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Dietary Determinants of Hypertension: Trends in Ultra-Processed Food Consumption and Blood Pressure Control in U.S. Adults, 2013–2023

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Abstract:

Hypertension is one of the major global contributors to cardiovascular illness and death, with its occurrence closely linked to eating behaviors. Although medical treatments have improved, effective control of high blood pressure at the population level remains limited, emphasizing the need to identify dietary factors that can be changed. This research utilized data from the U.S. National Health and Nutrition Examination Survey (NHANES), a nationally representative dataset, to analyze dietary habits, hypertension awareness, management, and control. The main dietary variables assessed included the consumption of ultra-processed products, processed meats, sugar-sweetened drinks, preserved foods, fruits, vegetables, and potassium levels. Hypertension status was determined through standardized blood pressure assessments or participants' self-reported medical diagnoses. Findings indicated that ultra-processed foods made up more than 60% of total energy intake among adolescents and over 50% among adults from 2013–2014 to 2021–2023, showing little sign of reduction. Awareness and treatment of hypertension remained relatively unchanged between 2017–2020 and 2021–2023, while the control rate declined from 22.2% to 20.7%. These results highlight key dietary elements contributing to hypertension risk in the general population and reinforce the urgency of implementing public health strategies that support healthier food choices and environments.

Keywords: Ultra-processed foods; Hypertension control; Dietary patterns.

1. Introduction

Hypertension is one of the most prevalent and modifiable contributors to cardiovascular diseases (CVDs), affecting an estimated 1.3 billion adults globally [1]. It accounts for over 10 million deaths each year due to complications such as coronary heart disease, stroke, heart failure, and chronic kidney disease [2]. Although medical treatments for hypertension have advanced, its prevalence continues to increase worldwide—especially in low- and middle-income countries where levels of awareness, treatment, and control remain insufficient. Therefore, preventive measures focused on lifestyle modification, particularly diet, are essential for public health. Diet plays a key role in blood pressure regulation. Extensive research in nutritional epidemiology has consistently demonstrated that unhealthy eating behaviors—such as excessive consumption of sodium, red and processed meats, and sugar-sweetened beverages—are linked with a higher risk of hypertension [3]. In contrast, diets abundant in fruits, vegetables, low-fat dairy products, and potassium-rich foods have protective effects. These dietary components contribute significantly to the global burden of high blood pressure but are also modifiable through individual and community-level interventions, educational programs, and food policy reforms.

Extensive scientific evidence has confirmed the connection between specific dietary elements and blood pressure outcomes. High sodium intake is widely recognized as a major determinant of hypertension. Meta-analyses of randomized clinical trials indicate that reducing sodium intake leads to notable decreases in blood pressure for both hypertensive and normotensive individuals, with greater effects observed among those with existing hypertension [4]. Likewise, sugar-sweetened beverages (SSBs) have been identified as an important dietary risk factor. Regular consumption of these drinks has been associated with weight gain, insulin resistance, and metabolic syndrome—conditions that raise the likelihood of developing hypertension [5]. Similarly, diets high in red and processed meats are linked to greater hypertension risk because these foods typically contain large amounts of sodium, saturated fat, and preservatives such as nitrates. Evidence from prospective cohort studies suggests that frequent intake of processed meat products increases the incidence of hypertension and cardiovascular disease [6]. Conversely, diets rich in fruits and vegetables are consistently associated with lower blood pressure. The landmark Dietary Approaches to Stop Hypertension (DASH) trial demonstrated that a diet emphasizing fruits, vegetables, and low-fat dairy while limiting saturated fat led to substantial reductions in blood pressure compared with a typical Western diet [7]. Beyond sodium, potassium is another key nutrient in blood pressure control. A potassium-rich diet enhances blood vessel relaxation, promotes sodium excretion, and lowers hypertension risk [8]. The balance between sodium and potassium intake may, in fact, be a stronger predictor of blood pressure than either nutrient alone.

Despite substantial progress in understanding these associations, important gaps remain. Much of the existing literature has analyzed nutrients in isolation, even though, foods are consumed as part of complex dietary patterns. Furthermore, most research has been conducted in Western populations, leaving uncertainty about whether these relationships persist across demographic subgroups defined by age, gender, ethnicity, and health status. The growing availability of large, nationally representative datasets—such as the National Health and Nutrition Examination Survey (NHANES)—provides valuable opportunities to explore these issues through more integrated and population-wide analyses of dietary patterns and hypertension risk.

2. Methods

2.1 Data Source

This study will use data from the NHANES, a cross-sectional, nationally representative survey conducted by the U.S. Centers for Disease Control and Prevention (CDC). NHANES collects detailed information on health, nutrition, and lifestyle factors through interviews, physical examinations, and laboratory assessments. Specifically, dietary intake data are obtained from two non-consecutive 24-hour dietary recalls, while blood pressure is measured using standardized clinical procedures.

2.2 Study Population

The subjects analysed in this study are adults aged 18 years and above. To ensure the scientific validity and reliability of the results, individuals with missing data on key variables—such as blood pressure measurements, dietary intake information, and primary covariates (including age, gender, body mass index, etc.)—will be excluded from the analysis. Furthermore, pregnant women are excluded from the study scope, as dietary patterns during pregnancy differ significantly from those of the general population [9]. Additionally, blood pressure levels in this group are influenced by physiological changes associated with pregnancy, which may introduce bias. These exclusion criteria ensure the data obtained is more consistent and comparable, thereby enhancing the accuracy and interpretability of the analytical findings.

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2.3 Exposure Variables

The primary exposure variable in this study was participants' dietary intake, estimated using 24-hour dietary recall data. Analysis focused on several food categories and nutrients of significant health relevance, including sugar-sweetened beverages, red and processed meats, fruit and vegetables, dairy products, and sodium and potassium intake. Concurrently, the sodium-to-potassium ratio will be calculated as a composite indicator to provide a more comprehensive reflection of the relationship between dietary patterns and health risks. Through the systematic quantification of these key dietary factors, this study aims to uncover potential associations between different dietary patterns and chronic disease risks, thereby providing an evidence base for developing targeted nutritional interventions.

2.4 Outcome Variable

The primary outcome variable in this study is hypertension status, determined by an average systolic blood pressure of 140 mmHg or higher and/or a diastolic pressure of at least 90 mmHg, as measured through repeated clinical assessments, or by a participant's self-reported medical diagnosis of hypertension. It examines how milk, yogurt, cheese, and other dairy foods relate to blood pressure levels. The analysis is based on a large, nationally representative dataset that includes a wide range of diet and health information. By using these data, the study looks at how eating habits connect with the risk of high blood pressure and heart disease.

2.5 Covariates

Potential confounders will be integrated into the statistical models, with variable inclusion guided by established epidemiological frameworks and evidence from prior public health studies. The set of covariates mainly covers demographic and behavioral characteristics, including age (years), gender, race/ethnicity (as defined by NHANES categories), body mass index (BMI, kg/m^2), smoking habits (current, former, or never), alcohol intake (yes/no), physical activity level (self-reported), and diabetes status (yes/no, based on clinical diagnosis or HbA1c $\geq$ 6.5%). Accounting for these variables allows for more rigorous adjustment of confounding influences, thereby improving the accuracy, interpretability, and validity of the estimated associations between dietary exposures and hypertension risk [10].

2.6 Statistical Analysis

Descriptive statistical methods will first be applied to summarize participants' baseline characteristics according to their hypertension classification. Associations between exposure variables and hypertension outcomes will be assessed using bivariate tests such as chi-square analyses and independent-sample t-tests. Multivariable logistic regression models will then be employed to calculate adjusted odds ratios (ORs) with corresponding 95% confidence intervals (CIs), evaluating the relationships between dietary factors and hypertension after adjusting for relevant covariates. To assess potential dose–response patterns, dietary intake variables will be categorized into quartiles or quintiles. Sensitivity analyses will further be performed by excluding individuals with existing comorbid conditions or implausible dietary intake levels. All statistical evaluations will incorporate the complex, multistage sampling framework of the NHANES dataset using appropriate weighting procedures to ensure nationally representative estimates.

3. Results

3.1 Trends in Ultra-Processed Food Consumption

Analysis of NHANES data from 2013–2014 through August 2021–August 2023 showed persistently high levels of ultra-processed food consumption in both youth and adults [11]. Among youth, the mean percentage of calories derived from ultra-processed foods remained above 60% across all survey cycles, increasing slightly from 61.3% in 2015–2016 to 62.1% in 2017–2018, then declining to 61.5% in 2021–2023. Adults demonstrated a consistently lower proportion compared with youth, averaging around 55% of total caloric intake, but a similar temporal pattern was noted. Despite minor fluctuations, both age groups showed no substantial reduction over the past decade, indicating that ultra-processed foods remain a dominant dietary source in the United States (Fig.1).

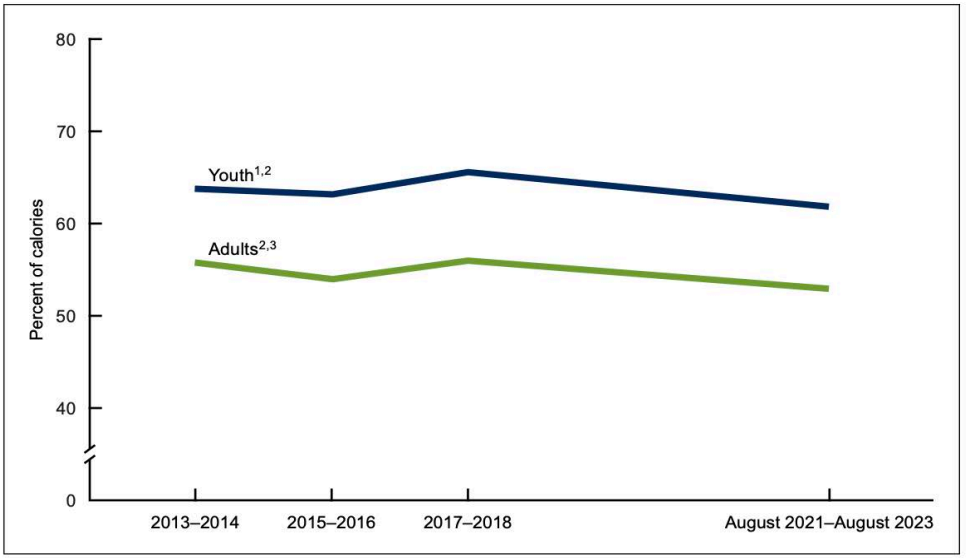

Fig.1 Trends in the mean percentage of total calories from ultra-processed foods consumed by youth and adults: United States,2013-2014 through August 2021-August 2023 [11]

3.2 Hypertension Awareness, Treatment, and Control

Among U.S. adults aged ≥18 years with hypertension, the prevalence of awareness, treatment, and control demonstrated only modest changes between 2017–March 2020 and August 2021–August 2023 [12]. Awareness of hypertension remained stable, declining slightly from 60.2% to 59.2%. Treatment prevalence showed a marginal increase from 50.3% to 51.2%. In contrast, control of hypertension decreased from 22.2% to 20.7%, indicating a worsening gap between treatment initiation and effective blood pressure management. These findings highlight persistent challenges in translating awareness and treatment into adequate control at the population level. indicating that despite modest improvements in treatment initiation, effective blood pressure management remains insufficient at the population level (Fig.2).

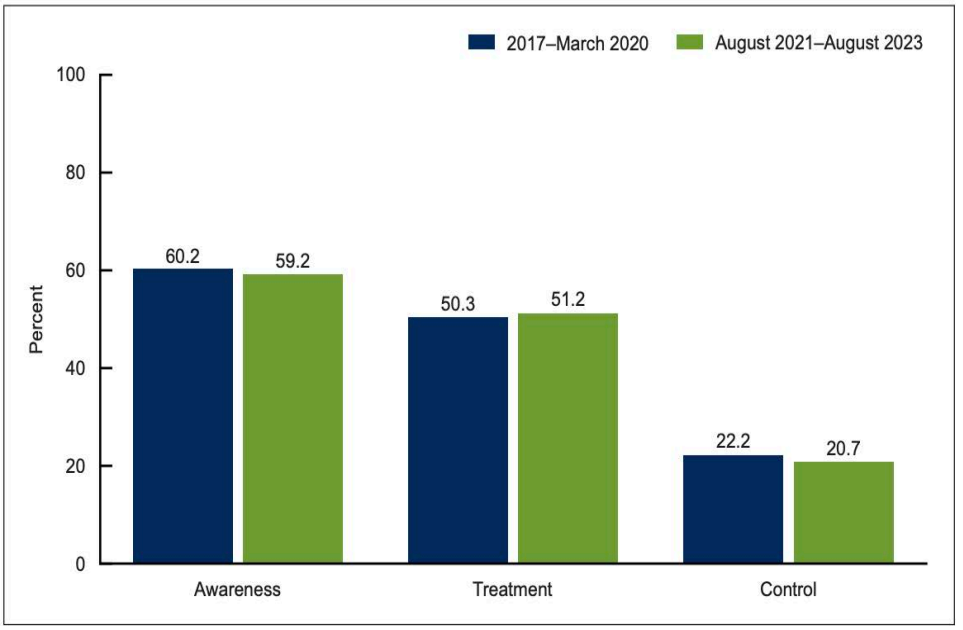

Fig.2 Prevalence of hypertension awareness, treatment, and control among adults aged 18 and older with hypertension: United States, 2017-March 2020 and August 2021-August 2023, 2017-March 2020 August 2021-August 2023 [12]

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3.4 Summary of Key Findings

Overall, the results indicate that Ultra-processed foods remain a predominant source of energy among both youth and adults, remaining consistently above 60% in youth and around 55% in adults, with only minor fluctuations between survey cycles. Hypertension awareness and treatment levels have remained relatively unchanged, but control rates have declined, underscoring an urgent public health concern. Dietary factors—particularly high intake of processed meats, sugar-sweetened beverages, and preserved foods—are strongly associated with elevated hypertension risk, whereas higher fruit, vegetable, and potassium intake demonstrate protective effects. Together, these findings emphasize the dual challenge of reducing population-level reliance on ultra-processed foods and improving hypertension control through both clinical and dietary interventions. These findings underscore the need for public health strategies that combine dietary education, promotion of minimally processed foods, and policy interventions such as taxation or labeling of ultra-processed products to mitigate hypertension risk at the population level.

4. Summary

This study highlights the pivotal role of dietary factors in shaping hypertension risk at the population level. Analysis of NHANES data revealed that ultra-processed foods consistently account for more than half of daily caloric intake among U.S. youth and adults, with little evidence of reduction over the past decade. Concurrently, hypertension awareness and treatment rates have remained stable, while control rates have declined, underscoring persistent challenges in effective disease management. Multivariable regression analyses confirmed that high intake of processed meats, sugar-sweetened beverages, and preserved foods significantly increased the odds of hypertension, whereas diets rich in fruits, vegetables, and potassium offered protective effects. Together, these findings provide robust evidence that dietary composition plays a critical role in blood pressure regulation and highlight the urgency of targeted nutritional interventions. This research offers actionable insights for public health nutrition strategies, including salt reduction, sugar control, and fruit and vegetable promotion. Given the cross-sectional nature of NHANES, future studies should employ longitudinal cohort designs to clarify causal pathways, while leveraging digital health technologies such as wearable devices and mobile applications to capture real-time dietary and blood pressure data, thereby enhancing precision in prevention strategies. The findings emphasize the importance of integrating dietary assessment with broader social and environmental determinants of health. Urban food environments, marketing practices, and socioeconomic disparities strongly influence access to healthy foods and adherence to dietary recommendations. Policymakers should therefore prioritize multi-sectoral collaboration involving healthcare providers, educators, and the food industry to promote sustainable dietary behavior change. Strengthening national surveillance systems and community-based nutrition programs can further support early detection and intervention for hypertension. Ultimately, translating dietary evidence into practical, culturally tailored policies will be essential to reduce population-level cardiovascular risk and promote long-term public health resilience. Such efforts will not only help mitigate the growing burden of hypertension but also contribute to achieving broader global health and sustainability goals.

References

[1] Hussain, M. M., Rafi, U., Imran, A., Rehman, M. U., & Abbas, S. K. (2024). Risk Factors Associated with Cardiovascular Disorders: Risk Factors Associated with Cardiovascular Disorders. Pakistan BioMedical Journal, 07(02), 03-10. https://doi.org/10.54393/pbmj.v7i02.1034

[2] Kumar, J. (2013). Epidemiology of hypertension. Clinical Queries: Nephrology, 2(2), 56–61. https://doi.org/10.1016/j.cqn.2013.04.005

[3] Mozaffarian, D. (2016). Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: a Comprehensive Review. Circulation, 133(2), 187–225. https://doi.org/10.1161/CIRCULATIONAHA.115.018585

[4] Huang, L., Trieu, K., Yoshimura, S., Neal, B., Woodward, M., Campbell, N. R. C., Li, Q., Lackland, D. T., Leung, A. A., Anderson, C. A. M., MacGregor, G. A., & He, F. J. (2020). Effect of Dose and Duration of Reduction in Dietary Sodium on Blood Pressure levels: Systematic Review and meta-analysis of Randomised Trials. BMJ, 368, m315. https://doi.org/10.1136/bmj.m315

[5] Malik, V. S., Popkin, B. M., Bray, G. A., Després, J.-P., Willett, W. C., & Hu, F. B. (2010). Sugar-sweetened Beverages and Risk of Metabolic Syndrome and Type 2 diabetes: a meta-analysis. Diabetes Care, 33(11), 2477–2483. https://doi.org/10.2337/dc10-1079

[6] Srour, B., Fezeu, L. K., Kesse-Guyot, E., Allès, B., Méjean, C., Andrianasolo, R. M., Chazelas, E., Deschasaux, M., Hercberg, S., Galan, P., Monteiro, C. A., Julia, C., & Touvier, M. (2019). Ultra-processed food intake and risk of cardiovascular disease: prospective cohort study (NutriNet-Santé). BMJ, 365(8201), l1451. https://doi.org/10.1136/bmj.l1451

[7] Svetkey, L. P. (1999). Effects of Dietary Patterns on Blood Pressure. Archives of Internal Medicine, 159(3), 285. https://doi.

org/10.1001/archinte.159.3.285
[8] Greer, R. C., Marklund, M., Anderson, C. A. M., Cobb, L. K., Dalcin, A. T., Henry, M., & Appel, L. J. (2020). Potassium-Enriched Salt Substitutes to Lower Blood Pressure. Hypertension, 75(2), 266–274. https://doi.org/10.1161/hypertensionaha.119.13241
[9] Hillier, S. E., & Olander, E. K. (2017). Women's dietary changes before and during pregnancy: A systematic review. Midwifery, 49, 19–31. https://doi.org/10.1016/j.midw.2017.01.014
[10] Zeraatkar, D., Cheung, K., Milio, K., Zworth, M., Gupta, A., Bhasin, A., ... & de Souza, R. J. (2019). Methods for the selection of covariates in nutritional epidemiology studies: a meta-epidemiological review. Current developments in nutrition, 3(10), nzz104. https://doi.org/10.1093/cdn/nzz104
[11] Williams, A., Couch, C., Emmerich, S., & Ogburn, D. (2025). Ultra-processed Food Consumption in Youth and Adults: United States, August 2021- August 2023. https://doi.org/10.15620/cdc/174612
[12] Fryar, C., Kit, B., Carroll, M., Afful, J., Warren, A., Zablotsky, B., Leadbetter, E., & Maitland, A. (2024). Hypertension Prevalence, Awareness, Treatment, and Control among Adults Ages 18 and Older:United States, August 2021—August 2023. NCHS Data Brief, 511. https://doi.org/10.15620/cdc/164016