sodium consumption in the population.

The findings from this review reveal that sodium intake in Costa Rica is considerably higher than recommended levels, and processed and fast foods are significant contributors to this elevated consumption. Núñez-Rivas et al. (2020) and Monge-Rojas found high sodium intake among youngsters and adolescents, respectively, with processed foods, snacks, and fast foods being the main sources of sodium.[1,9] Additionally, Heredia-Blonval et al. and Vega-Solano et al. (2019) highlighted the high sodium content in products from fast-food chains and packaged foods, underscoring the need for stricter regulations and adherence to sodium reduction guidelines by the food industry.[3,7] These findings are in line with global trends of increased consumption of processed and convenience foods, which contribute to elevated sodium intake and have adverse effects on cardiovascular health.

The systematic review consistently demonstrated a positive association between sodium intake and elevated blood pressure, a well-established risk factor for CVDs such as hypertension, stroke, and coronary heart disease. The meta-analysis by Blanco-Metzler et al. confirmed that reducing sodium intake was associated with significant reduction in blood pressure, particularly in individuals with hypertension.[15] This highlights the potential benefits of sodium reduction

initiatives in Costa Rica to reduce the burden of CVD. Furthermore, beyond blood pressure, high sodium intake has been associated with other cardiovascular risk factors, including oxidative stress, endothelial dysfunction, inflammation, and insulin resistance.[8] These findings indicate that sodium intake influences multiple pathways that contribute to the development and progression of CVD.

Studies evaluating sodium reduction strategies in Costa Rica have provided valuable insights into the effectiveness of interventions. The program evaluation by Padilla-Moseley et al. (2022) assessed the impact of a dietary sodium reduction consortium involving multiple Latin American countries, including Costa Rica.[12] Such initiatives play a crucial role in raising awareness about the health implications of excessive sodium intake and encouraging sodium reduction in processed foods and meals prepared outside the home. Additionally, monitoring the nutritional content of ultra-processed snack food products, as studied by Gamboa-Gamboa et al. (2019), is essential for identifying potential targets for sodium reduction strategies.[14]

Challenges and Opportunities

The systematic review reveals several challenges in addressing sodium consumption and its impact on cardiovascular health in Costa Rica. Firstly, the prevalence of high sodium intake in youngsters and adolescents highlights the need for early interventions to promote healthier dietary habits from a young age. School-based nutrition education programs and public health campaigns can play a vital role in instilling healthier eating behaviors and raising awareness about the risks associated with excessive sodium intake.

Secondly, addressing the high sodium content in processed and fast foods requires collaboration with the food industry and stricter regulatory measures. Encouraging food

manufacturers to adhere to sodium reduction guidelines and providing incentives for offering low-sodium alternatives can help reduce the population's sodium intake.

Thirdly, considering the influence of socioeconomic disparities on CVD prevalence and management, interventions should be designed to address access barriers to healthcare services and promote healthier lifestyles across diverse population groups.[14] Tailored interventions for vulnerable populations, particularly those from lower socioeconomic backgrounds, are essential to ensure equitable improvements in cardiovascular health.

Limitations and Future Directions

Some limitations should be acknowledged in interpreting the results of this systematic review. First, the heterogeneity of study designs, outcomes, and population characteristics limit the ability to conduct a meta-analysis. Instead, a narrative synthesis was performed to summarize and interpret the findings. Second, publication bias and potential confounding factors may influence the results. Sensitivity analyses were planned to assess the robustness of the findings against potential biases. Lastly, the data available for this review may not capture the most recent trends in sodium consumption and cardiovascular health in Costa Rica, highlighting the need for continuous monitoring and updated research in this field.

For future research, longitudinal studies tracking changes in sodium intake and cardiovascular health outcomes over time would provide valuable information on the long-term effects of sodium reduction interventions. Additionally, qualitative research exploring perceptions and barriers related to sodium consumption in Costa Rican communities could help tailor public health interventions for better effectiveness.

Conclusion

In conclusion, this systematic review provides a comprehensive synthesis of the existing literature on sodium intake and its impact on cardiovascular health in Costa Rica. The evidence highlights the significance of addressing sodium consumption to reduce the burden of CVD in the country. The findings from this review can inform evidence-based interventions and policies to promote cardiovascular health and improve overall well-being in Costa Rican populations. Future research should aim to address the identified gaps in knowledge and explore innovative strategies to effectively reduce sodium intake and mitigate the risk of CVD in this setting.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The author declares no conflict of interest.

Ethical Approval

As this study is based on a systematic review of existing literature, no ethical approval was required.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

References

1. Núñez-Rivas H, Holst-Schumacher I, Campos-Saborío N. Dietary Sources and Sodium/Salt Intake in Youngsters of Costa Rica. *Curr Dev Nutr*. 2020;4(Suppl 2):1465. Published 2020 May 29. doi:10.1093/cdn/nzaa061_093.
2. Campos H, Mata L, Siles X, Vives M, Ordovas JM, Schaefer EJ. Prevalence of cardiovascular risk factors in rural and urban Costa Rica. *Circulation*. 1992;85(2):648-658. doi:10.1161/01.cir.85.2.648.
3. Heredia-Blonval K, Blanco-Metzler A, Montero-Campos M, Dunford EK. The salt content of products from popular fast-food chains in Costa Rica. *Appetite*. 2014;83:173-177. doi:10.1016/j.appet.2014.08.027.
4. Vega-Solano J, Blanco-Metzler A, Madriz-Morales K, Fernandes-Nilson E-A, Labonté ME. Impact of salt intake reduction on CVD mortality in Costa Rica: A scenario modelling study. PLoS ONE. 2021;16(1):1-11. doi:10.1371/journal.pone.0245388.
5. Blanco-Metzler A, Núñez-Rivas H, Vega-Solano J, Montero-Campos MA, Benavides-Aguilar K, Cubillo-Rodríguez N. Household Cooking and Eating out: Food Practices and Perceptions of Salt/Sodium Consumption in Costa Rica. *International Journal of Environmental Research and Public Health*. 2021; 18(3):1208. https://doi.org/10.3390/ijerph18031208.
6. Vadiveloo MK, Campos H, Mattei J. Seasoning ingredient variety, but not quality, is associated with greater intake of beans and rice among urban Costa Rican adults. *Nutrition Research*. 2016;36(8):780-788. doi:10.1016/j.nutres.2016.04.001.
7. Fort, M.P., Murillo, S., López, E. *et al.* Impact evaluation of a healthy lifestyle intervention to reduce cardiovascular disease risk in health centers in San José, Costa

Rica and Chiapas, Mexico. *BMC Health Serv Res* 15, 577 (2015). https://doi.org/10.1186/s12913-015-1248-7.

8. Vega-Solano J, Blanco-Metzler A, Benavides-Aguilar KF, Arcand J. An Evaluation of the Sodium Content and Compliance with the National Sodium Reduction Targets among Packaged Foods Sold in Costa Rica in 2015 and 2018. *Nutrients*. 2019; 11(9):2226. https://doi.org/10.3390/nu11092226.
9. Monge-Rojas R. Dietary intake as a cardiovascular risk factor in Costa Rican adolescents. *Journal of Adolescent Health*. 2001;28(4):328-337. doi:10.1016/s1054-139x(00)00214-7.
10. Zunigoa Alejandro. Costa Rican diet contains too much salt, Health Ministry says. *The Tico Times*. https://ticotimes.net/2021/03/09/costa-rican-diet-contains-too-much-salt-health-ministry-says-2. Published March 9, 2021. Accessed June 27, 2023.
11. Country Nutrition Profiles methodology 2021 - Global Nutrition Report. Accessed June 27, 2023. https://globalnutritionreport.org/documents/916/Country-Nutrition-Profiles-methodology_2023_Signed_off_final.pdf.
12. Padilla-Moseley J, Blanco-Metzler A, L'Abbé MR, Arcand J. A Program Evaluation of a Dietary Sodium Reduction Research Consortium of Five Low- and Middle-Income Countries in Latin America. *Nutrients*. 2022; 14(20):4311. https://doi.org/10.3390/nu14204311.
13. Arcand J, Blanco-Metzler A, Benavides Aguilar K, L'Abbe MR, Legetic B. Sodium Levels in Packaged Foods Sold in 14 Latin American and Caribbean Countries: A Food Label Analysis. *Nutrients*. 2019; 11(2):369. https://doi.org/10.3390/nu11020369.
14. Gamboa-Gamboa T, Blanco-Metzler A, Vandevijvere S, Ramirez-Zea M, Kroker-Lobos MF. Nutritional Content According to the Presence of Front of Package Marketing

Strategies: The Case of Ultra-Processed Snack Food Products Purchased in Costa Rica. *Nutrients*. 2019; 11(11):2738. https://doi.org/10.3390/nu11112738.

15. Blanco-Metzler A, de los Ángeles Montero-Campos M, Núñez-Rivas H, Gamboa-Cerda C, Sánchez G. Avances en la reducción del consumo de sal y sodio en Costa Rica. Pan American Journal of Public Health. 2012;32(4):316-320. doi:10.1590/S1020-49892012001000011.

AUGSBURG
UNIVERSITY

Augsburg University Institutional Repository Deposit Agreement

By depositing this Content ("Content") in the Augsburg University Institutional Repository known as Idun, I agree that I am solely responsible for any consequences of uploading this Content to Idun and making it publicly available, and I represent and warrant that:

- I am *either* the sole creator or the owner of the copyrights in the Content; or, without obtaining another's permission, I have the right to deposit the Content in an archive such as Idun.
- To the extent that any portions of the Content are not my own creation, they are used with the copyright holder's expressed permission or as permitted by law. Additionally, the Content does not infringe the copyrights or other intellectual property rights of another, nor does the Content violate any laws or another's right of privacy or publicity.
- The Content contains no restricted, private, confidential, or otherwise protected data or information that should not be publicly shared.

I understand that Augsburg University will do its best to provide perpetual access to my Content. To support these efforts, I grant the Board of Regents of Augsburg University, through its library, the following non-exclusive, perpetual, royalty free, worldwide rights and licenses:

- To access, reproduce, distribute and publicly display the Content, in whole or in part, to secure, preserve and make it publicly available
- To make derivative works based upon the Content in order to migrate to other media or formats, or to preserve its public access.

These terms do not transfer ownership of the copyright(s) in the Content. These terms only grant to Augsburg University the limited license outlined above.

Initial one:

X I agree and I wish this Content to be Open Access.

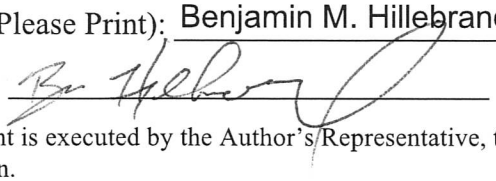
___ I agree, but I wish to restrict access of this Content to the Augsburg University network.

Work (s) to be deposited

Title: A Systematic Review of Sodium Intake and its Impact on Cardiovascular Health: Insights from Costa Rican Studies

Author(s) of Work(s): Benjamin M. Hillebrand

Depositor's Name (Please Print): Benjamin M. Hillebrand

Author's Signature:  Date: 8/3/23

If the Deposit Agreement is executed by the Author's Representative, the Representative shall separately execute the Following representation.

I represent that I am authorized by the Author to execute this Deposit Agreement on the behalf of the Author.

Author's Representative Signature: _____ Date: _____