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Lower 24- hour urinary sodium excretion is associated with hypertension control: the 2010 Heart Follow-Up Study

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Abstract

Among individuals with hypertension, controlling high blood pressure (BP) reduces the risk for cardiovascular events and death. Reducing dietary sodium can help achieve BP control. The study aim was to use a population-based sample utilizing the gold-standard for urinary sodium to quantify the degree with which sodium was independently associated with BP control among individuals with hypertension. Participants included 1 568 adults from the Heart Follow-Up Study, a New York City population-based representative study conducted in 2010. Participants collected urine for 24 hours and had BP and other anthropometrics measured. Hypertension was defined as systolic BP \geq 140 mmHg, diastolic BP \geq 90 mmHg, or being on BP lowering medication. Sodium intake (mg/day) was measured from a single 24-hour urine collection. Hypertension prevalence was 30.8%. Among those with hypertension, 64.6% were aware, 56.3% were treated, and 40.3% were controlled. Among those treated for hypertension, 73.0% were controlled. Mean sodium intake among those with hypertension was 3 564 mg/day. From multivariable adjusted logistic regression models, each 500mg decrease in 24-hour urinary sodium excretion was associated with a 18% higher odds of hypertension control among those with hypertension (1.18, 95% CI: 1.07, 1.30). In New York City, approximately one in three people has hypertension with a majority uncontrolled. Sodium intake among those with hypertension was 55% greater than recommended upper limit of 2 300 mg per day. Among individuals with hypertension, lower sodium intake was associated with hypertension control.

Keywords

hypertension; hypertension control; sodium; 24-hour urine

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CONFLICTS OF INTEREST/DISCLOSURES:

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INTRODUCTION

Hypertension (hypertension) is a major contributor to cardiovascular disease (CVD), the leading cause of death in the US.¹ Control of blood pressure (BP) among individuals with hypertension would avert approximately 46 000 deaths per year.² Thus, hypertension control is a major public health priority.³ Yet rates of hypertension and hypertension control are not uniformly distributed throughout the population. For example, populations with fewer economic resources and communities of color tend to have disproportionately higher rates of hypertension and/or lower rates of hypertension control.^{4–8} On-going surveillance of hypertension prevalence, awareness, treatment, and control is necessary to assess the impact of programmatic, clinical and policy interventions, including their effect on existing inequities.

Lifestyle modification, which includes adopting a healthy diet, such as Dietary Approaches to Stop Hypertension (DASH), can prevent and control hypertension^{9–11–10} and is also an important adjunct to medication treatment. Limited sodium intake complements the BP lowering impact of the DASH diet,^{12,13} yet sodium intake in relation to hypertension control has not been adequately explored in large population-based US studies. For example, studies that have examined sodium in relation to health outcomes have mostly utilized indirect sodium intake measurement methods which are subject to measurement error¹⁴ (e.g. dietary recall or food frequency questionnaire). To our knowledge, sodium measured directly from 24-hour urine collection, the gold standard measure of sodium intake,¹⁵ in a diverse US population-based representative sample, has never been assessed in relation to hypertension control.

Leveraging data from the New York City (NYC) Heart Follow-Up Study (HFUS), a population based sample representative of NYC adults, we aimed to 1) estimate the prevalence of hypertension, awareness, treatment, and control; and 2) examine whether 24-hour urinary sodium excretion is associated with hypertension control.

MATERIALS/SUBJECTS AND METHODS

Study Design

The HFUS is a cross-sectional study conducted in 2010 to assess sodium intake using 24-hour urine collection in a population-based, representative sample of NYC adults. Details of the study can be found in the comprehensive methodology report.¹⁶ Study participants were recruited from the Community Health Survey, an annual telephone survey conducted by the NYC Health Department that includes 8 000 to 10 000 adult New Yorkers.¹⁷ To obtain a representative sample of non-institutionalized adult New Yorkers, the Community Health Survey uses a dual frame sample design consisting of random-digit-dial landline telephone exchanges and a second frame of cellular telephone exchanges that cover NYC. The Community Health Survey also incorporates a disproportionate stratified random sample design to allow for analysis at the city, borough and neighborhood levels. Individuals who agreed to participate in the HFUS were mailed a urine collection kit, which included instructions on how to collect urine for a period of 24-hours. Medical technicians were scheduled to pick up each urine sample at the participants' home. The full clinical protocol,

including the 24-hour urine collection instruction booklet is available online.¹⁸ During the home visit, the medical technician took anthropometric measurements (height, weight, and blood pressure) and aliquoted urine from the participant's 24-hour collection and sent it directly to the research laboratory. Study participants also answered survey questions. The HFUS study was approved by the Institutional Review Board of the NYC Health Department and all participants provided informed consent. This study is registered at clinicaltrials.gov under NCT01889589.

Participation and Final Analytic Sample

Of the 6 799 Community Health Survey participants screened for the HFUS, 2 333 agreed to provide a urine sample, and 1 775 provided a 24-hour urine sample. Those who agreed to participate were slightly more likely than those who did not to be Latino, <65 years of age, have lower income, and to be obese. However, no meaningful difference in self-reported high blood pressure or general health status were observed between Community Health Survey and HFUS participants.[14] Anyone with an incomplete urine sample was excluded from the analysis (n=119). A urine sample was deemed incomplete due to the following implausibility criteria: total urine volume < 500 ml, creatinine < 6.05 mmol for men or < 3.78 mmol for women, or missing collection start or stop time.¹⁶ During data collection it was discovered that one technician used the incorrect BP cuff size to measure BP, thus 86 individuals for whom this applied were excluded from the analysis. An additional 2 participants were excluded due to missing hypertension medication information. From the original sample of 1 775, the 209 total participants excluded for reasons outlined above did not differ by age group, sex, race, or education from the final sample of 1 568 participants.

Blood pressure and hypertension measures

Blood pressure: BP was measured by a trained technician three times using a validated, automated sphygmomanometer (Model: Omron HEM 907)¹⁹ with 5 minutes rest in between each measurement, and readings were averaged.¹⁸ Hypertension was defined based on the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7),⁹ guidelines which were in place at the time the study was conducted, as: systolic BP of ≥ 140 mm Hg, or a diastolic BP of ≥ 90 mm Hg, or self-report of currently taking antihypertensive medications (described below). Awareness: Awareness was defined as having a self-report of hypertension among those with hypertension. Those who self-reported hypertension were also asked about age at which they were told this information. Treatment: was defined as self-reporting currently taking antihypertensive medications. Participants also self-reported whether their medications included a diuretic. Control: For hypertension control we considered 2 definitions. For our *first aim*, to describe rates of hypertension control, we defined hypertension control based on JNC7 clinical guidelines:⁹ having hypertension and SBP < 140 mmHg and a DBP < 90 mmHg for all individuals except those who self-reported having diabetes or chronic kidney disease, for whom control was defined as SBP < 130 mmHg and DBP < 80 mmHg. For our *second aim*, to examine whether 24-hour urinary sodium excretion is associated with hypertension control, we used one blood pressure control definition (SBP < 140 mmHg and DBP < 80 mmHg) for all individuals given that our interest was to understand the relationship

between sodium and blood pressure regardless of whether the person was meeting clinical treatment guidelines.

Urinary measures

24-hour urine samples were analyzed in the collaborating laboratory at Mount Sinai Hospital and Medical School for urinary sodium, potassium, albumin, and creatinine.¹⁶ Sodium and potassium were measured using the ion-selective electrode potentiometric method; albumin using the immunoturbidimetry using the Tina-quant methodology; and creatinine using the Jaffe kinetic colorimetric method, all on the Roche DPP Modular analyzer. Laboratory values were normalized to a 24-hour collection period.

Measures of other variables

Participants self-reported their: age, sex, race/ethnicity (defined as mutually exclusive categories: White, Black, Latino, Asian, or Other), educational attainment (classified as less than a high school (HS) education, a HS education or equivalent, or more than HS). Household income was also self-reported and grouped into households that make: less than 200% of the federal poverty level (FPL), 200–399% of the FPL, or 400% of the FPL or greater. Neighborhood poverty was defined based on the percentage of the population in each respondent's neighborhood (a conglomerate of geographically bordered and demographically similar zip codes or United Hospital Fund areas) below 200% of the FPL; categorized as a low, medium, or high poverty neighborhood. Participants reported their nativity and years living in the US which was then coded into either US born, which included Puerto Rico and US territories, or foreign-born. The foreign-born category was further dichotomized into those living in the US for < 10 years and those living here for 10 or more years. Insurance status (yes/no) was also self-reported.

Participants were additionally asked about a family history of CVD and reported whether they were told by a doctor that they had diabetes (not including during pregnancy). We calculated urinary albumin to creatinine ratio (UACR) and used a threshold value of 30 mg/g to indicate microalbuminuria (or chronic kidney disease).²⁰ During the in home visit, technicians measured weight in kilograms and height in meters. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared and grouped into 3 categories: < 25, 25 – 29.9, or 30 kg/m².

Participants were asked how often they had any alcoholic beverages in the last 30 days and about how many drinks they consumed on days that they did drink. Number of drinks per day was then calculated; a heavy drinker was defined as drinking 3 or more drinks per day among men or 2 or more drinks among women. Participants were also asked a series of questions regarding their physical activity habits. Responses were used to define physical activity levels as: meeting or not meeting 2008 physical activity guidelines.²¹ Finally, participants were asked, "Are you cutting down on salt to help [lower or control high blood pressure; prevent high blood pressure]?" response options were: "yes," "no," or "I don't add salt."

Statistical Methods

Socio-demographic, clinical, and behavioral characteristics of the population overall and by hypertension status were described; chi-square tests for categorical variables and t-tests for continuous variables were used to determine differences by hypertension status. The prevalence of hypertension, awareness, treatment, and control were estimated overall and by key socio-demographic characteristics; t-tests for proportions were used to test for differences across socio-demographic groups. Except for age-specific estimates, all estimates were age standardized to the 2000 US standard population.

For the second aim, to assess the association of sodium with hypertension control, we plotted the distribution of 24-hour urinary sodium excretion among individuals with hypertension by hypertension control status. Next, using logistic regression analyses, we modeled whether increments of 500mg less sodium was associated with hypertension control among all individuals with hypertension and among all individuals treated for hypertension. For these models, we adjusted for: socio-demographics (age, sex, race, education, income, nativity/years in the US, insurance status), clinical characteristics (family history of CVD, diabetes, microalbuminuria, BMI), and behavioral characteristics (heavy drinking, meeting 2008 physical activity guidelines, 24-hour urinary potassium excretion, and self-reporting reducing salt to control BP). Given that diuretic use can alter electrolyte excretion,²² we also directly tested for an interaction between diuretic use and sodium excretion in relation to hypertension control. In a supplementary analysis, we stratified our logistic regression models by diuretic use. Statistical significance was determined at the $\alpha=.05$ level and $\alpha=.10$ for interactions. Data were analyzed using SUDAAN software (version 11.0; Research Triangle Institute, Research Triangle Park, North Carolina).

Code Availability

Code used to analyze these data can be shared following an email request.

RESULTS

Compared to individuals without hypertension, those with hypertension were older, more likely to be: men (61.0% vs. 43.7%), Black (30.1% vs. 18.6%), have a household income less than 200% of the FPL (56.1% vs. 44.7%; Table 1), have a higher mean BMI (31.7 kg/m² vs. 26.8 kg/m²), report a family history of CVD (46.3% vs. 35.3%), and report having diabetes (16.9% vs. 7.1%), Table 1. Mean urinary sodium excretion was significantly higher among individuals with hypertension compared to those without hypertension (3 564 vs. 3 120 mg/day, $p=0.04$).

In 2010, the prevalence of hypertension in NYC was 30.8% (Figure 1). hypertension prevalence was higher in: older adults, men vs. women (34.6% vs. 27.4%), Blacks vs. Whites (41.1% vs. 24.7%), among those living in with an income below 200% of the FPL vs. above 400% of the FPL (35.1% vs. 24.0%), and among those living in neighborhoods of high vs. low poverty (37.3% vs. 24.5%).

The prevalence of hypertension awareness, treatment, and control is displayed in Table 2. Among individuals with hypertension, the prevalence of hypertension awareness was 64.6%,

with a mean age of first being told of their diagnosis by a provider of 46.2 years (data not shown). Hypertension awareness was more common among: older vs. younger adults, women vs. men, and those born in the US vs. foreign-born with < 10 years in the US. Among individuals with hypertension, the prevalence of treatment was 56.3%; treatment was more common among: older vs. younger adults and women vs. men. Among individuals with hypertension, the prevalence of hypertension control was 40.3%, with a greater prevalence of control among: older vs. younger adults, women vs. men, Whites vs. Latinos, those born in the US vs. foreign-born with < 10 years in the US, and among those with vs. without health insurance. Among individuals treated for hypertension, 62.9% were clinically controlled.

The distribution of 24-hour urinary sodium excretion among individuals with hypertension according to hypertension control is displayed in Figure 2. Mean 24-hour urinary sodium excretion was not significantly different among individuals with controlled vs. uncontrolled hypertension (3 072mg vs. 3 799mg, $p=0.06$). However, among individuals treated for hypertension, mean 24-hr urinary sodium excretion was lower among those with controlled vs. uncontrolled hypertension (3 072 vs. 4 224, $p=0.03$).

From fully adjusted logistic regression models (Table 3), each 500mg incremental decrease in 24-hr urinary sodium excretion was associated with a higher odds of hypertension control among all individuals with hypertension (OR: 1.18, 95% CI: 1.07, 1.30) and among individuals treated for hypertension (OR: 1.21, 95% CI: 1.08, 1.36).

Among individuals treated for hypertension, there was a significant interaction between 24 hour urinary sodium excretion and diuretic use ($p=0.052$), resulting in stratified models (presented in supplemental Table 1). From these fully adjusted models, among individuals treated for hypertension, each 500mg incremental decrease in 24-hr urinary sodium excretion was associated with hypertension control among those on diuretics (OR: 1.37, 95% CI: 1.09, 1.71); with no association among those not taking diuretics (OR: 1.12, 95% CI: 0.96, 1.31).

DISCUSSION

In 2010, almost one in three NYC adults had hypertension, including a substantial proportion who were unaware. Among those with hypertension, 64.6% were aware, 56.3% were treated, and only 40.3% were clinically controlled. Mean urinary sodium excretion in NYC adults with hypertension was 3 564mg/day, 55% higher than current recommendations of no more than 2 300 mg/day (for the general population free of hypertension).²³ Urinary sodium excretion was strongly and inversely associated with hypertension control; each 500 mg incremental decrease in urinary sodium excretion was independently associated with a 18% higher odds of control among those with hypertension, and with a greater association among individuals treated for hypertension, especially on diuretics.

Our estimates of the prevalence of hypertension, treatment, and control by key demographic characteristics mirrors other findings during the same time period. For example, the 2010 NYC hypertension prevalence of 30.8% from the current study is similar to the national

estimate of 30% using data from the 2007–2010 NHANES cycle.²⁴ Likewise, data from NHANES has also shown that among women vs. men, the prevalence of hypertension is lower, while the prevalence of hypertension awareness, treatment, and control is higher.²⁴ Also consistent with prior studies,^{25,26} we found that the prevalence of hypertension and hypertension awareness was highest in Blacks, yet the prevalence of hypertension control was low in this group (significantly lower than Whites in the fully adjusted models-not shown). In NYC, premature mortality rates of heart disease and stroke in Blacks are higher than Whites.²⁷ Addressing such disparities in hypertension in control will be an essential for eliminating race inequities in early death.

Due to differences in BP measurement methodology, we were unable to directly compare other estimates of hypertension in NYC. Despite this limitation, it is interesting to note that in 2004, the prevalence of hypertension in NYC, also clinically measured, was 25.6%.²⁶ This perceived increase appears to be largely driven by rising rates of hypertension among younger age groups. For example, the prevalence of hypertension among those aged 20–44 was 6.5% in 2004²⁶ and 12.5% in the current 2010 study. Likewise, among those aged 45–64, the prevalence of hypertension was 31.4% in 2004 and 43.2% in the current 2010 study.²⁶ The National Longitudinal Study of Adolescent Health (Add Health) produced similar results, showing an unexpectedly high prevalence of hypertension (19%) among younger adults age 24–32 in 2008.²⁸ These data, suggestive of increasing rates of hypertension among younger age groups, are troubling for several reasons. First, earlier exposure to high BP is associated with increased CVD risk.²⁹ Further, rates of hypertension awareness, treatment, and control tend to be lower among younger vs. older adults, as shown from the current results and from other studies.^{30,31} Taken together, these findings suggest that routine clinical surveillance and awareness education efforts should be targeted to include younger populations.

Lifestyle modification is known to improve hypertension control.¹¹ It is estimated that on average, adopting a DASH eating plan, limiting sodium intake, engaging in physical activity, and limiting alcohol consumption could help reduce SBP by approximately 8–14, 2–8, 4–9, and 2–4 mm Hg respectively.¹⁰ Notably, in our study, we found that each 500 mg lower increment of urinary sodium excretion was independently associated with a 18% higher odds of hypertension control among all with hypertension and among those treated for hypertension with any drug. This association between lower sodium intake and hypertension control is at least partly attributable to the stronger association between sodium and BP among individuals with vs. without hypertension,³² which is perhaps a reflection of greater salt sensitivity among those with hypertension. Interestingly, among individuals with hypertension reporting taking diuretics, each 500 mg lower increment of urinary sodium excretion was independently associated with a 37% higher odds of hypertension control, a substantially stronger effect size in this restricted sample. Though striking, we were unable to determine whether these findings reflect a true association, or are indicative of a differential bias in the measurement of sodium among diuretic users. However, these findings do underscore the importance of properly accounting for medication usage and type, especially within the context of urinary sodium and potassium excretion.

The current study is not without limitations. Due to the cross-sectional design of the study, it was not possible to establish temporality. Further, our definition of hypertension may have been subject to measurement error: 1) BP was only assessed at one visit; typically high BP is necessary at two visits before an official hypertension diagnosis can be made⁹ and 2) the hypertension definition was not inclusive of individuals who may have been lifestyle controlled (i.e. those self-reporting hypertension, not on medications, and without elevated BP on exam). Despite this, any potential bias due to this measurement error is unlikely to be differential and thus estimates are likely biased, if at all, towards the null. Additionally, the study sample only consisted of 560 individuals with hypertension and therefore was not powered for sub-group analyses – or even of larger subgroups of the NYC population such as Asian Americans, who may be particularly vulnerable given their highly sodium dense diets.^{33,34} Further, 24-hour sodium excretion only reflects sodium intake on one day only and may not accurately reflect habitual sodium intake.³⁵ Finally, there are a variety of criteria in the published literature for ruling out incomplete collections³⁶ and thus studies like ours can be subject to underestimation of sodium excretion if a significant number of incomplete collections are included. While we applied criteria from other studies for volume and non-adjusted creatinine to create cut-offs to minimize this risk,³⁷ we acknowledge that our sample may still have included incomplete collections biasing our results towards the null. Despite such limitations this study possesses notable strengths. It is the first study of its kind to estimate sodium consumption in a local US population based sample using the gold standard of 24-hour urine collection. Thus, both the exposure and outcome measures were objectively assessed in this large, diverse, representative population.

The prevalence of hypertension in NYC is high; almost one in three adult residents has hypertension. Concurrently rates of hypertension awareness, treatment, and control are sub-optimal, particularly among younger adults. Inequities by race/ethnicity, particularly among Blacks, are substantial. Surveillance and interventions that result in sustained improvements of modifiable behaviors associated with hypertension—such as sodium intake—including closing existing disparities, is essential. In the current study, urinary sodium excretion was high and also found to be a strong and independent factor associated with hypertension control. These findings highlight gaps in hypertension awareness, treatment, and control—particularly among younger populations and people of color—and emphasize the importance of sodium reduction as a means to achieve BP control among individuals and populations with hypertension.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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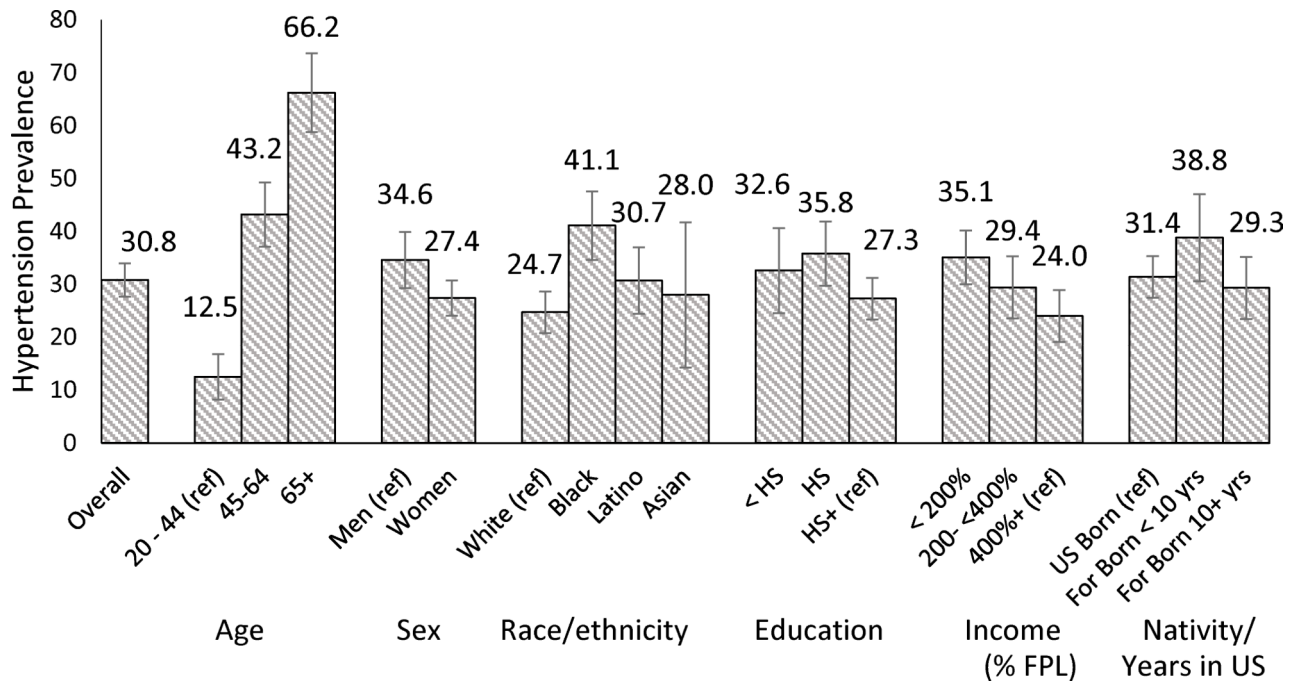


Figure 1:
 Prevalence of hypertension according to socio-demographic characteristics, HFUS 2010.
 HFUS: Heart Follow-Up Study; HS: High school; US: United States
 All estimates are age adjusted to the US 2000 standard population (except age specific estimates).
 Boldface indicates an estimate’s relative standard error, a measure of precision is large (30%) and should be interpreted with caution.
 *Indicates estimate is significantly different from the reference, $p < 0.05$.

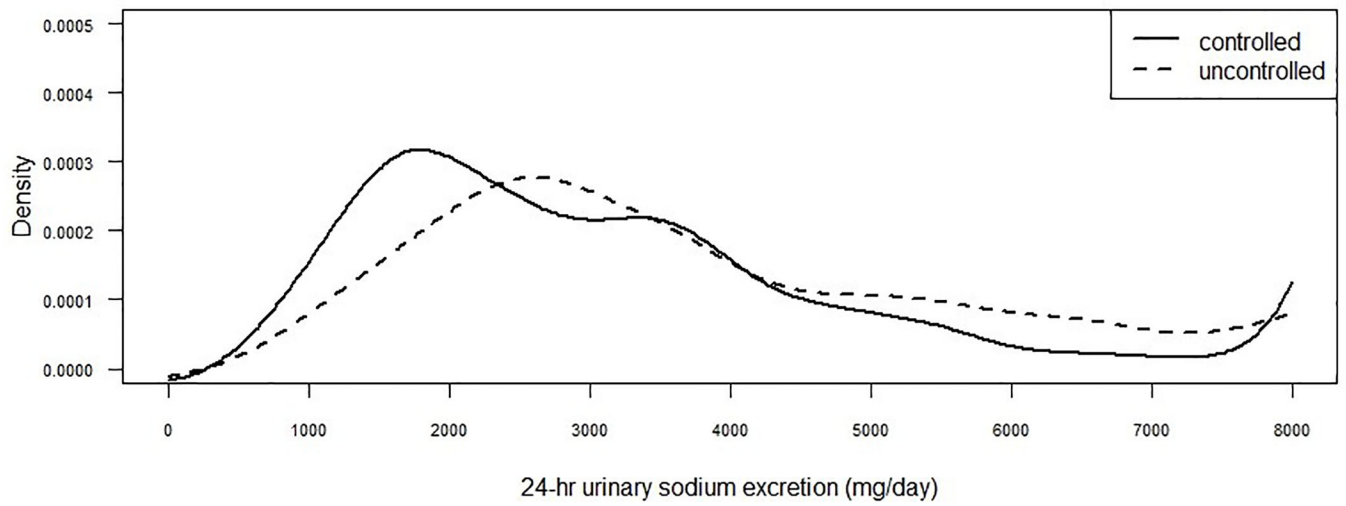


Figure 2:
 Distribution of 24-hour urinary sodium excretion by BP control† in those with hypertension, HFUS 2010.
 † defined by systolic blood pressure <140 mmHg and a diastolic blood pressure BP <90 mmHg for all individuals

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Table 1:

Characteristics by overall sample and those with and without hypertension, HFUS 20010.

	Overall (unweighted N=1568)		Hypertension Status				P-Value
			Yes (unweighted n=560)		No (unweighted n=1008)		
	% or Mean	SE	% or Mean	SE	% or Mean	SE	
Age group, %							<0.01
18–44	56.1	1.9	23.7	3.6	69.7	2.0	
45–64	28.2	1.6	41.3	3.3	22.7	1.8	
65+	15.7	1.2	35.0	3.1	7.5	1.0	
Men, %	45.8	2.0	61.0	3.6	43.7	2.4	0.01
Race, %							<0.01
White	38.9	1.8	29.6	3.8	42.7	2.3	
Black	23.0	1.6	30.1	4.5	18.6	1.8	
Latino	23.7	1.7	23.2	4.5	23.8	2.0	
Asian	10.5	1.5	14.2	5.1	11.9	1.9	
Education, % < High School	20.9	1.8	23.5	4.6	20.4	2.2	0.08
Poverty, % < 200% FPL	48.1	2	56.1	5.1	44.7	2.4	0.04
Neighborhood poverty, % high poverty	30	1.6	39.1	5.1	26.7	1.8	0.01
Nativity/years in the US, %							0.83
US Born	56.3	2	59.9	5.3	56.3	2.4	
Foreign Born in US 10+ years	34.7	2	32.8	5.1	35.2	2.4	
Foreign Born in US < 10 years	9	1.2	7.4	2.8	8.5	1.3	
Has health insurance, %	82.5	1.6	79.2	4.7	83.5	1.7	0.27
Clinical Characteristics							
Family history of CVD, %	39	1.8	46.3	4.6	35.3	2.2	0.01
Body mass index (kg/m ²), mean	28.1	0.3	31.7	0.6	26.8	0.3	<0.01
<25 (kg/m ²), %	33.7	1.9	15.1	3.5	41.6	2.3	
25 – 29.9 (kg/m ²), %	35.6	2	34.7	5.1	37.3	2.4	
30+ (kg/m ²), %	30.8	1.8	50.2	5.2	21.1	2	
Systolic BP (mmHg), mean	122	0.6	136.3	1.3	117	0.5	<0.01
Diastolic BP (mmHg), mean	74.4	0.4	84.7	0.8	71.6	0.4	<0.01
Hypertension medication use, %	22.4	1.3	56.3	4.6			
Diuretic use, %	10.5	1	22.8	2.1			
Diabetes, %	11.2	1.1	16.9	2.2	7.1	1.3	<0.01
Microalbuminuria, %	10.2	1.2	11.5	1.9	7.6	1.3	<0.01
Mean urinary creatinine excretion (mmol/24 hours)							
Men	11.7	0.3	11.8	0.7	11.6	0.4	0.74
Women	8.8	0.3	9.1	0.5	8.6	0.3	0.31
Behavioral Characteristics							
Heavy Drinker, %	5.2	1	5.3	2.6	5.4	1.2	0.86

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	Hypertension Status						P-Value
	Overall (unweighted N=1568)		Yes (unweighted n=560)		No (unweighted n=1008)		
	% or Mean	SE	% or Mean	SE	% or Mean	SE	
Meets 2008 physical activity guidelines, %	62.9	2	63.9	4.5	65	2.4	0.45
Reduces salt to control blood pressure, %	55.9	2	71.8	4.9	48.6	2.3	<0.01
Sodium (mg/day), mean	3196	59	3564	207	3120	66	0.04
Potassium (mg/day), mean	2173	42	2196	129	2203	48	0.96

BP: blood pressure; CVD: cardiovascular disease; FPL: federal poverty limit; HFUS: Heart Follow-Up Study; SE: standard error.

All estimates are age adjusted to the US 2000 standard population (except age specific estimate).

Boldface indicates an estimated relative standard error, a measure of precision is large (> 30%) and should be interpreted with caution.

Heavy drinker is defined as 2 or more drinks per day among women or 3 or more among men

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Table 2:

Prevalence of hypertension awareness, treatment, and control by demographic characteristics, HFUS 2010.

	Individuals with hypertension (unweighted n=560)						Individuals treated for hypertension (unweighted n=423)	
	Awareness		Treatment		Control		Control [‡]	
	%	SE	%	SE	%	SE	%	SE
Overall	64.6	5.1	56.3	4.6	40.3	4.5	62.9	6.4
Age group								
20 – 44 (ref)	46.2	9.2	32.7	8.3	22.3	7.9	68.2	11.6
45–64	83.3*	3.6	80.7*	3.7	45.4*	4.6	56.3	5.0
65+	89.1*	3.3	87.0*	3.5	50.3*	5.4	57.9	5.8
Sex								
Female (ref)	76.9	6.7	69.1	7.0	45.5	7.5	67.8	7.4
Male	57.1*	6.4	48.2*	5.7	26.4	5.4	58.2	9.0
Race								
White (ref)	65.2	7.8	64.1	7.8	43.6	7.3	68.0	10.3
Black	76.1	7.7	54.5	7.2	29.0	6.7	53.0	12.2
Latino	52.9	7.3	46.4	5.8	23.6*	4.5	42.1	12.6
Asian	68.9	14.2	68.9	14.2	53.1	15.7	83.7	6.9
Education								
More than high school (ref)	65.4	6.9	62.9	6.9	39.7	7.1	66.3	7.6
High school	66.8	9.3	47.4	5.8	23.1	4.0	42.1	12.2
Less than high school	62.8	10.7	53.3	8.8	35.0	8.4	68.6	11.2
Poverty level								
400%+ FPL (ref)	64.4	8.0	57.1	7.2	29.4	5.9	52.8	10.9
200 – 400% FPL	83.7	8.2	82.9	8.2	44.3	12.2	53.7	14.0
Less than 200% FPL	63.4	7.4	52.8	6.8	35.9	6.9	73.5	6.5
Neighborhood poverty								
Low (ref)	57.3	9.7	56.1	9.7	28.6	5.4	42.6	12.2
Medium	73.1	7.6	71.0	7.8	47.4*	8.5	69.2	6.7
High	61.2	7.3	45.0	3.6	25.4	3.4	57.5	9.8
Nativity/years in the US								
US Born (ref)	71.0	5.8	61.0	5.9	38.0	6.2	65.6	6.7
Foreign Born, 10+ yrs in US	60.5	8.5	54.1	7.0	30.2	5.2	53.3	12.2
Foreign Born, < 10 yrs in US	31.8*	5.7	31.8	5.7	18.1*	6.2	27.9*	7.5
Insurance coverage								
Yes (ref)	69.2	5.9	62.4	5.8	39.2	5.7	65.0	16.4
No	47.3	9.8	35.5	7.2	10.1*	3.6	34.7	16.4

FPL: federal poverty limit; HFUS: Heart Follow-Up Study; SE: standard error; Yrs: years.

All estimates are age adjusted to the US 2000 standard population (except age specific estimate). Yrs: years.

Boldface indicates an estimated relative standard error, a measure of precision is large ($\geq 30\%$) and should be interpreted with caution.

* Indicates estimate is significantly different from the reference, $p < 0.05$.

‡ Control is defined as systolic blood pressure < 140 mmHg and a diastolic blood pressure BP < 90 mmHg for all individuals except those who self-reported having diabetes or chronic kidney disease, for whom control was defined as systolic blood pressure < 130 mmHg and a diastolic blood pressure BP < 80 mmHg

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Table 3:

Association of 24-hour urinary sodium excretion with hypertension control[‡], HFUS 2010.

	Among all individuals with hypertension (unweighted n=560)		Among individuals treated for hypertension (unweighted n=423)	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Per 500 mg less sodium				
Model 1	1.05	0.97, 1.14	1.11 [*]	1.06, 1.21
Model 2	1.07	0.99, 1.16	1.11 [*]	1.02, 1.21
Model 3	1.11 [*]	1.02, 1.20	1.11 [*]	1.00, 1.23
Model 4	1.18 [*]	1.07, 1.30	1.21 [*]	1.08, 1.36

[‡]Control is defined as systolic blood pressure <140 mmHg and a diastolic blood pressure BP <90 mmHg for all individuals.

^{*} indicates estimate is significant, p<0.05

CI: Confidence interval; HFUS: Heart Follow-Up Study

Model 1 is adjusted for: age, sex, race, education, poverty, nativity/years in the US, and insurance status.

Model 2 additionally adjusts for: family history of CVD, diabetes, microalbuminuria, and BMI.

Model 3 additionally adjusts for: heavy drinking, meeting 2008 physical activity guidelines, potassium intake, and reducing salt to control BP.

Model 4 additionally adjusts diuretics

Summary Table

What is Known about the topic	What this study adds
<ul style="list-style-type: none">• High sodium consumption is associated with higher blood pressure.• On a population basis, sodium consumption is in excess.	<ul style="list-style-type: none">• In 2010, the prevalence of hypertension among New York City residents was 30.8% with 64.6% aware, 56.3% treated, and only 40.3% controlled.• Mean 24-hour urinary excretion among New York City residents with hypertension was 3,564 mg/day, exceeding the recommendation of < 2,300 mg/day by 55%.• Every 500 mg decrement of urinary sodium excretion was associated with an 18% greater odds of hypertension control.

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