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A population survey with 24-hour urine collections

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Mean dietary salt intake in Nepal: A population survey with 24-hour urine collections

Short Title: NEUPANE, Salt intake in Nepal

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Abstract

High salt (Sodium Chloride) intake raises blood pressure and increases the risk of developing hypertension, a major risk factor for cardiovascular disease. Little is known about salt intake in Nepal, and no study has estimated salt consumption from 24-h urinary sodium excretion. Participants (n=451) were recruited from the Community-Based Management of Non-Communicable diseases (COBIN) cohort of Nepal in 2018. Salt intake was estimated by analyzing 24-hour urinary sodium excretion. Multivariate linear regression was used to estimate differences in salt intake. The mean (±SD) age and salt intake were 49.6 (±9.8) years and 13.3 (±4.7) gram/person/day, respectively. Higher salt intake was significantly associated with male gender (β for female=−2.4; 95% CI:-3.3, -1.4) and younger age (β_{10yrs}= -1.4 ; 95% CI: -1.4, -0.5 ) and higher BMI (β=0.1; 95% CI: 0.0; 0.2). A significant association was also found between increase in systolic blood pressure and higher salt intake (β =0.3; 95% CI: 0.0, 0.7). While 55% reported that they consumed just the right amount of salt, 98% were consuming more than the
WHO recommended salt amount (<5 gm/person/day). Daily salt intake in this population was over twice the limit recommended by the WHO, suggesting a substantial need to reduce salt intake in this population. It also supports the need of global initiatives such as WHO’s Global Hearts Initiative’s SHAKE technical package and Resolves to Save Lives for sodium reduction in low and middle income countries like Nepal.

**Keywords:** Salt intake, sodium, hypertension, nutrition, population studies, 24 hour urinary sodium excretion
Background

High salt (sodium chloride) intake raises blood pressure (BP) and increases the risk of developing hypertension.\(^1,2\) Reducing dietary salt intake is a cost-effective, population-level intervention to reduce the burden of hypertension.\(^3\) The World Health Organization (WHO) recommends a salt intake of <5 g/day (<2 grams sodium/day) to reduce high blood pressure and associated cardiovascular diseases.\(^4\) The member states of the WHO have adopted the voluntary global target of a 30% reduction in mean population salt intake by 2025.\(^5\) However, estimating dietary sodium intake at population level presents practical and methodological challenges. As a result, salt consumption is often not estimated, at least by valid methods, making it difficult to assess the true burden of salt consumption.

For multiple reasons, dietary assessment often underestimates sodium intake. Dietary survey methods do not quantify discretionary salt used during cooking and salting food at the table.\(^6\) Further, nutrition databases used to estimate sodium in individual foods are plagued by missing data and inaccuracies. Studies that use single or multiple spot urine collection also have many limitations and do not provide an accurate estimate of sodium intake.\(^7\) Well-collected, 24-hour urinary sodium excretion avoids the issues of underestimation of salt intake that occurs in assessment through dietary survey methods (dietary recall, food diaries and food frequency questionnaires).\(^8\) The International Consortium for Quality Research on Dietary Sodium/Salt (TRUE) recommends multiple 24 hour-urine samples collected over a series of days from a representative population sample to assess an individual’s 24-hour dietary sodium intake,\(^7\) however, a single 24-hr urine is sufficient to estimate a population’s mean intake. Globally, population-based surveys on estimating salt consumption using 24-h urine are limited. Many low income countries, including Nepal, do not have such studies, which are also uncommon in that region.\(^9\)

The current level of salt intake among the Nepali population is unknown. No study conducted in Nepal has measured sodium consumption using 24-hour urine samples. In our earlier study on knowledge, attitudes, and practices related to salt consumption in Nepal, we highlighted the need for estimating salt consumption by the 24-hour urine collection method, given the context of rapidly changing lifestyle and food habits in Nepal.\(^10\) This study aims to estimate the amount of...
salt intake using 24-hour urine analysis from a population-based survey among the Community-based management of non-communicable diseases (COBIN) cohort of Nepal.

**Materials and Methods**

We conducted a community-based survey among adults in Pokhara Municipality (formerly known as Lekhnath Municipality) in Kaski district of Western Nepal from July 2018 to December 2018. Participants were recruited from the COBIN cohort. The protocol and methodology of the COBIN project has been published elsewhere. In brief, COBIN was established in 2013 mainly for two purposes: a) to conduct epidemiological studies of major non-communicable disease in Nepal and b) to design and test low cost, appropriate and sustainable strategies to manage major non-communicable diseases in low resource settings. It has a cohort of 2815 randomly selected participants from 2815 randomly selected households of Lekhnath Municipality.

**Sampling and sample size**

The primary aim of our study was to estimate the amount of salt intake in Nepal using 24-hour urine analysis. We randomly selected 500 out of the 2815 total participants using computer enrolled in the COBIN cohort using systematic random sampling technique. One person did not give consent to participate in the study and 48 were considered incomplete and excluded from the analyses. With a sample size of 451, our study had excellent precision, producing two-sided 95% confidence interval with a distance from the mean to the limits that is +/- 0.34 g/24 h when the estimated standard deviation is 3.7 g/24 h.

**Data Collection**

Four data enumerators with health science background were trained for three days for data collection. Before visiting the homes of selected participants, the enumerators attempted to contact survey participants through their mobile numbers. If the participant was not reachable, the data enumerator visited the house of the participant with the help of a Female Community Health Volunteer. For verification of respondents, we asked their date of birth, family members name and contact number. Once the respondent was identified, informed consent was taken for interview, physical measurement and 24-hour urine collection. Participants were eligible to
participate in the study if they were enrolled in the COBIN cohort, had given consent to participate on this study, and were not pregnant or menstruating at the time of urine collection. If a participant was menstruating, the participant was approached after a week for urine collection.

Demographic and Anthropometric variables

We used the modified version of the WHO STEPwise approach to surveillance (STEPS) survey questionnaire for data collection. All questionnaires, consent forms, information sheets, and urine collection instructions were translated in Nepali. Age, sex and height were obtained from the COBIN database whereas education level, weight, blood pressure, tobacco use, and alcohol consumption were collected at the time of data collection.

Physical Measurement

Weight was measured in kilogram to the nearest 100 g using a digital scale on a flat surface. Body mass index (BMI) was calculated by dividing weight (in kg) by square of height (in meters), classified as: underweight (BMI<18.5), normal (18.5-24.9), overweight (25.0-29.9) and obesity (≥30). Blood pressure was measured using OMRON Model HEM-7203 (Omron Healthcare, Tokyo, Japan) expressed as millimeters of mercury (mm Hg). Three measurements were performed on the left arm with 5-min intervals in between. Final blood pressure was calculated as an average of the second and third measurements. Blood pressure <120/80 is reported normotensive and blood pressure ≥ 140/90 or currently taking antihypertensive medication is reported hypertension. Systolic blood pressure between 120-139 and diastolic blood pressure 80-89 is reported pre-hypertension.

24-hour urine collection

Participants were given verbal and written instructions for 24-hour urine collection. They were asked to discard the first void of the urine collected in the morning and provide the time that this occurred. They were then explicitly instructed to begin collecting subsequent urine voids for the next 24-hour, including the first urine of the following morning. Participants were asked to provide the time of the final urine and report any issues with collection, such as missed collection or spillage. If any issues were identified related to collection, the participant was asked to re-collect the urine. Urine collected was stored in a provided container, and participants were
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1 asked to store it in a cool, dry area, with the lid on tight. No preservatives were added in the
2 collected urine.

3 Processing of urine samples
4 Urine samples were collected by field staff on the day of completion and transferred to a local
5 laboratory immediately where volume was measured and analysis were made. Sodium
6 concentration in urine specimens were determined by the ion selective electrode (ISE) method
7 using the SENSA CORE ST-200 Pro Electrolyte Analyzer (Sensa Core Medical Instrumentation
8 Pvt. Ltd, India). The creatinine level was analyzed using gesan Chem 200 analyzer using
9 Creatinine LR liquid reagent. For the purpose of the primary analyses, urine samples were
10 considered incomplete if any of the following occurred: 1) Total 24-hour urinary volume was
11 < 500 mL; 2) estimated daily urinary creatinine excretion was < 6 mmol for men or < 4 mmol for
12 women; 3) Self-reported spillage of more than 30 ml. By doing this, we excluded 48 samples
13 from the analysis.

14 Statistical Analysis
15 Summary statistics were presented as means and standard deviations (SD) (for normally
16 distributed variables). Categorical variables were presented as frequencies and percentages.
17 Multivariate linear regression was used to estimate the differences of salt intake (grams) by
18 adjusting age, sex, body mass index, advice to reduce salt by health professional, awareness of
19 salt reduction in food and extra salt added before eating were adjusted. We also used multivariate
20 linear regression to explore the association between blood pressure and salt consumption
21 adjusting for age, sex ethnicity, education, body mass index, diabetes, currently taking
22 antihypertensive medication, doctor’s recommendation to reduce salt intake, instant food
23 consumption, knowledge about importance of reducing salt, daily tobacco use and daily alcohol
24 consumption. A two-sided P-value < 0.05 was considered statistically significant at 95%
25 confidence interval (95% CI). The statistical package Stata version 15 was used for all analyses.

26 Ethical Approval
Ethical approval was obtained from Nepal Health Research Council, Kathmandu, Nepal. All study participants were informed about the study objectives, procedures, and their role in the study and written informed consent was obtained.

Results
A total of 451 participants completed questionnaires and met the 24-hour urine sample collection criteria. The demographic characteristics of the study participants are presented in Table 1. The mean age of participants was 49.6 years (SD ±9.8), and the majority of them were female (65%) belonging to upper caste (57%) (Table 1). The mean body mass index (BMI) was 26.1 (SD±4.3) kg/m². Overweight and obese participants constituted 43% and 18% of the sample, respectively. The percentage of daily alcohol users and daily tobacco users were 9% and 26%, respectively. The mean systolic blood pressure was 129±18 mm Hg and diastolic blood pressure was 83±10 mm Hg. The proportion of normotensive, prehypertensive and hypertensive was 23%, 37% and 39% respectively. Out of 178 hypertensive participants, 61% were aware about their status, 50% received treatment and 25% had controlled blood pressure.

Table 1: Characteristics of Study Participants

Urinary salt excretion and associated factors

The 24-hour salt, urinary volume and urinary creatinine levels are presented in Table 2. Overall, estimated mean salt intake was 13.3g/person/day (SD ± 4.7).

Table 2: Mean (95% CI) salt intake, urine volume, and creatinine estimated from 24-hour urine samples

When adjusted for all the available confounding variables as shown in Table 3, age was negatively and significantly associated with salt intake. With each 10-year increase in age, salt consumption decreased by 1.4 g (95% CI: -1.4, -0.5 ). Females had 2.4 g (95% CI: -3.3, -1.4 ) lower salt consumption compared to males. With every 1 kg/m² increase in BMI salt consumption increased with 0.1 g (95% CI: 0.0, 0.2). Although awareness of salt reduction was not significantly associated with the salt intake, 55% of respondents thought that they consumed just the right amount of salt, 98% were consuming above the WHO recommended limit. Almost half of the respondents reported that they consumed processed food containing high amounts of

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Nevertheless, 60% of the participants reported that it is very important to reduce their salt intake in their food.

Table 3: Differences in 24-hour salt (g) by risk factors

Association between urinary salt excretion and blood pressure

The association between urinary salt excretion and blood pressure is presented in Table 4. In a multivariate analysis adjusting for all the available confounding variables, for each one-gram increase in salt intake, systolic blood pressure was predicted to increase by 0.3 mm Hg (β=0.3; 95% CI: 0.0; 0.7).

In a stratified analysis, one gram increase in salt intake among hypertensive participants was positively associated with increase in systolic blood pressure (β for SBP =0.7, 95% CI: 0.1; 1.2), but no associations were found in normotensives. Likewise, for each one gram increase in salt intake, diastolic blood pressure was predicted to increase by 0.3 (95% CI: 0.0; 0.6) among hypertensive participants, but no association were found among all participants and in normotensives.

Table 4: Relationship of Blood Pressure with Salt Intake, Adjusted Analyses

Discussion

This is the first community-based survey to estimate salt intake using 24-hour urine analysis in Nepal. We found the mean salt intake was 13.2g/person/day (SD ± 4.7). The mean salt intake is over twice the limit (< 5g/day) recommended by the WHO for prevention of high blood pressure. It is also higher than global estimate 9.3(9.0-9.7) g/day as reported by meta-analysis for estimation of salt intake using 24-hour urine analysis.\textsuperscript{17} Likewise, the current estimate is much higher than mean salt intake reported in some states of India i.e. 8.59 g/day (95% CI 7.73–9.45) in Delhi and Haryana, and 9.46 g/day (95% CI 8.95–9.96) in Andhra Pradesh\textsuperscript{18} and other cross-sectional studies from China (11.8 ± 4.5 g/day)\textsuperscript{19}, Korea (9.9 ± 4.6 g/day)\textsuperscript{20}, Brazil (10.3±4.1 g/day)\textsuperscript{21} and median salt intake from South Africa 7.1 g/day (IQR: 5.0-10.4)\textsuperscript{22} using 24-hour urine analysis method. However, it was lower than a study from Bangladesh 17.0 g/day (95% CI 13.8–20.2)\textsuperscript{23} and studies from Tibet, China.\textsuperscript{24}
The estimated salt intake based on 24-hour urinary samples is 5.0 g higher than the salt intake reported by dietary assessment methods in the same study area. Previous study used a salt spoon method to measure salt added during cooking for the two main meals of the day (the traditionally larger morning meal and evening meal). Salt consumption in Nepal is derived mainly from salt added during cooking, and the previous estimate of 8.0 g/day likely accurately reflects discretionary salt added during preparation of the two main meals of the day. However, use of the salt spoon methodology did not assess salt intake from salty condiments, snacks (including packaged or street foods), salty drinks, food eaten outside home, and additional meals consumed during the day.

This study highlights the importance of using 24-hour urinary methods to estimate salt intake over dietary assessment methods, as it accurately captures the amount of sodium when people eat food outside of the home. People are unaware of how much salt was added to meals or snacks eaten outside home or snacks as these foods were prepared by others.

A recent increase in processed food with higher salt content has been observed in LMIC settings including Nepal, but has not been widely studied and likely contributes significantly to dietary salt intake. In the current study, more than half of the respondents reported eating instant food sometimes or regularly. Such foods are common among relatively younger population which is also reflected in our study as younger population had statistically significant higher salt consumption. Similar to other studies, increasing unit of BMI was associated with higher salt consumption. The association found in this study between systolic blood pressure and salt intake in general population is consistent with other studies. Despite the widespread knowledge that salt consumption is a major nutritional factor associated with SBP level, we did not find statistically significant association between SBP among non-hypertensive participants in a stratified analysis. This result should be interpreted cautiously, because the same size was small and the design was cross-sectional.

The study has several strength and limitations. Given the complexity of the urine collection procedure, we provided protocols to assist with handling and transportation of urine to the lab. The timing of collection was recorded, and cross checking for incomplete sample or spillage was performed. If incorrect methods or spillage occurred, participants were approached for recollection. One limitation is that we only collected a single 24-hour urine sample per participant.
Collection of multiple 24-hour urine samples, although ideal, was not feasible in the current population-based study setting. Still a single 24-hour urine from a large sample of population is sufficient to estimate the mean salt intake of that population. A second limitation is that we did not exclude participants with kidney disease or those who were taking diuretics from the analysis. People with kidney disease or those who were taking diuretics might have different level of sodium excretion. The third limitation is generalizability of this study for other areas of Nepal. The study has rigorous internal validity due to population based survey using random samples. However, generalizability to the whole nation or other areas of Nepal need to be interpreted cautiously. We anticipate the similar results at national level because previous COBIN studies are consistently proximal to the national estimates for non-communicable diseases and their risk factors.

This study has important public health implications for Nepal. Given the high prevalence of hypertension, namely 28% in Nepal, intervening to lower dietary salt intake presents an opportunity to realize significant health benefits at the population level. It is estimated that high systolic blood pressure alone accounts for 45% deaths and 46% disability of cardiovascular disease (26). A recent study estimated that reducing sodium intake by 30% would delay 40 million deaths globally in the next 25 years (27). Our study can be used as a benchmark to assess the impact of salt reduction efforts in Nepal.

Conclusions

Estimated daily salt intake in this community-based survey in Nepal was over twice the limit recommended by the WHO. Community-based interventions for behavior modification through health education and dietary counseling may be effective in this population where salt is added during cooking and at the table, but attention must also be paid to interventions targeting the marketing, availability, and labeling of processed foods as this was also a significant source of salt intake. These findings make a strong case for action to reduce salt consumption in Nepal because the estimates of salt intake obtained are well above the WHO recommended levels. It also supports the global initiatives such as WHO’s Global Hearts Initiative’s SHAKE technical package and Resolves to Save Lives for sodium reduction in low and middle income countries like Nepal.

Acknowledgement

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The field study was supported by the Public Health Institute (PHI) through financial support from Centers for Disease Control and Prevention (CDC), USA; Jayanti Memorial Trust (JMT), Nepal and Nepal Development Society. AES is supported by the South African National Research Foundation (SARChI), and the South African Medical Research Council. DN, MEH, DZ and LJA receive support from Vital Strategies, which funds the Resolve to Save Lives initiative. Dr Appel received support from the Mid-Atlantic Obesity Research Center (NORC) under NIH award number P30DK072488. We thank the FCHVs and the staff and individuals in the communities who participated in the study. We would like to acknowledge Jacqui Webster and Joseph Alvin Santos of George Institute for Global Health, Australia for providing initial support during the design of the study. The authors are solely responsible for the design and conduct of this study, all analyses, the drafting of the manuscript, and its final content.

**Source of Funding**

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**Disclosures: None**

**References**


5. WHO. A comprehensive global monitoring framework including indicators and a set of voluntary global targets for the prevention and control of noncommunicable diseases. Geneva: World Health Organization (WHO);2012.


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<table>
<thead>
<tr>
<th>Variables</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, years</td>
<td>49.6±9.8</td>
</tr>
<tr>
<td>Mean BMI, kg/m²</td>
<td>26.2±4.3</td>
</tr>
<tr>
<td>Mean systolic blood pressure, mm Hg</td>
<td>129.1±18.0</td>
</tr>
<tr>
<td>Mean diastolic blood pressure, mm Hg</td>
<td>83.4±10.3</td>
</tr>
<tr>
<td>Female, %</td>
<td>295 (65.4%)</td>
</tr>
<tr>
<td>Level of Education, %</td>
<td></td>
</tr>
<tr>
<td>Low (up to primary level)</td>
<td>265 (58.8%)</td>
</tr>
<tr>
<td>Medium (Secondary and high school)</td>
<td>158 (35.0%)</td>
</tr>
<tr>
<td>High (University or college level)</td>
<td>28 (6.2%)</td>
</tr>
<tr>
<td>Ethnicity, %</td>
<td></td>
</tr>
<tr>
<td>Upper Caste</td>
<td>256 (56.8%)</td>
</tr>
<tr>
<td>Janajati</td>
<td>141 (31.3%)</td>
</tr>
<tr>
<td>Dalit, Religious minority and others</td>
<td>54 (12.0%)</td>
</tr>
<tr>
<td>Daily tobacco user</td>
<td>118 (26.2%)</td>
</tr>
<tr>
<td>Daily alcohol drinker</td>
<td>40 (8.9%)</td>
</tr>
<tr>
<td>Self-reported diabetes</td>
<td>41 (9.1%)</td>
</tr>
</tbody>
</table>
Table 2: Mean (95% CI) salt intake, urine volume, and creatinine estimated from 24-hour urine samples

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt, g/24 h</td>
<td>13.3 (12.8-13.7)</td>
<td>14.4 (13.6-15.2)</td>
<td>12.69 (12.2-13.2)</td>
</tr>
<tr>
<td>Urine volume mL/24 h</td>
<td>2584 (2482-2685)</td>
<td>2843 (2657-3029)</td>
<td>2446.78 (2328-2565)</td>
</tr>
<tr>
<td>Urine creatinine, mg/24 h</td>
<td>12.3 (11.8-12.8)</td>
<td>14.82 (13.9-15.7)</td>
<td>11.0 (10.4-11.5)</td>
</tr>
</tbody>
</table>
Table 3: Differences in 24-hour urine sodium (g) by risk factors*

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>N</th>
<th>(%)</th>
<th>Coef.* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age, per 10-year increase</strong></td>
<td>450</td>
<td></td>
<td>-1.4 (-1.4, -0.5)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>155</td>
<td>(35)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>295</td>
<td>(65)</td>
<td>-2.4 (-3.3, -1.4)</td>
</tr>
<tr>
<td><strong>Body Mass Index, per kg/m²</strong></td>
<td>450</td>
<td></td>
<td>0.1 (0.0, 0.2)</td>
</tr>
<tr>
<td><strong>Advice to reduce salt by health professional</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>369</td>
<td>(82)</td>
<td>Reference</td>
</tr>
<tr>
<td>Yes</td>
<td>81</td>
<td>(18)</td>
<td>0.4 (-0.7, 1.6)</td>
</tr>
<tr>
<td><strong>Importance of salt reduction in food</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very important</td>
<td>270</td>
<td>(60)</td>
<td>Reference</td>
</tr>
<tr>
<td>Somewhat important</td>
<td>121</td>
<td>(27)</td>
<td>0.9 (-0.1, 1.9)</td>
</tr>
<tr>
<td>Not important/Do not know</td>
<td>59</td>
<td>(13)</td>
<td>-0.4 (-1.7, 0.9)</td>
</tr>
<tr>
<td><strong>Add extra salt before eating</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily/most of the time</td>
<td>20</td>
<td>(4)</td>
<td>Reference</td>
</tr>
<tr>
<td>Sometimes of rarely</td>
<td>112</td>
<td>(25)</td>
<td>-0.8 (-3.0, 1.4)</td>
</tr>
<tr>
<td>Never</td>
<td>318</td>
<td>(71)</td>
<td>-1.5 (-3.6, 0.6)</td>
</tr>
</tbody>
</table>

* Adjusted for age, sex, recommended by doctor to reduce salt intake, importance of salt reduction in food and added extra salt before eating

*BMI has one missing value and regression analysis was conducted among 450 participants.

* Coefficients are rounded to one decimal place
### Table 4: Relationship of Blood Pressure with Salt Intake, Adjusted Analyses*

<table>
<thead>
<tr>
<th></th>
<th>Systolic BP**</th>
<th>p-value</th>
<th>Diastolic BP</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All Participants (n= 450)</strong></td>
<td>0.3 (0.0, 0.7)</td>
<td>0.05</td>
<td>0.1 (-0.1, 0.3)</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>Non-hypertensive</strong> (n=273)</td>
<td>0.1 (-0.2, 0.3)</td>
<td>0.60</td>
<td>-0.1 (-0.3, 0.1)</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Hypertensive (n= 177)</strong></td>
<td>0.7 (0.1, 1.2)</td>
<td>0.02</td>
<td>0.3 (0.0, 0.6)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*Age, sex, ethnicity, education, body mass index, diabetes, antihypertensive medication in the last two weeks for hypertensive, doctor’s recommendation to reduce salt intake, instant food consumption, knowledge about importance of reducing salt, daily tobacco use and daily alcohol consumption

** mmHg per gm/d of salt

- Coefficient are rounded to one decimal place