Diet and Blood Pressure: Differences among Whites, Blacks and Hispanics in New York City 2010

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Objectives: Our study examined: 1) racial/ethnic differences in sodium and potassium intake; and 2) racial/ethnic differences in the relationship between dietary intake and blood pressure.

Design & Methods: Data were collected in New York City in 2010, and included a telephone health survey, a 24-hour urine collection and an in-home clinical exam. Linear regression was used to examine the association of sodium and potassium intakes with blood pressure separately by race/ethnicity, age and sex among 1568 participants.

Results: The results indicate large differences by population subgroup in: 1) nutrient intake, and 2) the relationship between sodium and potassium intake and blood pressure. Black and Hispanic males aged ≤50 consume considerably more sodium and less potassium than their White counterparts. The regression results indicate a strong association between diet and blood pressure among Blacks and Hispanics only.

Conclusions: Based on our assessment of the association of sodium and potassium intakes and blood pressure measurements, we find that young Black and Hispanic males aged ≤50 years have the poorest diet quality and may be the most at risk for developing diet-related hypertension. (*Ethn Dis*. 2014; 24[2]:175–181)

Key Words: Hypertension, Nutrition, Blood Pressure, Racial/Ethnic Differences

Background

Hypertension is a major modifiable risk factor for cardiovascular disease, which is the leading cause of death nationally and in New York City (NYC).[1,2] Previous studies have found the prevalence of hypertension among Blacks to be roughly twice that among Whites, and the mortality risk from hypertension among Blacks with hypertension is more than twice that of Whites with hypertension.[3–5]

High sodium intake may be more strongly associated with high blood pressure and hypertension among Blacks compared with Whites.[6] Low potassium intake can indicate a lack of fruit and vegetable consumption, which can increase blood pressure[7] and appears to have a greater influence on hypertension in Blacks compared with Whites.[8–10] The ratio of sodium to potassium serves as an overall indicator of diet quality.[3,9]

Previous research on population-level nutrient intake in the United States has relied upon self-reported dietary intake measures from the National Health and Nutrition Examination Survey (NHANES). The Survey's median daily sodium intakes were: (3423 mg/day) among Whites compared to (3161 mg/day) among Blacks; NHANES median potassium intakes were lower among Blacks (2193 mg/day) compared to Whites (2712 mg/day).[11] The age pattern of hypertension differed both by race and by sex.[12] Prior studies have found that Blacks aged ≤50 have a higher mortality risk from hypertension and cardiovascular disease, as much as seven times the mortality risk of Whites aged ≤50 years.[5,13] The prevalence of hypertension among women aged ≤50 years is substantially lower than that of men; these prevalence rates converge after age 50, which corresponds to hormonal changes among women after menopause.[12]

Self-reported intake data, such as data collected by NHANES, can be subject to bias in reporting, which may vary systematically with education and socioeconomic status.[14] While 24-hour urine collections have been used in the United Kingdom, Canada, Australia and Finland as the gold standard for sodium intake,[15–17] to our knowledge, they have not been used to represent population-level data in the United States. Using objective rather than self-reported data in a large racially diverse population-based sample, we test the hypotheses that there are differences by race/ethnicity in: 1) nutrient intake, and 2) the relationship between diet and blood pressure.

Methods

Study Design

Our study used data from the Heart Follow-Up Study (HFUS), conducted by the NYC Department of Health and Mental Hygiene in 2010. The HFUS was a follow-up to the 2010 Community Health Survey (CHS), an annual telephone-based (both cell phones and landlines) health survey of 8,000–10,000 NYC adults.[18] The CHS recruited participants based on 42 zip

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code-based neighborhoods to ensure geographic representation across NYC.

Detailed information on HFUS recruitment and participation has been published previously.[19] The HFUS excluded individuals who were: pregnant, breastfeeding or lactating, or on current or past dialysis. The HFUS participants received telephone instructions on participation, were mailed a urine collection kit, scheduled a home visit with a medical technician, and performed a 24-hour urine collection. The home visit occurred the day after collection. Medical technicians first collected a signed consent form, and proceeded to aliquot the 24-hour urine collection, record anthropometric measurements (height, weight and waist circumference) and take three seated blood pressure readings according to NHANES protocol.[20] The urine samples were sent to a collaborating laboratory for the analysis.

The Institutional Review Board of the NYC Health Department approved this study. Participants received $100 compensation for study completion.

Study Population

Of the CHS participants surveyed in 2010, 5830 adults were eligible for participation in HFUS; of these, 2333 (40.0%) agreed to participate and 1775 (30.4%) completed participation. Incomplete samples were defined as those with total urine volume <500 mL or a urinary creatinine level <6.05 mmol/L in males and <3.78 mmol/L in females, based on biologic implausibility. Participants who self-reported missing a urine collection during the 24-hour period were excluded. More detailed information can be found in the appendix of Angell et al.[21]

Incomplete samples or invalid samples, including 86 samples with medical technician errors, were excluded from the final dataset. Of 1568 participants with valid samples, 1453 classified themselves as White, Black or Hispanic, and were included in the analysis.

Measurement and Definitions

All sodium, potassium, albumin and creatinine testing was performed by a single laboratory. Sodium and potassium content were determined using the ion-selective electrode potentiometric method on the Roche DPP modular analyzer. Urinary creatinine was determined using the Jaffe kinetic colorimetric method on the Roche DPP modular analyzer.

USDA/FDA Dietary Guidelines recommend a sodium limit of 2300 mg/day for individuals not at high risk of hypertension and a sodium limit of 1500 mg/day for those at high risk,[6,22] including those aged >50 years, Blacks, or individuals with hypertension (HTN), diabetes or chronic kidney disease. Hypertension was defined according to NHANES criteria as an average of three measurements with: systolic blood pressure (SBP) of ≥140 mm Hg, or an average diastolic blood pressure (DBP) of ≥90 mm Hg. Individuals who reported taking antihypertensive medications were classified as hypertensive. Chronic kidney disease was defined as having a 24-hour albumin excretion of >30 mg/day.

Information on demographics (age, sex, race/ethnicity, income) and health conditions and behaviors were obtained via self-report during the survey. Body mass index was calculated from exam measurements of height and weight.

Statistical Methods

All analyses incorporated sampling weights based on the 2006-2008 American Community Survey to account for sampling design, oversampling and nonresponse. All laboratory values were normalized to represent a 24-hour period based on report of urine collection start and end times.

To estimate the relationship between nutrient intake and blood pressure, the study estimated linear regression models of SBP (mm Hg), by nutrient intake (sodium, potassium, and the sodium-to-potassium ratio). These models were stratified for a total of 12 subgroups by race/ethnicity, sex and age. All models were adjusted for BMI and self-reported heavy drinking, income, and age (continuous) to account for age-related blood pressure increases within the two age groups. Adjustments for antihypertensive medication (not shown) did not change the results of the model; models for diastolic blood pressure (not shown) presented similar patterns. Data were analyzed using SAS version 9.2 and SUDAAN software (version 10.0; Research Triangle Institute, Research Triangle Park, North Carolina).

RESULTS

Table 1 presents demographic data with raw sample sizes and weighted proportions. The data indicated differences in both income and obesity status by race/ethnicity, thus requiring a need to control for the characteristics in our regression models.

Table 2 shows the results from our first hypothesis and indicated large differences in nutrient intake by race/ethnicity and age. Blacks in NYC, particularly Black males aged ≤50 years, consumed much larger amounts of sodium and much smaller amounts of potassium than their White counterparts. Most notably, Black males aged ≤50 years in NYC had a mean sodium intake of 4360 mg/day compared to 3240 mg/day for White males aged ≤50 years ($P<.001$).

Additionally Black males had a lower potassium intake than White males, suggesting a lower intake of fruits and vegetables. For Black males aged ≤50 years the mean potassium consumption was 1860 mg/day compared to 2740 mg/day for White males ($P<.001$); the value was 2030 mg/day for Hispanic males aged ≤50 years ($P<.01$). The intake data also indicated that White females aged ≤50 consumed significantly more potassium than other female groups ≤50 years of age

Table 1. Demographic characteristics of the study population

		Males			Females		
	All	White	Black	Hispanic	White	Black	Hispanic
Weighted population, *n*	6,222,960	1,275,456	633,485	507,835	1,101,478	801,192	1,011,832
Unweighted sample size	1568	299	157	152	285	256	304
Sample size (aged ≤50)	796	129	91	97	102	135	177
Sample size (aged >50)	772	170	66	55	182	119	125
Weighted distributions, %							
Age group							
18–44	56.1	54.2	63.3	71.3	45.0	53.0	62.2
45–64	28.2	26.2	31.6	23.4	30.8	30.0	24.7
≥65	15.7	19.6	5.0	5.3	24.2	17.0	13.1
Poverty/Income[a]							
<200%	52.8	22.6	63.2	67.9	29.9	63.2	84.5
200–399%	16.0	17.4	14.5	18.1	19.5	20.2	9.3
≥400%	31.2	60.0	22.3	14.0	50.6	16.6	6.2
(Missing)	(11.2)	(6.4)	(8.3)	(10.9)	(16.6)	(10.2)	(10.3)
Heavy drinking[b]							
Yes	5.4	8.3	2.0	3.2	11.7	7.3	1.2
BMI Categories							
Underweight	2.5	.4	3.5	2.0	5.2	.2	4.6
Healthy weight	31.5	31.5	21.4	28.2	45.8	23.1	15.6
Overweight	35.6	47.4	41.7	27.5	23.4	24.2	42.9
Obese	30.3	20.8	33.4	42.4	25.6	52.6	36.9
Age ≤50 - blood pressure category[c]							
Healthy blood pressure	56.6	44.8	23.5	34.5	77.0	69.7	71.9
Pre hypertensive	28.2	41.6	47.5	42.5	19.2	13.5	18.2
Treated hypertension	6.1	6.6	3.5	5.0	2.0	11.7	4.5
Untreated hypertension	9.2	7.1	25.6	18.0	1.8	5.1	5.4
Age >50 - blood pressure category							
Healthy blood pressure	17.3	19.7	7.6	14.2	20.3	15.6	14.0
Pre hypertensive	25.3	29.4	23.1	29.8	27.6	13.9	30.3
Treated hypertension	49.8	40.0	58.8	26.8	47.1	66.1	52.2
Untreated hypertension	7.5	10.9	10.5	29.3	5.1	4.4	3.5
HTN, (NHANES definition)	29.6	27.5	40.2	30.0	26.4	37.0	23.0
HTN age ≤50	15.2	13.6	29.0	23.0	3.8	16.8	10.0
HTN age >50	57.3	50.9	69.3	56.0	52.2	70.4	55.7
All ages - currently taking HTN Meds (aware of HTN)	71.5	76.7	59.0	50.9	84.9	67.9	55.6
All ages - currently taking HTN Meds (everyone)	21.7	19.4	19.3	11.3	23.6	32.4	18.7

BMI, body mass index; HTN, hypertension.
[a] Poverty/income is based on the household-level federal poverty line (FPL) with 100% representing the FPL.
[b] Heavy drinking was defined as men reporting ≥2/drinks per day and women ≥1/drinks per day.
[c] NHANES healthy blood pressure: systolic BP (SBP) <120 and diastolic BP (DBP) <80; prehypertension SBP 120–139 or DBP 80–89; treated HTN - individuals with healthy BP who are taking antihypertensive medication; untreated HTN, individuals taking antihypertensive medication but with unhealthy BP.

(2340 mg/day for Whites; 1600 mg/day for Blacks, $P<.001$; and 1860 mg/day for Hispanics, $P<.01$).

Overall, the differences by race/ethnicity in sodium or potassium consumption were less extreme among older individuals (aged>50). Older Black males did not differ from older White males in sodium intake, although they did consume less potassium (2190 vs 2620 mg/day, $P<.001$).

Table 2d shows that Black males (all) had a higher SBP than White males (all) with means of 132 vs 124 mm Hg for age ≤50 ($P<.001$); and 136 vs 129 mm Hg for age >50 ($P<.05$) using a two sample *t*-test. There were no significant differences in blood pressure between White males and Hispanic males. The sodium-to-potassium ratio has been shown to have a stronger association with higher blood pressure than either sodium or potassium alone[3,9] and shows that Whites had a healthier diet than Blacks or Hispanics in NYC (Figure 1). The ratio for Whites was 1.33 compared to a ratio of 2.15

Table 2. Weighted means of key variables: sodium, potassium, sodium-to-potassium, and blood pressure

	All (*n*=1568)		White (*n*=584)		Black (*n*=413)		Hispanic (*n*=456)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
A. Sodium, mg/d								
both sexes	3200	60	3030	90	3420[a]	140	3360[a]	130
males - all	3540	100	3240	120	4110[c]	220	3920[a]	250
age ≤50	3610	130	3240	160	4360[c]	240	4030[a]	260
age >50	3370	120	3240	150	3460	280	3490	290
females - all	2920	70	2780	140	2870	140	3080	120
age ≤ 50	2990	100	2990	190	3020	160	3000	130
age >50	2790	90	2550	140	2620	200	3290[b]	190
B. Potassium, mg/d								
both sexes	2170	40	2540	80	1800[c]	80	2000[c]	60
males - all	2380	80	2770	130	2040[c]	130	2070[c]	110
age ≤50	2270	100	2740	170	1860[c]	110	2030[b]	120
age >50	2620	80	2820	110	2490	260	2190[c]	120
females - all	1990	40	2280	80	1620[c]	80	1970[b]	80
age ≤50	1940	60	2340	120	1600[c]	100	1860[b]	80
age >50	2060	60	2210	90	1640[c]	80	2250	150
C. Ratio of sodium to potassium								
both sexes	1.68	.04	1.33	.05	2.15[c]	.09	1.82[c]	.06
males - all	1.71	.05	1.32	.06	2.29[c]	.13	2.02[c]	.10
age ≤50	1.83	.07	1.39	.07	2.54[c]	.14	2.10[c]	.10
age >50	1.41	.05	1.21	.05	1.64[b]	.15	1.71[b]	.15
females - all	1.65	.05	1.34	.07	2.03[c]	.12	1.72[c]	.08
age ≤50	1.74	.07	1.42	.10	2.23[c]	.14	1.73[a]	.08
age >50	1.49	.06	1.25	.07	1.70[b]	.13	1.68[b]	.14
D. Systolic blood pressure, mm Hg								
both sexes	121.7	.63	121.3	.80	126.0[b]	1.20	119.6	1.30
males - all	126.6	.79	124.4	1.10	131.9[c]	1.60	128.0	2.00
age ≤50	126.6	.79	121.9	1.20	130.4[c]	1.90	125.7	2.20
age >50	130.6	1.38	128.5	1.70	135.7[a]	2.90	136.5	4.40
females - all	117.5	.85	117.8	1.60	121.3	1.50	115.4	1.40
age ≤50	111.4	.85	109.4	1.50	115.6[b]	1.40	111.1	1.60
age >50	128.0	1.31	127.5	2.30	130.9	2.70	126.5	1.80
E. Diastolic blood pressure, mm Hg								
both sexes	74.3	.46	72.8	.70	77.2[c]	.90	73.7	1.00
males - all	76.1	.64	73.1	.80	79.6[c]	1.30	77.3[a]	1.80
age ≤50	75.7	.83	72.3	1.00	78.6[b]	1.70	76.7	2.20
age >50	77.1	.92	74.4	1.30	82.1[c]	1.60	79.3[a]	2.00
females - all	72.7	.63	72.4	1.10	75.3	1.30	72	1.10
age ≤50	71.1	.82	69.8	1.50	74.2[a]	1.60	70.5	1.40
age >50	75.5	.82	75.4	1.40	77.1	1.80	75.8	1.30

[a] $P<.05$, reference, White.
[b] $P<.01$.
[c] $P<.001$.

($P<.001$) for Blacks and 1.82 ($P<.001$) for Hispanics. Younger Black males had the highest sodium-to-potassium ratio at 2.54 and older White males had the lowest ratio at 1.21.

Table 3 presents the results from our second hypothesis that there are differences by race/ethnicity in the influence of dietary intake on blood pressure. This table shows results from regression models of SBP and: 1) sodium intake; 2) potassium intake; and 3) the sodium-to-potassium ratio. Also shown are beta coefficients of 48 separate models of SBP and dietary intake by subgroup (age, sex and race/ethnicity). The data show a distinct pattern of significant relationships in the top left quadrant (younger males) and the bottom right quadrant (older females). For instance, a 1000 mg increase in daily sodium consumption corresponded with an increase in SBP among younger Black males of 1.9 mm Hg ($P<.05$); in contrast each 1000 mg increase in potassium intake corresponded with a decrease in SBP among younger Black

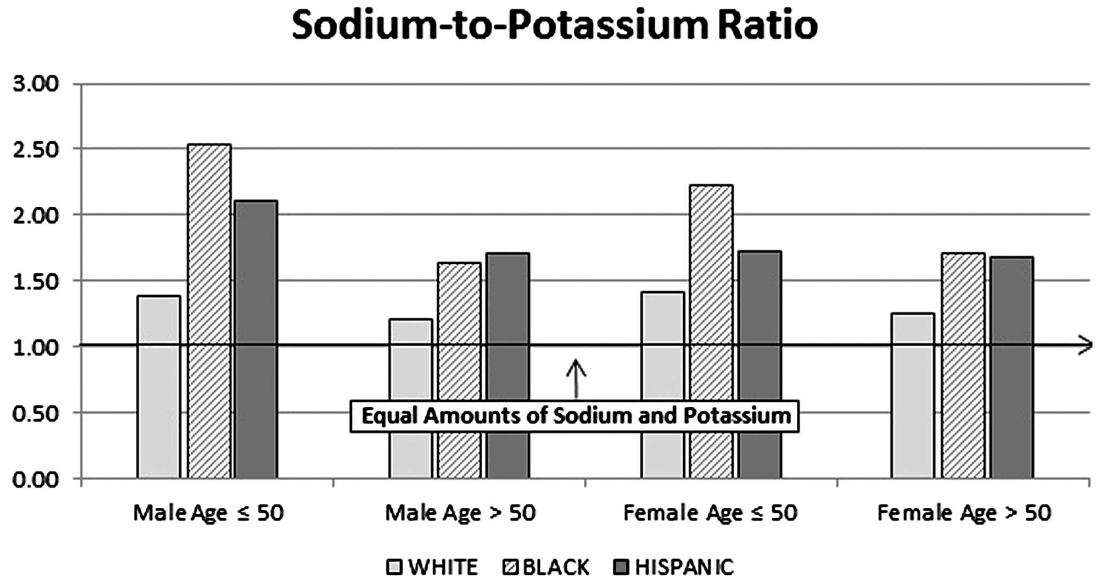

Fig 1. Sodium-to-potassium ratio by race, sex, age group

males of 4.1 mmHg ($P<.05$). Among older Black females a 1000 mg increase in sodium was associated with a 5.7 mmHg ($P<.001$) increase in SBP; among older Hispanic females a 1000 mg increase in potassium was associated with a 3.5 mm Hg decrease in SBP. Throughout all the models, significant relationships between SBP and diet were seen only in Blacks and Hispanics.

DISCUSSION

Our study found notable differences in intake values of sodium and potassium by population subgroup and also differences in the relationship of both sodium and potassium on SBP. Most notably, among younger males, HFUS data estimate the sodium intake values for Blacks and Whites to be 4360 vs 3240 mg/day ($P<.001$). Additionally, younger Black males consumed far less potassium than younger White males: 1860 vs 2740 mg/day, ($P<.001$) potentially indicating a deficiency of fruit and vegetable consumption among young Black males.

Additionally, the associations between diet and blood pressure are strongest for younger Black and Hispanic males aged ≤50; and for older Black and Hispanic females. Among older men hypertension appears common even among individuals eating limited sodium, and hypertension was not common in women aged ≤50. Overall, these results show a need to examine differential effects of diet on blood pressure by population subgroups.

While the mean values for population-level sodium intake are similar in NHANES and NYC HFUS data (3200 vs 3490 mg/day),[15] sub-population analyses show large differences between NYC HFUS and NHANES data. The HFUS data indicate that Blacks consume substantially more sodium than Whites, while self-reported NHANES data showed Blacks consuming less sodium than Whites. While HFUS data were collected in NYC and are not national data, the differences between self-reported values from NHANES and clinical estimates from HFUS provide support for the value of clinical estimates, particularly 24-hour urine, in assessing sub-population differences.

Our study found notable differences in intake values of sodium and potassium by population subgroup and also differences in the relationship of both sodium and potassium on systolic blood pressure.

The sodium-to-potassium ratio indicates that White males and females of all ages have the most heart-healthy diets with the largest difference among younger males. Dietary intake may be affected by neighborhood-level poverty, with fast food and other less-healthy options more prevalent in high-poverty areas,[22] which often have high proportions of Blacks and Hispanics. Thus neighborhood-level factors, such as access to fresh produce, may affect differences in nutrient intake.

Our study had several important limitations: first, the data used for this study came from a cross-sectional sample, and thus we cannot establish temporality related to a change in diet. Sodium and potassium intakes measured in a 24-hour urine collection may

Table 3. Linear regression coefficients of systolic blood pressure (mm Hg) and nutrient intake, stratified by race/ethnicity sex, and age

	Aged ≤50 (*n*=796)		Aged >50 (*n*=772)	
	Beta Coefficients[a] (Stratified Models)	SE	Beta Coefficients[a] (Stratified Models)	SE
Males				
(1M) Sodium, per 1000 mg - males	.95	.57	.75	.85
White males	−.32	.83	1.46	.99
Black males	1.93[b]	.77	.06	1.46
Hispanic males	1.72[b]	.80	1.26	3.40
(2M) Potassium, per 1000 mg – males	.57	1.65	−1.43	1.20
White males	2.20	1.74	−2.17	1.27
Black males	−4.10[b]	1.71	2.18	2.31
Hispanic males	−3.40	2.15	−1.21	4.34
(3M) Sodium: potassium ratio, per 1 unit - males	2.50[c]	.93	1.64	1.88
White males	−1.19	2.03	4.28	2.76
Black males	3.37[c]	1.17	−3.73	2.98
Hispanic males	3.68[b]	1.53	2.56	5.27
Females				
(1F) Sodium, per 1000 mg - females	1.28[b]	.55	2.28[b]	1.01
White females	.83	1.02	2.05	.27
Black females	1.60	.97	5.70[d]	1.96
Hispanic females	1.49	1.33	.41	1.31
(2F) Potassium, per 1000 mg - females	−1.43	1.07	−3.75[c]	1.31
White females	−2.22	1.29	−2.59	.20
Black females	−1.27	1.93	−5.02	3.62
Hispanic females	−.11	2.75	−3.52[b]	1.50
(3F) Sodium: potassium ratio, per 1 unit - females	1.78[b]	.82	5.63[c]	1.83
White females	2.91	1.62	6.75	3.97
Black females	1.29	.93	9.10[d]	2.48
Hispanic females	−.26	2.15	2.12	2.10

Data present the beta coefficients and standard errors for 48 separate models for SBP on: 1) sodium; 2) potassium; and 3) sodium-to-potassium ratio. Refer to Table 1 (rows 2–4) for sample sizes on the stratified models.
[a] Models adjusted for age (continuous), BMI, heavy drinking, and income.
[b] $P<.05$.
[c] $P<.01$.
[d] $P<.001$.

not be representative of an individual's general intake. The data are designed to provide population-level estimates representative of NYC and not to provide individual-level estimates or national estimates.

Second, while 24-hour urine collection is the gold standard measure of sodium intake (reflecting ~97% of sodium consumed), it only reflects ~80–85% of potassium intake.[23,24] Potassium may be underestimated, and the sodium-to-potassium ratio may be overestimated. Additionally, while few studies have estimated potassium intake by race using clinical measurements, one study raised concerns that Blacks retain more of their potassium than Whites in 24-hour urine collections, given the same diet.[25] In spite of these limitations, our study, to our knowledge, is the first in the United States to use clinical measurements (24-hour urine collections) to examine dietary intake in a diverse population-representative sample.

CONCLUSION

Our study showed significant associations between diet and blood pressure among Blacks and Hispanics. The results indicated that Black and Hispanics have both a poorer diet relative to Whites and may have an increased vulnerability to developing diet-based hypertension. Our study indicates a need for dietary change, particularly among young (aged ≤50) Black and Hispanic males who present both the poorest diets and highest relative hypertension prevalence. The results also show a strong association between diet and blood pressure among older (aged >50) Black and Hispanic females, while there was no significant association between diet and blood pressure among males aged >50.

In addition to efforts that would benefit the NYC adult population on the whole, nutrition education directed towards young Black and Hispanic males and increased access to healthy foods in low income neighborhoods may be particularly valuable. These findings shed light on the need to consider individual-level risk and subpopulation differences in: (1) actual nutrient intake, and (2) the relationship between sodium and potassium intake and systolic blood pressure.

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