ORIGINAL RESEARCH

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Mean Dietary Salt Intake in Urban and Rural Areas in India: A Population Survey of 1395 Persons

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***Background*—**The scientific evidence base in support of population-wide salt reduction is strong, but current high-quality data about salt intake levels in India are mostly absent. This project sought to estimate daily salt consumption levels in selected communities of Delhi and Haryana in north India and Andhra Pradesh in south India.

***Methods and Results*—**In this study, 24-hour urine samples were collected using an age- and sex-stratified sampling strategy in rural, urban, and slum areas. Salt intake estimates were made for the overall population of each region and for major subgroups by weighting the survey data for the populations of Delhi and Haryana, and Andhra Pradesh. Complete 24-hour urine samples were available for 637 participants from Delhi and Haryana and 758 from Andhra Pradesh (65% and 68% response rates, respectively). Weighted mean population 24-hour urine excretion of salt was 8.59 g/day (95% CI 7.68–9.51) in Delhi and Haryana and 9.46 g/day (95% CI 9.06–9.85) in Andhra Pradesh (P=0.097). Estimates inflated to account for the minimum likely nonurinary losses of sodium provided corresponding estimates of daily salt intake of 9.45 g/day (95% CI 8.45–10.46) and 10.41 g/day (95% CI 9.97–10.84), respectively.

***Conclusions*—**Salt consumption in India is high, with mean population intake well above the World Health Organization recommended maximum of 5 g/day. A national salt reduction program would likely avert much premature death and disability. **(*J Am Heart Assoc*. 2017;6:e004547. DOI: 10.1161/JAHA.116.004547.)**

Key Words: 24-hour urinary sodium • high blood pressure • hypertension • India • population studies • population survey • salt • salt intake • sodium

The burden of noncommunicable disease in India is large, with cardiovascular conditions responsible for ≈2.3 million deaths each year, almost a quarter of which are ascribed to high blood pressure. Excess salt consumption is a leading cause of high blood pressure and has been reported as the seventh leading cause of mortality worldwide, responsible for an estimated 1.65 million deaths each year.[1,2] The World Health Organization's (WHO) global action plan for the prevention and control of noncommunicable diseases identifies a 25% reduction in premature mortality from cardiovascular disease, a 25% reduction in raised blood pressure, and a 30% reduction in mean population salt intake as targets for 2025. In addition, the WHO recommends maximum dietary salt intake of 5 g/day for adults.[3,4]

A number of population surveys assessing dietary salt consumption in India have estimated mean intake as >5 g/day,[5,6] with the recent estimate from a national 24-hour dietary recall survey done in 2010 being 7.5 g/day.[7] Dietary recall surveys, although widely used to assess population nutrient intake, often underestimate dietary salt consumption because of underreporting of food intake, selective nonparticipation of individuals, and difficulty in quantifying use of discretionary salt.[8–10] Dietary sodium estimation from 24-hour urine samples is widely considered to provide more accurate measurement of salt intake, but such data are scant for India. In support of the development of evidence for a

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Accompanying Tables S1 through S3 and Figures S1 through S3 are available at http://jaha.ahajournals.org/content/6/1/e004547/DC1/embed/inline-supplementary-material-1.pdf

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national salt reduction strategy for India, we completed a large population survey of dietary salt intake using the 24-hour urine assessment method. We included urban and rural areas in Delhi and Haryana and in Andhra Pradesh, which were selected to be broadly representative of the north–south variation in the Indian population.

Methods

The methods for this cross-sectional survey were described previously[11] and are summarized below. The study protocol was approved by the Indian Health Ministry's steering committee and the human research ethics committees of the Center for Chronic Disease Control in New Delhi and the University of Sydney in Australia. Written informed consent was obtained from all participants. The survey was conducted between February and June 2014.

Selection of Areas for Study

The study was undertaken in slum and urban areas and rural communities in north India (Delhi and Faridabad, Haryana) and in south India (Hyderabad and West Godavari, Andhra Pradesh). These areas are diverse in terms of the sociodemographic variability in India but were not intended to capture the full range of population groups or dietary habits in the country.

Selection of Participants

Recruitment of participants was stratified by sex and age as well as area (slum, urban, and rural) and limited to 1 person per household. In Delhi and Haryana, census enumeration blocks (for urban areas) and villages (for rural areas) were sampled at random from within the study area. In Andhra Pradesh, the census enumeration blocks and villages were selected to be broadly representative of those in the state using a purposive process. In both regions, a census list including information about the age and sex of all inhabitants was compiled for selected census enumeration blocks and villages, and a random sample of the population was invited to participate until recruitment numbers in each stratum were filled.

Data and Specimen Collection

In rural areas, before data collection began, the Panchayat (local administrative body) was engaged, and permission to conduct the study in each area was obtained. Trained field researchers conducted household interviews over 2 visits within 1 week. Consenting participants provided questionnaire data and underwent measurements of height, weight, waist circumference, and blood pressure. Participants were then provided with detailed verbal and written instructions along with a kit for their urine collection. A urine collection day was agreed, and a reminder call was placed to the participant the evening before their scheduled starting date. On the morning of the collection day, on rising, participants were asked to discard the first void of the day and to record the date and time as the starting point for the urine collection period on a collection sheet provided. They were instructed to collect all subsequent urine voids over the next 24-hour period; urine was collected for the whole day and night, including the first void of the following day, and stored in a 5-L container in the insulated bag provided. If the participant reported duration of collection of <24 hours, >1 void missed, or >1 episode of substantial spillage of a void, the collection was deemed incomplete, and the participant was offered the option to redo the 24-hour collection.

Weight, height, and waist circumference were measured using the standard WHO STEPS protocol,[12] and weight and height were used to calculate body mass index (BMI) as weight in kilograms divided by height in square meters. Blood pressure was measured using an Omron HEM7121 standard blood pressure monitor. In Andhra Pradesh, 3 measurements were taken with 3-minute intervals between each. The first measurement was discarded, and an average of the second 2 measurements was used. In Delhi and Haryana, 2 measurements were taken, and if the second measurement differed by >10 mm Hg for systolic blood pressure or 5 mm Hg for diastolic blood pressure, a third measurement was taken. The average of the 2 measurements, or of the last 2 measurements if a third measurement was taken, was used.

Processing of Urine Samples

Urine samples were collected by field researchers on the day of completion and transferred to a local laboratory where volume was measured and an aliquot was drawn for assay. Aliquots were transferred to a central laboratory in Delhi for analysis. Urinary sodium, potassium, and creatinine were determined using the ion-selective electrode method for sodium analysis and the buffered kinetic Jaffe reaction without deproteinization for urine creatinine assay. For the purpose of the primary analyses, urine samples were considered incomplete if any of the following occurred: (1) Total 24-hour urinary volume was <500 mL; (2) estimated daily urinary creatinine excretion was <6 mmol for men or <4 mmol for women; (3) reported duration of collection was <24 hours; (4) >1 void was reported as missed; or (5) there was >1 episode of significant spillage of a void.

Statistical Analysis

The quantity of sodium and creatinine in each 24-hour urine collection was calculated by multiplying the concentration of the analyte by the volume of the sample. The volume of the 24-hour urine collection was adjusted for self-reported collection time as follows: (total volume collected in liters/self-reported collection time in hours)×24 hours. Mean values for the slum, urban, and rural populations and an overall estimate for each region (Delhi and Haryana and Andhra Pradesh) was estimated with the Taylor series linearization method in a survey procedure (*proc surveymeans* in SAS 9.4 [SAS Institute]) that accounted for survey weights, strata, and clustering in the study design. Sampling weights were developed from the probability of selection of the site and the number in each household, and these were then weighted for the reported population structures of Delhi and Haryana and of Andhra Pradesh (Table 1). We conducted sensitivity analyses based on all participants who provided a urine sample regardless of completeness and for subsets that excluded participants using a variety of different criteria for likely completeness of the sample collection. In addition, we made best estimates of intake that were inflated by 10% to account for minimum likely losses of sodium through sweat and feces.[8] We used the Taylor series linearization method[13,14] (implemented in *proc surveyreg*) to estimate regression coefficients and variance of coefficient differences (univariate analyses) in salt intake among subgroups defined by age, sex, BMI, area (slum, urban, rural), and state (Delhi and Haryana, Andhra Pradesh) and for association between salt intake and continuous variables (BMI, age, and blood pressure). A *t* test was used to test whether the survey-adjusted regression coefficient was different from 0. For association between categorical variables, we used the Rao–Scott chi-square test (implemented in *proc surveyfreq*), which accounts for survey design.[15] For continuous variables, we extended the analyses (repeating the method detailed earlier) and tested the association between BMI, age, and blood pressure (systolic and diastolic) simultaneously in a multivariable analysis (reporting BMI plus age plus systolic blood pressure and the diastolic blood pressure coefficient from an analysis with BMI plus age plus diastolic blood pressure). We tested whether these variable were linear by including a polynomial form of each variable and reported the latter if it was a significantly better fit. We considered differences or associations of $P<0.05$ to be evidence that the effect or difference was likely to be real. Estimates of salt (in grams) were derived from sodium (in grams) by multiplying by 2.54.

Results

Overall, 1041 persons were selected for the survey in Delhi and Haryana and 712 agreed to participate (68% overall response rate: slum 67%, rural 76%, and urban 65%). The corresponding numbers for Andhra Pradesh were 1291 and 840 (65% overall response rate; slum 67%, rural 79%, and

Table 1. Study Participants and Corresponding Populations of Delhi and Haryana and Andhra Pradesh

		Survey Participants (n)				State Population (n)			
		Andhra Pradesh		Delhi and Haryana		Andhra Pradesh		Delhi and Haryana	
	Age Group, y	Male	Female	Male	Female	Male	Female	Male	Female
Slum	20–39	40 (5.3%)	41 (5.4%)	42 (5.9%)	48 (6.7%)	1 207 466 (2.2%)	1 114 500 (2.1%)	690 616 (3.5%)	440 885 (2.2%)
	40–59	44 (5.8%)	42 (5.5%)	36 (5.1%)	37 (5.2%)	389 364 (0.7%)	294 210 (0.5%)	364 595 (1.8%)	224 544 (1.1%)
	≥60	42 (5.5%)	43 (5.7%)	26 (3.7%)	38 (5.3%)	55 779 (0.1%)	49 217 (0.1%)	121 305 (0.6%)	86 770 (0.4%)
Urban	20–39	50 (6.6%)	44 (5.8%)	27 (3.8%)	35 (4.9%)	5 651 488 (10.5%)	4 326 537 (8.0%)	2 516 342 (12.7%)	2 389 346 (12.0%)
	40–59	49 (6.5%)	46 (6.1%)	36 (5.1%)	47 (6.6%)	1 913 818 (3.5%)	1 864 745 (3.5%)	1 328 446 (6.7%)	1 216 900 (6.1%)
	≥60	45 (5.9%)	46 (6.1%)	32 (4.5%)	51 (7.2%)	613 403 (1.1%)	572 509 (1.1%)	441 991 (2.2%)	470 243 (2.4%)
Rural	20–39	33 (4.4%)	40 (5.3%)	53 (7.4%)	51 (7.2%)	9 307 171 (17.3%)	9 431 664 (17.5%)	2 802 225 (14.1%)	2 512 408 (12.6%)
	40–59	36 (4.7%)	39 (5.1%)	45 (6.3%)	40 (5.6%)	5 477 027 (10.2%)	5 547 813 (10.3%)	1 434 133 (7.2%)	1 331 466 (6.7%)
	≥60	41 (5.4%)	37 (4.9%)	33 (4.6%)	35 (4.9%)	2 872 878 (5.3%)	3 235 213 (6.0%)	745 065 (3.7%)	767 826 (3.9%)

Values in parentheses denote percentage of population.

urban 56%) (Table 2). For those who agreed to take part, complete data from the questionnaire, the physical examination, and a 24-hour urine sample were available for 710 of 712 (99%), 710 of 712 (99%), and 637 of 712 (89%) participants, respectively, in Delhi and Haryana and for 758 of 840 (90%), 758 of 840 (90%), and 758 of 840 (90%) participants, respectively, in Andhra Pradesh. Across both regions, 157 of 1552 (10%) persons did not return a 24-hour urine sample, and 438 of 1395 (31%) persons returned a sample suspected to be incomplete. Participants who did not provide a complete 24-hour urine collection were more likely to be older, female, or from a rural site.

Estimated Salt Consumption

Overall urinary salt excretion was estimated to be 8.59 g/day (95% CI 7.68–9.51) in Delhi and Haryana and 9.46 g/day (95% CI 9.06–9.85) in Andhra Pradesh (P=0.097) (Table 3). With 10% inflation to adjust for minimum likely losses of sodium in sweat and feces, the corresponding best estimates of daily salt intake were 9.45 and 10.41 g/day, respectively (Table 3). Salt intake was highest in slum sites, followed by rural sites, and lowest in urban sites in Delhi and Haryana (P=0.003); the pattern appeared similar in Andhra Pradesh, although it was not significantly different across area of residence in that state (P=0.121). Salt intake was higher among men compared with women in both regions (Delhi and Haryana, $P \leq 0.001$; Andhra Pradesh, P=0.032) and varied across age groups in Delhi and Haryana (P=0.010) (Table S1). There was a positive association of BMI with salt intake in Andhra Pradesh (P=0.012) but not in Delhi and Haryana (univariate analysis, P=0.733) (Figure S1A and S1B). Salt intake did not differ significantly across age groups in Andhra Pradesh (P=0.162), although the association was graphically comparable to that for Delhi and Haryana (Figure S2A and S2B). There was no detectable association between blood pressure and salt intake in Delhi and Haryana or in Andhra Pradesh (univariate analysis, P=0.663 and P=0.981, respectively) (Figure S3A through S3D) or between participant subsets defined on the basis of presence or absence of diabetes mellitus or presence or absence of prior stroke (all $P>0.094$) (Table 4). There was no evidence of association of BMI, age, or diastolic or systolic blood pressure with salt intake when they were mutually adjusted for in a multivariable model (BMI plus age plus diastolic blood pressure and BMI plus age plus systolic blood pressure) (Table S2). Participants in Delhi and Haryana reporting a history of chronic kidney disease consumed significantly less salt than those who reported not having the disease ($P<0.001$), but the number of cases was very small, and no corresponding difference was detected in Andhra Pradesh (P=0.573) (Table 4). Estimates of mean intake differed by −1.5 to +0.04 g/day for Delhi and Haryana and by −0.33 to +1.25 g/day for Andhra Pradesh when more stringent criteria were used for excluding larger numbers of possibly incomplete 24-hour urine sample collections (Table S3).

Table 2. Characteristics of Study Participants in Delhi and Haryana and Andhra Pradesh (N=1395)

	Delhi and Haryana (n=637)	Andhra Pradesh (n=758)
Mean age, y	40.2	40.2
Female, %	47.5	49
Mean BMI	24.3	24.3
Site of residence, %		
Slum	9.7	5.8
Urban	42.1	27.7
Rural	48.2	66.5
Highest level of education, %		
Primary school	43.2	61.5
Secondary school	30.3	24.7
Above secondary school	26.5	13.8
Employment status, %		
Employed/domestic duties	43.6	66.7
Unemployed/student	56.4	33.3
BMI, kg/m^2		
<25	58.2	61.9
25 to <30	25.9	27.5
≥30	15.9	10.6
Blood pressure, %		
SBP ≥140 or DBP ≥90	73.8	75.7
SBP <140 and DBP <90	26.2	24.3
Tobacco use, %		
Never	70.2	74.3
Not daily	0.3	11.2
Daily	29.5	14.5
History of stroke, %		
Yes	0.7	0.5
No	99.3	99.5
History of type 2 diabetes mellitus, %		
Yes	5.4	7.0
No	94.6	93.0
History of chronic kidney disease, %		
Yes	0.6	2.4
No	99.4	97.6

BMI indicates body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.

Table 3. Overall Weighted Mean (95% CI) Salt Intake, Urine Volume, and Creatinine Estimated From 24-Hour Urine Samples for Delhi and Haryana and Andhra Pradesh

	Delhi and Haryana (n=637)	Andhra Pradesh (n=758)	*P* Value
Salt, g/24 h	8.59 (7.68–9.51)	9.46 (9.06–9.85)	0.097
Salt inflated by 10%*	9.45 (8.45–10.46)	10.41 (9.97–10.84)	
Urine volume, mL/24 h	1483.62 (1340.50–1626.74)	1519.34 (1266.38–1772.30)	0.799
Urine creatinine, mg/24 h	10.95 (9.78–12.12)	9.06 (7.82–10.29)	0.044

*Inflation by 10% applies to salt intake in grams per 24 hours only.

Discussion

Our best estimates of salt consumption in Delhi and Haryana and in Andhra Pradesh, made using the preferred method of 24-hour urine collection with inflation for nonurinary losses of sodium, are about twice the WHO-recommended maximum of 5 g/day. We found evidence of excess consumption in both regions, for both sexes, in urban and rural populations, among all age groups, and across subsets defined by different characteristics of employment and education. The high levels of estimated intake are not surprising because Indian cuisine uses substantial amounts of salt for food preparation and for seasoning at the table.[16] In rural areas, people eat salted pickles in large quantities and, in some cases, still rely on the salting of food for preservation purposes. In urban areas, populations are making progressively greater use of chain restaurants and fast food outlets, which often add significant quantities of salt during food preparation.[16,17] Although there remains a strong likelihood that the estimates we obtained are not exactly correct, there is little doubt that salt consumption in India is far above that recommended for the great majority of the population. Accordingly, it appears highly likely that the Indian population would benefit from the development and implementation of a national salt reduction program, particularly given the high and rising burden of uncontrolled hypertension.[17]

Variation in salt intake across slum, urban, and rural populations; across age groups; and across BMI groups has been reported previously by studies done in other communities.[18–21] The absence of an association between salt intake and blood pressure is unsurprising, given the large errors in measurement of both parameters in individuals, and is a frequent finding in studies of this type.[22,23] Large day-to-day variability in blood pressure levels and sodium excretion means that only studies with large sample sizes and/or multiple measurements of exposure and outcome can robustly define the association. The significant association between chronic kidney disease and salt intake in Delhi and Haryana but not in Andhra Pradesh is statistically pronounced but is based on very few records. The sometimes consistent and sometimes inconsistent findings for salt consumption in population subgroups across Delhi and Haryana and in Andhra Pradesh is likely to reflect both the play of chance and real differences in the features of the groups studied. The presence of significant differences, for example, in salt intake across slum, urban, and rural populations in Delhi and Haryana but not in Andhra Pradesh probably reflects the play of chance rather than any real difference between the northern and southern regions. Likewise, the differences between Delhi and Haryana and Andhra Pradesh in the association of salt intake with age is minor and is also unlikely to reflect any substantive variation in consumption patterns by age across the 2 regions. For BMI, the reason why the typical positive association with salt intake[24] was not observed in Delhi and Haryana is unclear and may be due to some specific aspect of the diets of more versus less obese persons in that region. Average energy intake and quantity of food consumed is understood to be a primary driver of higher salt intake in younger compared with older adults, in men compared with women, and usually in those with higher versus lower BMI.[24] The small difference in 24-hour urinary creatinine excretion between Delhi–Haryana and Andhra Pradesh may be due to different rates of consumption of animal protein.[25]

Key strengths of this research are the large size of the populations included and the recruitment of participants from regions in north and south India that span slum, urban, and rural populations. This provides for some capacity to generalize the findings to areas of India other than those studied, although there will be parts of India for which significant uncertainty about salt intake remains. We achieved good response rates and used weighting to control for differences in age, sex, and place of residence of those sampled compared with the respective populations of the regions. This means that the summary estimates for Delhi and Haryana and for Andhra Pradesh should be good reflections of average salt intake in the populations for which we made inferences. Response rates, however, were imperfect, and weighting may not have fully adjusted for systematic difference in those that did and did not agree to take part. The survey benefited from the use of the accepted best method of quantification of dietary sodium intake based on 24-hour urine collection. The sensitivity analyses demonstrated that incompleteness of 24-

Table 4. Weighted Mean Salt Intake (g/day; 95% CI) Estimated From 24-Hour Urine Samples for Population Subgroups in Delhi and Haryana and Andhra Pradesh

	Delhi and Haryana	*P* Value*	Andhra Pradesh	*P* Value*
Male	9.39 (8.24–10.54)	0.0007	9.97 (9.21–10.74)	0.0318
Female	7.69 (6.54–8.84)		8.87 (8.25–9.50)	
Site				
Slum	8.96 (7.66–10.26)	0.0033	10.39 (9.11–11.67)	0.1213
Urban	6.83 (6.14–7.52)		8.56 (7.49–9.63)	
Rural	8.59 (7.32–9.86)		9.15 (8.73–9.57)	
Age, y				
20–39	8.65 (7.41–9.89)	0.0096	9.68 (8.90–10.46)	0.1615
40–59	8.95 (7.38–10.52)		9.19 (8.39–9.99)	
≥60	7.52 (6.05–8.98)		8.73 (7.73–9.73)	
Highest level of education				
Primary school	8.57 (7.12–10.03)	0.4102	9.35 (8.58–10.12)	0.9450
Secondary school	8.99 (7.83–10.14)		9.66 (8.23–11.09)	
Above secondary school	8.16 (7.03–9.28)		9.48 (8.01–10.96)	
Employment status				
Employed/domestic duties	9.63 (8.42–10.83)	0.0151	9.72 (9.21–10.23)	0.0715
Unemployed/student	7.66 (6.57–8.75)		8.90 (8.07–9.74)	
BMI, kg/m^2				
<25	8.71 (7.55–9.87)	0.7330	8.79 (8.38–9.20)	0.0123
25 to <30	8.67 (7.49–9.86)		10.30 (9.28–11.32)	
≥30	7.99 (6.35–9.64)		10.99 (9.31–12.67)	
Blood pressure				
SBP ≥140 or DBP ≥90	8.80 (7.48–10.12)	0.6634	9.47 (7.97–10.97)	0.9797
SBP <140 and DBP <90	8.51 (7.60–9.43)		9.45 (8.95–9.95)	
Tobacco use				
Never	8.32 (7.39–9.24)	0.5797	9.32 (8.71–9.93)	0.7057
Not daily	8.70 (7.70–9.70)		10.15 (8.13–12.17)	
Daily	9.18 (7.63–10.73)		9.58 (8.44–10.72)	
Stroke				
Yes	7.59 (4.18–11.01)	0.5341	7.46 (2.96–11.95)	0.3609
No	8.60 (7.74–9.46)		9.46 (8.97–9.96)	
Type 2 diabetes mellitus				
Yes	8.91 (7.02–10.80)	0.7316	11.17 (9.36–12.97)	0.0940
No	8.58 (7.69–9.47)		9.33 (8.75–9.92)	
Chronic kidney disease				
Yes	5.92 (5.50–6.34)	<0.0001	8.74 (6.11–11.36)	0.5725
No	8.60 (7.73–9.47)		9.48 (8.97–9.98)	

BMI indicates body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.
**P* homogeneity across subgroups.

hour collection within the included samples was unlikely to have seriously affected the primary conclusions that we drew. Multiple 24-hour urine samples are required to get an accurate estimate of an individual person's usual salt intake, but the associated high participant burden[26] precluded that option, and we used single measurements in large numbers instead. Because we estimated population average salt intake, this is an effective method of investigation, although the between-individual variability within the population will have been overestimated. Our decision to provide estimates inflated to account for nonurinary excretion of sodium[27] used a crude method but nonetheless should have provided a result closer to truth than the unadjusted value.

Perspectives

These data make a strong case for action to reduce salt consumption in India because the estimates of intake obtained are well above the WHO recommended maximum levels.[4] India has ratified the WHO global monitoring framework for the prevention and control of noncommunicable diseases (2013–2020),[28] which includes a target to reduce salt intake by 30% by 2025. Although the formulation of a salt-reduction strategy that will be best suited to India will require the synthesis of our data with multiple other information sources, it is likely that a combination of actions targeting consumers, industry, and government will be required.[29] Because processed foods are still not as widely consumed throughout India as in more developed countries, the emphasis of the program will need to be directed accordingly. Large amounts of salt added during food preparation, for example, at home or by street vendors will require behavior-changing interventions targeting individuals and restauranteurs, along with resetting of social norms and food-reformulation efforts targeting the food industry. Promotion of the use of salt substitutes might also be an effective means of reducing sodium intake.[30] Regardless of the methods used, the available evidence from other jurisdictions[7] and extensive modeling suggests that a salt reduction program in India would both prevent large numbers of incident cases of hypertension as well as strokes and heart attacks. Furthermore, it is likely that this would be achieved at low total cost and in a highly cost-effective way.[31] An effective salt reduction program in India should make a significant contribution to the country's efforts to deliver on its commitment to the "25 by 25" goal of reducing chronic disease burden in the country[32] by one-quarter by 2025.

Author Contributions

Johnson wrote the first draft of this paper, which Neal edited for important content. Rogers did the statistical analyses. All authors reviewed and provided comments on subsequent iterations.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Salt intake by age, sex and region for urban slum, urban non-slum and rural areas

		Delhi/Haryana		Andhra Pradesh	
		Male	**Female**	**Male**	**Female**
Slum	**20-39**	5.35 (3.86 - 6.85)	6.06 (5 - 7.12)	8.62 (6.36 - 10.88)	7.38 (7.23 - 7.52)
	40-59	6.82 (5.87 - 7.78)	6.26 (4.63 - 7.89)	8.37 (6.99 - 9.74)	6.21 (5.82 - 6.6)
	60+	6.85 (5.37 - 8.32)	6.49 (4.15 - 8.84)	7.61 (5.75 - 9.48)	5.09 (4.09 - 6.09)
Urban	**20-39**	9.69 (7.28 - 12.1)	6.96 (5.88 - 8.05)	11.44 (10.7 - 12.18)	8.88 (5.61 - 12.15)
	40-59	8.37 (6.17 - 10.58)	6.43 (5.19 - 7.67)	9.86 (8.6 - 11.11)	9.23 (8.28 - 10.19)
	60+	6.79 (5.38 - 8.21)	4.83 (3.44 - 6.23)	8.74 (6.33 - 11.16)	6.83 (6.14 - 7.53)
Rural	**20-39**	8.9 (6.76 - 11.05)	7.28 (5.13 - 9.43)	9.75 (8.14 - 11.35)	8.66 (7.55 - 9.77)
	40-59	10.44 (7.48 - 13.39)	8.94 (5.28 - 12.6)	8.68 (6.84 - 10.52)	7.77 (6.56 - 8.98)
	60+	7.66 (4.11 - 11.2)	8.05 (5.55 - 10.56)	6.45 (5.31 - 7.59)	6.71 (4.82 - 8.6)

Table S2. The association between blood pressure, body mass index, age and salt intake in Delhi and Haryana and Andhra Pradesh

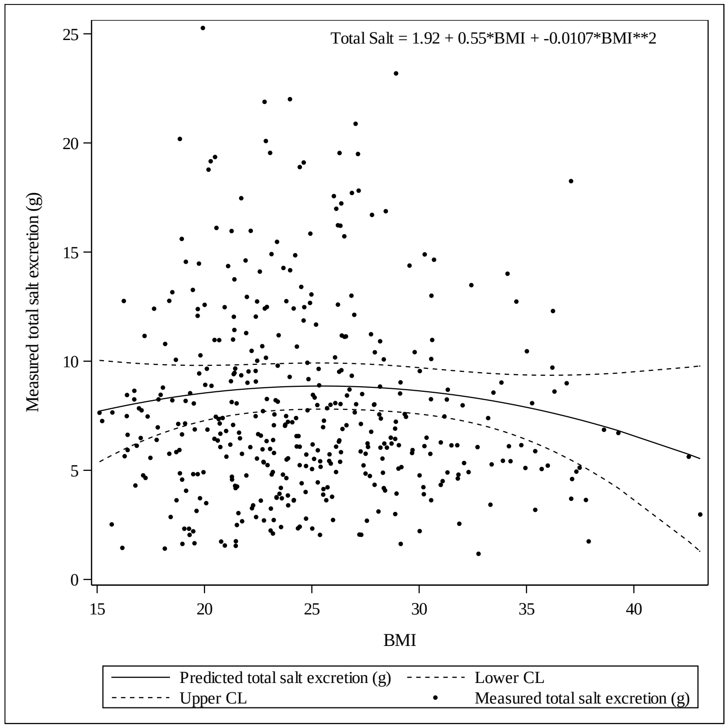
		Delhi and Haryana		Andhra Pradesh	
		β coefficient (95% CI)	**p-value**	**β coefficient (95% CI)**	**P-value**
Univariate					
	SBP	0.01 (-0.02 - 0.03)	0.64	0.00 (-0.03 - 0.03)	0.97
	DBP	0.02 (-0.03 - 0.06)	0.48	0.04 (-0.06 - 0.14)	0.46
	BMI	-0.03 (-0.16 - 0.10)	0.67	0.14 (-0.03 - 0.30)	0.10
	AGE	-0.01 (-0.06 - 0.03)	0.57	-0.02 (-0.05 - 0.00)	0.10
Multivariate					
	SBP (BMI + AGE)	0.01 (-0.02 - 0.04)	0.41	0.00 (-0.04 - 0.04)	0.91
	DBP (BMI + AGE)	0.03 (-0.03 - 0.09)	0.37	0.03 (-0.07 - 0.13)	0.58
	BMI (SBP + AGE)	-0.04 (-0.17 - 0.10)	0.60	0.15 (-0.04 - 0.33)	0.11
	AGE (SBP + BMI)	-0.02 (-0.07 - 0.03)	0.45	-0.04 (-0.08 - 0.00)	0.08

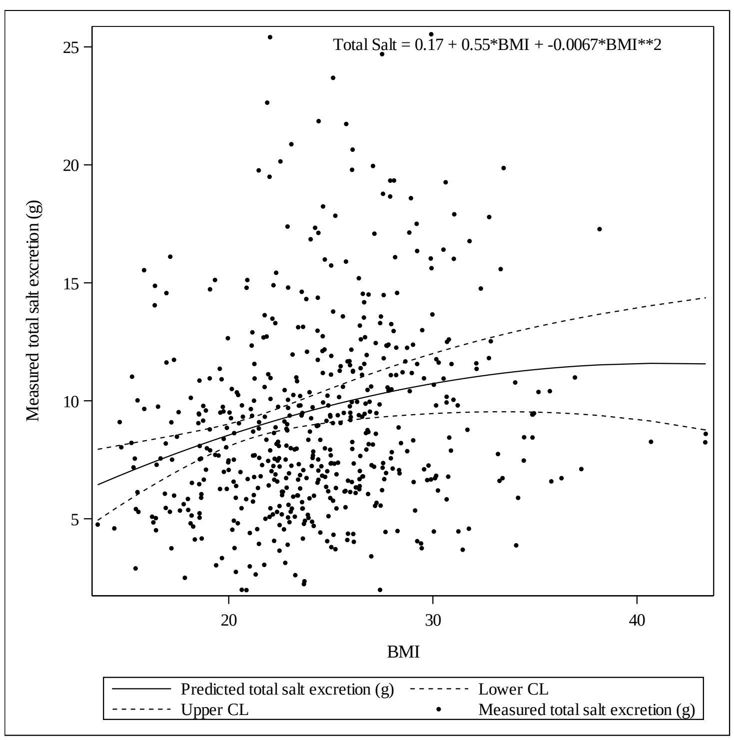
Table S3. Effects on weighted mean salt intake for Delhi/Haryana and Andhra Pradesh using different assumptions about completeness of 24-hour urine collections

	Criteria for exclusion of urine specimens	Delhi and Haryana (n=637)		Andhra Pradesh (n=758)	
		(n excluded)	Mean salt g/day (95% CI)	(n excluded)	Mean salt g/day (95% CI)
1.	mCER: <350mg/day OR >3500mg/day	59	7.81 (7.07 - 8.55)	102	9.11 (8.56 - 9.66)
2.	**Creatinine range Men: <6mmol OR >30mmol Women: <4mmol OR >25mmol**	**204**	**8.59 (7.81-8.67)**	**161**	**9.46 (9.24-8.76)***
3.	Creatinine ≤5mmol/day OR ≤6mmol/day AND Volume <1000mL	209	8.84 (8.03 - 9.65)	282	9.65 (9.13 - 10.16)
4.	Ratio of Creatinine (mg/day) to body weight (kg) <10.8 OR >25.2	305	7.85 (6.94 - 8.77)	302	9.34 (8.79 - 9.90)
5.	<0.6 of [Creatinine (mmol) x 113] ÷ [21 x body weight (kg)]	275	9.18 (8.22 - 10.14)	355	9.66 (9.11 - 10.20)
6.	Ratio of Creatinine (mg/day) to body weight (kg) <11 OR >20	346	7.63 (6.58 - 8.68)	389	8.98 (8.32 - 9.63)
7.	Creatinine range Men: 15-25mg/kg/day Women: 10-20mg/kg/day	441	6.39 (5.60 - 7.18)	559	8.90 (8.58 - 9.23)
8.	Creatinine range Men: 14-26mg/kg/day Women: 11-20mg/kg/day	469	6.93 (5.98 - 7.89)	585	8.96 (8.57 - 9.34)
9.	<0.7 of [Creatinine (mmol) x 113] ÷ [21 x body weight (kg)]	365	9.99 (8.96 - 11.02)	452	9.86 (9.36 - 10.35)
10.	mCER: <15mg/kg/day	377	9.93 (8.84 - 11.02)	462	9.88 (9.37 - 10.38)
11.	Creatinine range Men: 177-221umol/kg/day, Women: 133-177umol/kg/day	556	7.63 (5.72 - 9.54)	688	8.79 (8.44 - 9.15)

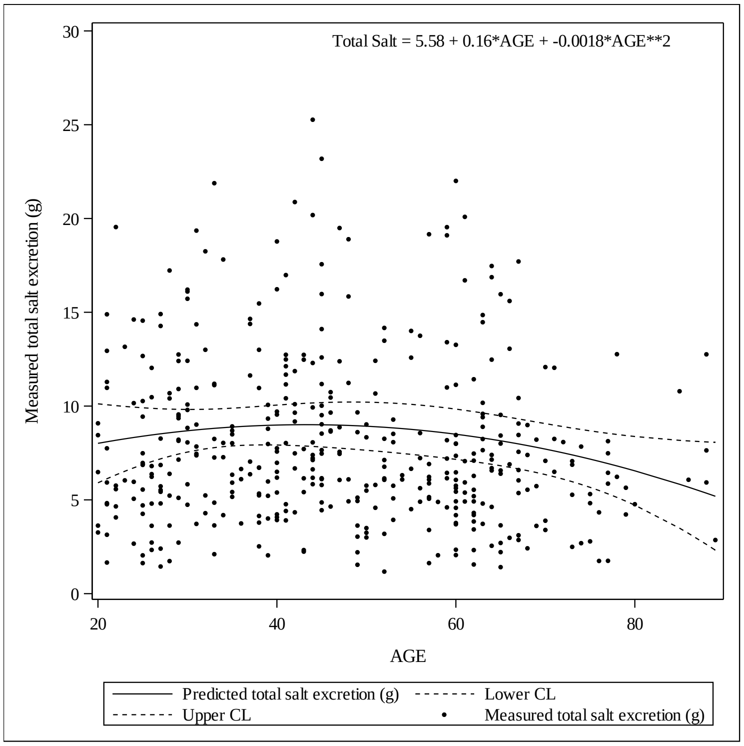
*Criteria used for primary analyses

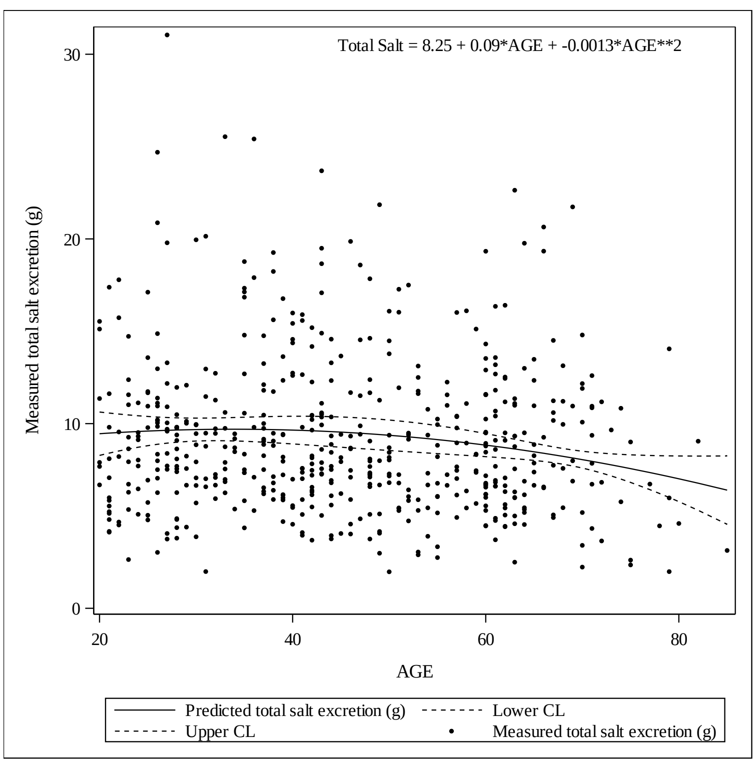
Figures S1a and S1b. The association of salt intake with body mass index by region



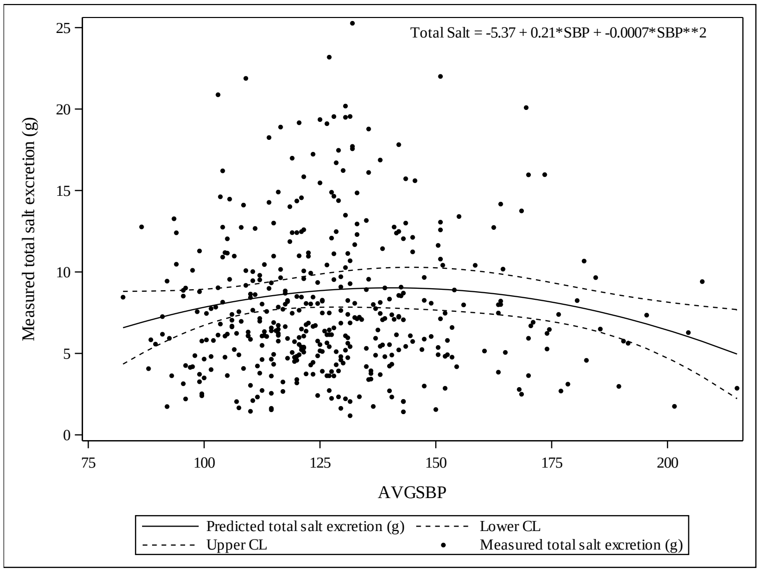


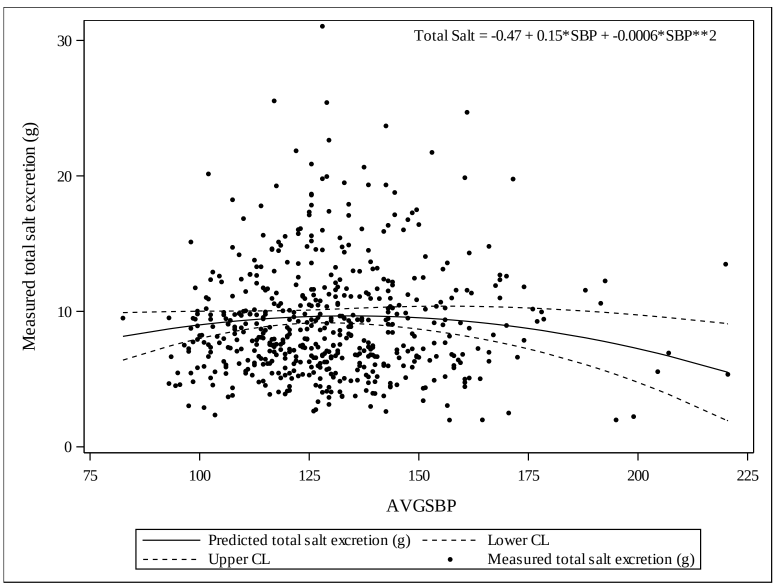
Figures S2a and S2b. The association of salt intake with age by region

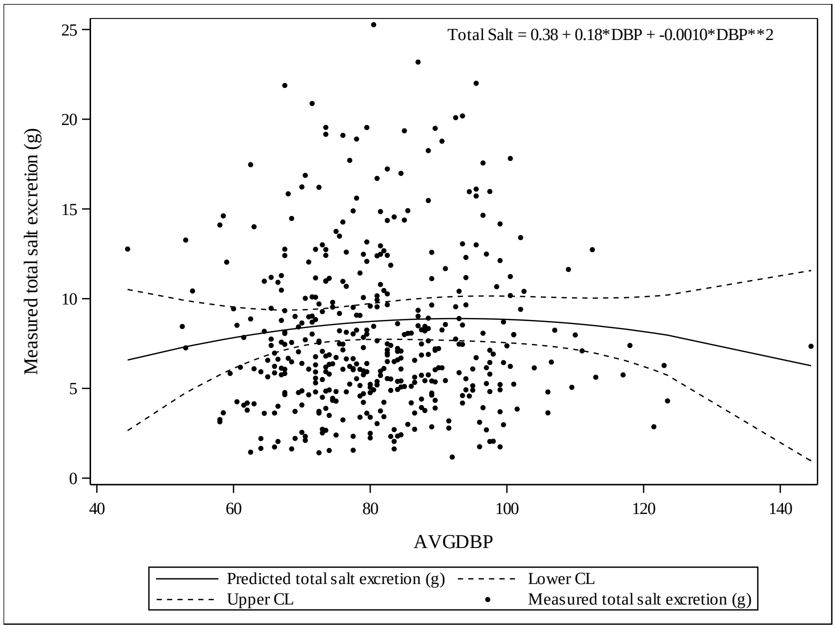


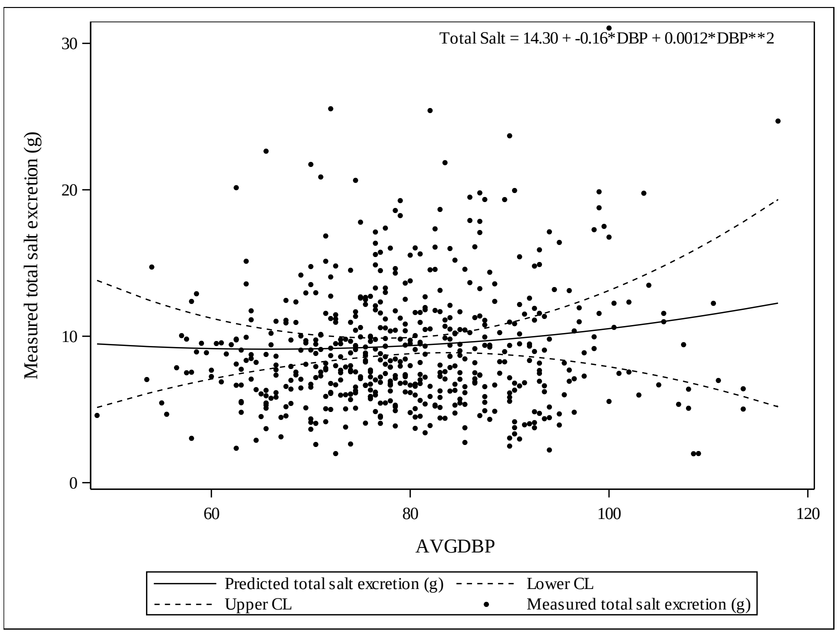


Figures S3a, S3b, S3c, and S3d. The association of salt intake systolic and diastolic blood pressure by region






Total Salt = 0.38 + 0.18*DBP + -0.0010*DBP**2
Measured total salt excretion (g)
AVGDBP
Predicted total salt excretion (g)
Lower CL
Upper CL
Measured total salt excretion (g)


Total Salt = 14.30 + -0.16*DBP + 0.0012*DBP**2
Measured total salt excretion (g)
AVGDBP
Predicted total salt excretion (g)
Lower CL
Upper CL
Measured total salt excretion (g)

Supplemental Figure Legends:

Figure S1. A. Relationship between BMI and salt intake in Delhi and Haryana. **B.** Relationship between BMI relationship and salt intake in Andhra Pradesh.

Figure S2. A. Relationship between age and salt intake in Delhi and Haryana. **B.** Relationship between age and salt intake in Andhra Pradesh.

Figure S3. A. The association between systolic blood pressure and salt intake in Delhi and Haryana. **B.** The association between systolic blood pressure and salt intake in Andhra Pradesh. **C.** The association between diastolic blood pressure and salt intake in Delhi and Haryana. **D.** The association between diastolic blood pressure and salt intake in Andhra Pradesh.

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