Estimation of mean Population salt intakes using Spot Urine samples and its association to BMI, Hypertension, raised Blood Sugar and Blood Lipids: Findings from Non-communicable Disease Risk Factors (STEPS) Survey 2019 in Nepal

Abstract
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Results: The average (±SD) age of participants was 40 (14.1) years. Mean salt intake was estimated to be 9.1g/d derived from spot urine samples. A total of 69.4% of the population consumed more than the WHO’s recommended amount of 5 g salt per day, with almost half of the population 48.9% consuming more than 10 g of salt per day. Higher salt intake was significantly associated with male gender (β for male = 0.98g; 95% CI: 0.87, 1.1) and younger age groups (β 25-39 years = 0.08; 95% CI: -0.08, 0.23) and higher BMI (β = 0.19; 95% CI: 0.18, 0.21). Participants who were hypertensive, and had high cholesterol ate less salt than people who had normal blood pressure and cholesterol level (P=0.000).

Conclusions: These findings make a strong case for action to reduce salt consumption in Nepal to achieve the global target of a 30% reduction in population salt intake by 2025. Our study clearly highlighted the need of future studies using longitudinal data or randomized clinical trials to assess the role of dietary salt in the development / prevention of blood pressure, diabetes mellitus and cholesterol levels in Nepalese population.
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The data for this study was obtained from Non Communicable Diseases Risk Factors: STEPS Survey Nepal 2019. The data and other additional information about this study can be received upon request to Nepal Health Research Council (NHRC) Ramshah Path, Kathmandu, Nepal or corresponding author of this paper on reasonable request (email: Dr. Meghnath Dhimal, meghdhimal@nhrc.gov.np)
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Estimation of mean Population salt intakes using Spot Urine samples and its association to BMI, Hypertension, raised Blood Sugar and Blood Lipids: Findings from Non-communicable Disease Risk Factors (STEPS) Survey 2019 in Nepal

Running title: Associations of urinary sodium levels with BMI, Hypertension, raised Blood Sugar and Blood Lipids

List of authors:
Saroj Bhattarai¹, Bihungum Bista¹, Binod Kumar Yadav², Pradip Gynawali¹, Anil Poudyal¹, Anjani Kumar Jha¹, Meghnath Dhimal¹*

¹Nepal Health Research Council, Ramshah Path, Kathmandu, Nepal, bhattaraisaroj23@gmail.com
²Department of Biochemistry, Maharajgunj Medical Campus, Institute of Medicine, Tribhuvan University, Maharajgunj, Kathmandu, Nepal, binod3aug@gmail.com

*Corresponding Author:
Dr. Meghnath Dhimal, Chief/Senior Research Officer, Nepal Health Research Council, Government of Nepal, Ministry of Health Complex, Ramshah Path, Kathmand,Nepal,
Phone No. 0097714254220, Fax No. 0097714262469, Email: meghdhimal@nhrc.gov.np; meghdhimal@gmail.com
Abstract

**Background:** High dietary salt intake is recognized as a risk factor for several non-communicable diseases (NCDs), in particular cardiovascular diseases (CVDs), including heart attack and stroke. Accurate measurement of salt intake is essential for setting realistic goals and plans for salt reduction strategies. We used spot urine sample for the first time to estimate the mean population salt intake in Nepal. We also evaluate the association of salt intake with BMI, Hypertension, raised Blood Sugar and Blood Lipids and their relation with socio-demographic characteristics.

**Methods:** A population based cross sectional study was carried out from February to May 2019 using a WHO STEP-wise approach to surveillance. 4361 (67.6%) spot urine was collected from the men and women aged 15–69 for the analysis of salt intake. INTERSALT equation was used to calculate population salt intake. Student's ‘t’ test, ANOVA and multivariate linear regression regressions was used to assess the association between salt intake with explanatory factors. Statistical significance was accepted at \( P < .05 \).

**Results:** The average (±SD) age of participants was 40 (14.1) years. Mean salt intake was estimated to be 9.1g/d derived from spot urine samples. A total of 69.4% of the population consumed more than the WHO’s recommended amount of 5 g salt per day, with almost half of the population 48.9% consuming more than 10 g of salt per day. Higher salt intake was significantly associated with male gender (\( \beta \) for male = 0.98g; 95% CI: 0.87, 1.1) and younger age groups (\( \beta_{25-39 \ years} = 0.08; \ 95\% \ CI: -0.08, 0.23 \) and higher BMI (\( \beta = 0.19; \ 95\% \ CI: 0.18, 0.21 \)). Participants who were hypertensive, and had high cholesterol ate less salt than people who had normal blood pressure and cholesterol level (\( P == 0.000 \)).
Conclusions: These findings make a strong case for action to reduce salt consumption in Nepal to achieve the global target of a 30% reduction in population salt intake by 2025. Our study clearly highlighted the need of future studies using longitudinal data or randomized clinical trials to assess the role of dietary salt in the development/ prevention of blood pressure, diabetes mellitus and cholesterol levels in Nepalese population.

Keywords: Spot Urine, Salt Intake, INTERSALT, BMI, Hypertension, raised Blood Sugar and Blood Lipids, Nepal

Introduction

Sodium in the salt is the principal cation in extracellular fluid in the body, and is an essential nutrient necessary for normal cell function and for neurotransmission [1,2,3]. Salt is essential nutrient if consumed in limit. High dietary salt intake is associated with high blood pressure which is recognized as a risk factor for non-communicable diseases (NCDs), in particular cardiovascular diseases (CVDs), including heart attack and stroke [4,5,6]. Conclusive scientific evidence also found the association of excessive consumption of sodium with osteoporosis, cataract, kidney stones, and diabetes [4,6]. Globally, populations are consuming excessive amounts of salt, with the worldwide estimated mean salt intake being almost 9-12 g/day [7], in many countries and even higher intakes are found in Asia, which is associated with negative effects on health [8].

In Nepal, noncommunicable diseases (NCDs) are estimated to cause 60% of total deaths, with CVDs contributing to 22% of the deaths [9]. The 2019 WHO STEPwise approach to surveillance of non-communicable disease risk factor (STEPS) survey reported almost 24.5% of the Nepalese
population had raised blood pressure [10]. High blood pressure and CVDs place a large economic burden to the government [8,11,12]. The World Health Organization (WHO) recommends consuming less than 2 grams of sodium or 5 grams of salt per day amongst adults [13]. A 30% relative reduction in mean population intake of salt/sodium by 2025 relative to 2010 levels under WHO global action plan is one of the single most effective public health strategies to reduce the burden of NCDs worldwide [13]. Nepal has also incorporated it as one of the key targets in its 5-year multisectoral action plan for 2014-2020 [14]. To achieve this objectives accurate measurement of salt intake is essential for setting realistic goals and plans for salt reduction strategies [15].

For multiple reasons, dietary assessment survey and nutrition databases methods for estimation of salt intake often underestimates sodium intake [16]. The standard approach to measuring the mean salt intake of a population has been the collection of 24-h urine samples on a subset of individuals [17]. However, this method is troublesome, time consuming, costly to participants due to the complex nature of urine sample collection and may miss the sodium estimation excreted through non-urinary routes [18] and some dietary sodium derives from sources other than salt [19]. There has been a growing interest in finding less costly and burdensome alternatives to 24-h urine collection, such as spot urine samples [20]. Equations that use spot urine samples to estimate population salt intake have been explored as a possible alternative in a number of studies [21,22,23,24,25,26,27,28]. For a country to address an estimate of mean national salt intake and, in December 2013, the WHO incorporated measurement of mean population salt intake as an element of the WHO Stepwise approach to Surveillance (STEPS) protocol [29]. Hence; we used spot urine sample data from a nationally representative population
in Nepal for the first time to estimate the mean population salt intake. We also evaluate the association of salt intake with BMI, Hypertension, raised Blood Sugar and Blood Lipids and their relation with socio-demographic characteristics.

Methods

Study design and Sampling Technique

A population based cross sectional study was carried out from February to May 2019 using a WHO STEP-wise approach to surveillance. Survey population includes men and women aged 15–69 years who have been living at their place of residence for at least six months or visitors who stayed in the households the night before the survey are eligible to interview. National representative sample was selected using multistage cluster sampling. Sample size of 925 survey participants were sampled from each of seven provinces with the total sample size of 6475 participants aged 15 to 69 years. The survey listed all the households of 259 primary sample unit (PSUs) 37 PSUs in each of 7 Provinces, 25 households per PSU were sampled using systematic random sampling. From each of the selected household, one adult member of 15-69 years was sampled randomly for participation in the survey using the android tablet.

Data Collection

The survey was conducted using the standardized WHO NCD STEPS questionnaire version 3.2. 60 Field research assistant with public health, nursing, laboratory, health assistant education backgrounds were mobilized all over the Nepal. The data collection process included three steps. Step 1: This step comprised a Questionnaire to gather demographic and behavioral
Characteristics of the study population; face to face interview was carried out to fill the questionnaire. In Step 2: Anthropometric measurement: Blood pressure, height, weight, hip, waist circumference were measured. Weight was measured with a portable digital weighing scale (Seca, Germany). Waist and hip circumference was measured using a constant tension tape (Seca, Germany). Blood pressure was measured by using digital, automated blood pressure monitor (OMRON digital device) with a universal size cuff. Step 3: Biochemical measurements were undertaken to determine the proportion of the study population with diabetes, raised blood glucose and abnormal lipid level. Blood glucose and total cholesterol was measured through dry chemistry using CardioCheck PA Analyser as recommended and supported by WHO. Concentrations of glucose, total cholesterol were measured in capillary whole blood. Fasting samples was taken to measure raised blood glucose. Participants were instructed to fast overnight for 12 hours at the time of household visit for Step 1 and 2.

Estimation of 24-hour salt intake based on spot urine testing

For the estimation of the mean population salt intake, STEPs survey utilized spot urine sample as a proxy to 24-hour urine samples. Spot urine collection was done to identify the level of Sodium (Na), potassium (K) and creatinine.

Process

For urine collection, urine container with QR code was provided to participants to collect spot urine. Participants self-collected the urine samples at home before fasting for blood sample collection the next day during their scheduled appointment for biochemical measurements.
The collected urine sample was stored in dark place in normal room temperature until they were transported to the lab. Laboratory setup was done in every province headquarters and nearly located places. Determination of Na and K in urine is carried with Ion-selective Electrodes (ISE) in an automated Analyzer (Beckman Coulter, CA, USA) and creatinine was estimated in urine by the use of semi-automated biochemistry analyser (Nova Biomedical Cooperation, Waltham, MA, USA). The unit of measurements for Na and K was mmol/L, while creatinine was mg/dl. Participants who were pregnant, fasting before collecting the urine sample, having contaminated urine sample with blood were excluded at the time of analysis. Participants whose height was less than 100 cm or above 270 cm; weight was less than 20kg or above 350 kg were also excluded.

**Daily salt consumption estimation**

Nepal estimated the 24 hours salt intake for the first time, and it was not included in 2013 survey. Three main studies developed the estimation of 24-h urinary sodium intake from spot urine samples that are: Kawasaki, INTERSALT and Tanaka [21,25,27]. However, limited evidence support the preferential use of one equation over another in a given population/context [22,28]. For this survey, Nepal used the INTERSALT Southern European equation to estimate 24 hour mean salt intake because it was developed using large heterogeneous population sample [21].
For Southern Europe:

Male:

\[
(20.861 + 0.45 \times \text{Naspo} \left( \frac{\text{mmol}}{L} \right)) - 3.09 \times \text{Crspo} \left( \frac{\text{mmol}}{L} \right) + 4.16 \times \text{BMI} \left( \frac{\text{kg}}{m^2} \right) + 0.22 \times \text{Age(year)}
\]

Female:

\[
(21.98 + 0.33 \times \text{Naspo} \left( \frac{\text{mmol}}{L} \right)) - 2.44 \times \text{Crspo} \left( \frac{\text{mmol}}{L} \right) + 2.42 \times \text{BMI} \left( \frac{\text{kg}}{m^2} \right) + 2.34 \\
\times \text{Age(year)} - 0.03 \times \text{Age}^2(\text{year})
\]

**Naspo:** Sodium concentration in spot urine (mmol/L)  
**Crspo:** Creatinine concentration in spot urine (mmol/L)  
**BMI:** Body Mass Index

The equations given above compute 24 hour ‘sodium’ intake, which is then converted to ‘salt’ intake by the division of 17.1 (or multiplication of 2.54/1000*23) as a conversion factor to obtain the final estimated 24-hour salt intake in grams.
Data processing and analysis

Descriptive statistics for demographic and behavior were recorded for both the salt and the non-salt participants of the STEPS survey. All the analyses for this study were performed on STATA 13.1 version using survey (svy) set command, defining clusters and sampling weight information. The proportion of the population above the WHO-recommended guideline of 5 g/d of salt and sodium to potassium ratio were measured. Student's t test, ANOVA and Chi-square statistics were used to determine the association of mean salt consumption levels with explanatory factors. The association between salt intake and participant characteristics were explored using Multivariate linear regression regressions for age, sex, province, education, income, BMI, and Blood Pressure, Diabetes Mellitus and cholesterol. Statistical significance was accepted at $P<.05$.

Ethical consideration

Written informed consent was obtained from research participants before enrolling in the study after explaining the objective of study, voluntary participation, privacy, confidentiality, and their right to withdraw at any point of study. Ethical approval was obtained from the Ethical Review Board (ERB) of the Nepal Health Research Council (NHRC), Government of Nepal.
Results

Response rate

Amongst the initially planned 6475 sample size, 1 PSU with 25 participants was dropped, leaving 6450 as our total sample size. The number of participants consented and completed the survey for STEP 1 was 5593 (86.7%), Step 2 was 5582 (86.5%), and STEP 3 was 5350 (86.5%). Among them only 4361 (67.6%) participants consented provides the spot urine for analysis of salt intake. The demographic characteristics of the participants included in this study are displayed in "Table 1".

Characteristics of the 1998 male and 3595 female participants in the study are reported in "Table 1". The average (±SD) age of participants was 40 (14.1) years. Most of the participants (both male and female) reside in Municipality and had none/primary education. Mean BMI of female is slightly greater than that of male (22.8 kg/m² compared to 22.6 kg/m²). Mean blood pressure (BP) was higher in male than female (127.7/83 mm of Hg compared to 121.3/80.3 mm of Hg). Among the male respondents, more than one fourth (29.8%) of population were assessed as
having hypertension. Similarly, among the female respondents about 19.7% respondents had high blood pressure (i.e., SPB ≥140 mm Hg and/or DBP ≥90 mm Hg). More female participants (11.2%) reported having previously been diagnosed with hypertension on treatment compared to (7.0%) male participants. Diabetes mellitus (DM) was prevalent among male than female (6.3% compared to 5.3) in contrast female respondents had high cholesterol level than male (13.9% compared to 7.7%). More female participants reported of ever had a heart attack or chest pain from heart disease or stroke (1.4% compared to 0.8%) in male participants.

Table 1. Study population Characteristics

| Characteristics                     | Male n (%) | n   | Female n (%) | n   |
|-------------------------------------|------------|-----|--------------|-----|
| Age (mean) (SD) 39.9 (14.1)        | 42.2 (14.6)| 1998| 38.6 (13.7)  | 3595|
| Age range                           |            |     |              |     |
| 15-24                               | 13.8       | 275 | 15.8         | 568 |
| 25-39                               | 30.8       | 615 | 41.0         | 1,472|
| 40-54                               | 30.5       | 609 | 26.8         | 965 |
| 55-69                               | 25.0       | 499 | 16.4         | 590 |
| Residence                           |            |     |              |     |
| Metropolitan/Sub metropolitan city  | 13.8       | 276 | 11.9         | 429 |
| Municipality                        | 48.3       | 964 | 49.8         | 1,791|
| Rural municipality                  | 37.9       | 758 | 38.3         | 1,375|
| Province                            |            |     |              |     |
| Province 1 | 14.3 | 285 | 14.4 | 519 |
|----------------|------|-----|------|-----|
| Province 2 | **17.7** | 353 | 12.5 | 450 |
| Bagmati Province | 15.1 | 302 | 12.7 | 457 |
| Gandaki Province | 13.4 | 267 | 14.6 | 526 |
| Lumbini Province | 13.4 | 268 | 14.7 | 529 |
| Karnali Province | 13.1 | 261 | 15.2 | 547 |
| Sudurpashchim Province | 13.1 | 262 | 15.8 | 567 |
| **Education** | | | | |
| None/less than primary | 39.6 | 792 | 55.6 | 2,000 |
| Primary | 21.2 | 424 | 17.4 | 627 |
| Secondary | 23.3 | 466 | 17.3 | 622 |
| More than secondary | 15.8 | 316 | 9.6 | 345 |
| **Wealth** | | | | |
| Lowest | 25.2 | 504 | 32.0 | 1,149 |
| Second | 18.3 | 366 | 19.4 | 696 |
| Middle | 17.3 | 345 | 16.8 | 604 |
| Fourth | 16.9 | 338 | 15.0 | 540 |
| Highest | 22.3 | 445 | 16.9 | 606 |
| Height (mean) (SD) | 161.1 (7.8) | 1997 | 151.8(6.6) | 3522 |
| Weight (mean) (SD) | 58.7(11.1) | 1997 | 52.6(10.9) | 3522 |
| Waist circumferences (mean) (SD) | 80.4 (11) | 1997 | 79.9 (17.9) | 3522 |
| BMI (mean) (SD) | 22.6 (3.8) | 1992 | 22.8 (4.2) | 3507 |
| Normal (BMI 18.5-24.9) | 65.9 | 1992 | 65.1 | 3507 |
Mean salt intake was estimated to be 9.1g/d derived from spot urine samples "Table 2". Males had significantly higher salt intake than females (9.6 g/d compared to 8.7 g/d). A total of 69.4% of the population consumed more than the WHO’s recommended amount of 5 g salt per day, with almost half of the population 48.9% consuming more than 10 g of salt per day. The sodium/potassium ratio for the population was 3.4 (SE, 0.2).

Table 2. Weighted Results for Salt Intake, Potassium Intake, and Sodium/Potassium Ratio

|                                | Overall (4361) | Male (1600) | Female (2761) |
|--------------------------------|----------------|-------------|---------------|
| Salt intake, mean (S.E), g     |                |             |               |
| Underweight (BMI<=18.4)        | 10.7           | 1992        | 9.8           | 3507          |
| Overweight (BMI 25.0-29.9)     | 20.2           | 1992        | 19.8          | 3507          |
| Obese (BMI >= 30.0)            | 3.2            | 1992        | 5.3           | 3507          |
| SBP (mean) (SD)                | 127.7 (17.9)   | 1997        | 121.3 (17.3)  | 3585          |
| DBP (mean) (SD)                | 83.0(11.6)     | 1997        | 80.3(10.5)    | 3585          |
| BP (High)                      | 29.8           | 1966        | 19.7          | 3540          |
| People measured to be          |                |             |               |
| hypertensive on treatment      | 7.9            | 721         | 11.2          | 817           |
| Diabetes Mellitus              | 6.3            | 1834        | 5.3           | 3357          |
| Cholesterol (High)             | 7.7            | 1904        | 13.9          | 3438          |
| Ever had a heart attack or     |                |             |               |
| chest pain from heart disease  | 0.8            | 1998        | 1.4           | 3595          |
| or stroke                      |                |             |               |

SD, Standard deviation
|                                | Overall (n) | Mean, 95%-CI       |     |
|--------------------------------|-------------|--------------------|-----|
| Sex                            |             |                    |     |
| Women                          | 2761        | 8.8 (8.7-8.9)      | 0.000 |
| Men                            | 1600        | 9.6 (9.5-9.7)      |     |
| Age range                      |             |                    |     |

**Table 3. Association between Levels of Salt Intake with Participants' Characteristics**

S.E, Standard error

"Table 3" shows analysis on level of salt intake in relation to Participants' Characteristics. Salt intake was found to differ significantly between sex, age range, education, province, BMI, and cholesterol level of participants, which is significant at the 5% level of significance. However, there was no evidence of an association of salt consumption with hypertension, diabetes mellitus and wealth index of participants.
| Age      | Count | Mean (95% CI) | P          |
|----------|-------|---------------|------------|
| 15-24    | 614   | 9.0 (8.8-9.1) | 0.000      |
| 25-39    | 1617  | 9.3 (9.2-9.4) |            |
| 40-54    | 1245  | 9.2 (9.1-9.3) |            |
| 55-69    | 885   | 8.7 (8.5-8.8) |            |

**Education**

| Level                           | Count | Mean (95% CI) | P          |
|---------------------------------|-------|---------------|------------|
| None/less than primary          | 2152  | 8.9 (8.9-9.0) | 0.000      |
| Primary                         | 829   | 9.2 (9.1-9.4) |            |
| Secondary                       | 858   | 9.3 (9.2-9.4) |            |
| More than secondary             | 522   | 9.2 (9.1-9.4) |            |

**Wealth index**

| Level    | Count | Mean (95% CI) | P          |
|----------|-------|---------------|------------|
| Lowest   | 1281  | 9.1 (9.0-9.2) | 0.257      |
| Second   | 831   | 9.2 (9.1-9.3) |            |
| Middle   | 749   | 9.0 (8.9-9.2) |            |
| Fourth   | 670   | 9.0 (8.9-9.2) |            |
| Highest  | 830   | 9.1 (9.0-9.2) |            |

**Province**

| Province             | Count | Mean (95% CI) | P          |
|----------------------|-------|---------------|------------|
| Province 1           | 711   | 9.1 (8.9-9.2) | 0.000      |
| Province 2           | 713   | 8.9 (8.8-9.0) |            |
| Bagmati Province     | 674   | 9.0 (8.9-9.1) |            |
| Gandaki Province     | 726   | 9.1 (8.9-9.2) |            |
| Lumbini Province     | 96    | 8.7 (8.4-9.1) |            |
| Karnali province     | 717   | 9.4 (9.3-9.6) |            |
| Sudurpashchim Province| 724  | 9.1 (9.0-9.2) |            |
| BMI (kg/m²) | Male | Female | p-value |
|-------------|------|--------|---------|
| Underweight | 372  | 8.0 (7.8-8.2) | 0.000 |
| Normal      | 2771 | 8.9 (8.8-8.9) | |
| Overweight  | 962  | 9.7 (9.6-9.8) | |
| Obese       | 240  | 10.6 (10.4-10.9) | |

| Hypertension | Male | Female | p-value |
|--------------|------|--------|---------|
| No           | 3086 | 9.1 (9.0-9.2) | 0.735 |
| Yes          | 1220 | 9.1 (9.0-9.2) | |

| Diabetes     | Male | Female | p-value |
|--------------|------|--------|---------|
| No           | 3917 | 9.1 (9.1-9.2) | 0.533 |
| Yes          | 255  | 9.0 (8.8-9.3) | |

| Cholesterol  | Male | Female | p-value |
|--------------|------|--------|---------|
| No           | 3770 | 9.2 (9.1-9.2) | 0.000 |
| Yes          | 539  | 8.8 (8.6-8.9) | |

Male participants consumed on average 1g more salt than female. Young adult (25-39 years) participant ate more salt 0.08g than older (55-69 years) age group participants (P=<0.000). Although there was no significant difference observed, more than secondary education participants ate less salt than participants who had primary and secondary education. Salt intake decreases as wealth index of the participant's increases Compared to Province 1, participants living in Bagmati, Gandaki Province ate less salt compared to participants living in
Karnali and Sudurpashchim Province however, there was no significant association was observed among participants residing in Province 2 and Lumbini Province. Salt intake increased by 0.2g as BMI increased (0.19) (P==0.000). Participants who were hypertensive, and had high cholesterol ate less salt than people who had normal blood pressure and cholesterol level (P==0.000). Compared to non-diabetic participants diabetic participants ate less salt although this difference was nonsignificant "Table: 4".

Table 4. Multivariable analysis of Salt Intake with Participants' Characteristics

| Characteristics       | Coefficient (β) | S.E  | P-Value | 95%-CI     | R-Squared | Adjusted R-Squared |
|-----------------------|-----------------|------|---------|------------|-----------|--------------------|
| Female                | Reference       |      |         |            |           |                    |
| Male                  | 0.98            | 0.05 | 0.000   | (0.87-1.1) |           |                    |
| 15-24                 | Reference       |      |         |            |           |                    |
| 25-39                 | 0.08            | 0.08 | 0.333   | (-0.08-0.23) |           |                    |
| 40-54                 | -0.03           | 0.09 | 0.737   | (-0.20-0.14) |           |                    |
| 55-69                 | -0.43           | 0.10 | 0.000   | (-0.63-0.24) |           |                    |
| None/less than primary| Reference       |      |         |            |           |                    |
| Primary               | 0.01            | 0.07 | 0.846   | (-0.12-0.15) |           |                    |
| Secondary             | 0.23            | 0.08 | 0.756   | (-0.12-0.17) |           |                    |
| More than secondary   | -0.11           | 0.09 | 0.206   | (-0.29-0.06) |           |                    |
| Lowest                | Reference       |      |         |            |           |                    |
| Province/Group                        | Coefficient | Standard Error | z-value | p-value | Confidence Interval |
|--------------------------------------|-------------|----------------|---------|---------|---------------------|
| Second                               | 0.09        | 0.07           | 0.205   | (-0.05 - 0.24)     |
| Middle                               | -0.07       | 0.08           | 0.389   | (-0.22 - 0.09)     |
| Fourth                               | -0.19       | 0.08           | 0.024   | (-0.35 - 0.02)     |
| Highest                              | -0.31       | 0.09           | 0.000   | (-0.48 - 0.14)     |
| Province 1                           | Reference   |                |         |          |                     |
| Province 2                           | -0.05       | 0.09           | 0.543   | (-0.22 - 0.12)     |
| Bagmati Province                     | -0.31       | 0.09           | 0.000   | (-0.49 - 0.14)     |
| Gandaki Province                     | -0.20       | 0.08           | 0.019   | (-0.3 - 0.03)      |
| Lumbini Province                     | -0.25       | 0.17           | 0.153   | (-0.59 - 0.09)     |
| Karnali province                     | 0.52        | 0.09           | 0.000   | (0.34 - 0.69)      |
| Sudurpashchim Province              | 0.28        | 0.09           | 0.001   | (0.11 - 0.45)      |
| BMI                                  | 0.19        | 0.01           | 0.000   | (0.18 - 0.21)      |
| Hypertension (No)                    | Reference   |                |         |          |                     |
| Hypertension (Yes)                   | -0.28       | 0.06           | 0.000   | (-0.40 - 0.16)     |
| Diabetes (No)                        | Reference   |                |         |          |                     |
| Diabetes (Yes)                       | -0.09       | 0.11           | 0.405   | (-0.29 - 0.12)     |
| High Cholesterol (No)               | Reference   |                |         |          |                     |
| High cholesterol (Yes)              | -0.32       | 0.08           | 0.000   | (-0.47 - 0.17)     |
| Constant                             | 4.53        | 0.18           | 0.000   | (4.12 - 4.87)      |
To our best knowledge, this is the first study to provide an in-depth evaluation of the capacity of spot urine samples to estimate mean population-level salt intake in Nepalese population using a nationally representative sample. Estimation of salt intake based upon spot urine samples had excellent concordance with 24-hr urine collection measurements [30] and had outstanding sensitivity (97%) and specificity (100%) at classifying mean population salt intake as above or below the World Health Organization maximum guideline value of 5 g/day [31]. Our finding demonstrated the substantial heterogeneity in average population level salt intake in Nepalese population.

We found that mean 24-h salt intake was 9.6 g/day for men and 8.7 g/day for women, with mean salt intake 9.1 g/day among adult Nepalese population, higher than WHO recommended amount of 5 g/day and majority of population (69.4%) in our context consumed more salt than this recommendation. Interestingly, our study reported 31% of the population consumed over 10 g/day salt which is double than the WHO recommended value. The average mean salt consumption level in our study is comparable to small scale studies conducted in Nepal [8], in Urban South Indian Population [32], in some states of India [33], in Bhutan [34], and in Korea [35]. The salt intake value obtained in this study is slightly lower than the previous finding reported from Nepal [36], Bangladesh [37], and China [38] which uses 24-hour urine collection measurement method. However, both methods of measurements show salt consumption in Nepal is well above the WHO global recommendation, indicating urgent actions is needed to tackle the non-communicable disease crisis in the country and to take action to reduce population wide dietary salt intake to decrease the number of deaths from hypertension, cardiovascular disease and stroke. In low- and middle-income countries (LMICs) the major contributing factors to the
high amount of daily salt intake come from discretionary salt used during cooking and salting food at the table [39,40]. A study done in south India demonstrated that food items; pulse-based dishes, cereal-based dishes and vegetable-based dishes are the major contributors to daily salt intake [41]. We also observed that similar food habits among us and these all might be the responsible factors for high salt intake in Nepalese population. It has already been reported that intake of low sodium salt is beneficial to health in many aspect [42,43,44]. Thus, it is recommended to create awareness among the general public in LMICs to cut down the use of discretionary salt in foods to decrease the level of salt intake [39,42].

Our finding reported the sodium/potassium ratio for the studied population was 3.4 (SE, 0.2), which is consistent with the finding in previous study done by Samoa et al [45]. Reducing the Na/K ratio is essential for preventing hypertension and cardiovascular disease; however there is no generally accepted recommended guideline for the Na/K ratio [46,47]. Future studies are required to establishing the Na/K ratio for providing information to individuals regarding the risk of hypertension and cardiovascular disease [47]. The finding of this study suggested that higher value of salt intake in male than female which is consistent with other studies [8,32,35,36,45,48,49]. Most of the male population in Nepal is engaged in outdoor activity and most often consume prepared or ready to eat foods which might leads to greater sodium consumption among male than female. This study shows young adult (25-39 years) ate more salt as compared to age group between (15-24 years), however, salt consumption is decline in middle (40-54 years) and older (55-69 years) age group people which is not surprising as similar finding were observed in the study conducted in Nepal [36]. Nepalese economic structure has changed shifting away from agricultural food supply system towards modern processing food
supply system. The trade liberalization has made processed foods easily available at supermarkets and fast food outlets [50]. Our findings also align with the current study conducted in Lifestyle Practices and Obesity in Nepalese Youth which shows majority (75.78%) of respondents consumes fast-food [51]. Similarly, people with higher grade levels were significantly highly likely to be knowledgeable about risk factors of non-communicable disease [52], which also reflect in this study as salt intake is low in population who had education more than secondary level. Risk factors of non-communicable diseases increased with increasing wealth [53,54], however; in contrast to these findings our study shows salt consumption was decline in those people who were included in fourth and highest wealth index. This may be due to fact that wealthier population may be aware about risk factor of non-communicable disease and may change their lifestyle. Our study showed people who reside in Karnali and Sudhurpashchim province ate more salt than other province. Salt intake is increased as BMI increased in line with another study which shows that salt intake was higher in overweight and obese individuals, this may lead to susceptible to non-communicable disease in later life among those population[33,36,45,55,56]. The correlation of high salt intake with obesity is well known, but the biological mechanisms behind this correlation are not well understood yet. High sodium intake has been suggested as an indirect cause of obesity through increased thirst following consumption of highly salted foods causing an increased intake of sugar-sweetened soft drinks [57,58].

Unlike other studies conducted elsewhere [56,59,60,61], we didn’t find any significant association between increase salt intake and hypertension. It may be due to the fact that hypertensive individuals are aware about the amount of salt intake as they are advised by the treating physician and dietician about the amount of salt intake in their diet. A possible reason
for this is that patient with raised blood pressure and under medication advice to restrict sodium intake or phenotype of salt sensitivity is heterogeneous, influenced from genetic to environmental factors with multiple mechanisms that potentially link high salt intake to increases in blood pressure [62]. However, our finding reported salt intake was less among hypertensive population compared to non-hypertensive. Sodium reduction substantially lowered blood pressure, even among those with starting systolic blood pressure levels as low as 120 mm Hg [63]. These findings indicate potentially important health benefits from sodium reduction among normotensive as well as hypertensive individuals [63]. More importantly, sodium reduction among normotensive individuals could potentially avert or delay the development of hypertension with ageing, as the association between sodium intake and blood pressure is greater at older age [64]. High-salt intake is a major risk factor for developing hypertension in type 2 diabetes mellitus, but its effects on glucose homeostasis are controversial [65]. Similarly, we did not find the association of salt intake in diabetes population though there was decrease in salt intake in population who are diabetic than non-diabetic. This study finds association between salt intake and blood lipids, however there is no established conclusive evidence regarding the relationship between sodium intake and blood lipid level [61,66,67,68]. Study has shown mixed evidence on reducing sodium intake may had or no have significant adverse effect on blood lipids and association between sodium intake and all-cause mortality, incident cardiovascular disease and non-fatal coronary heart disease [61,69,70]. Our study clearly highlighted the need of further studies using longitudinal data or randomized clinical trials on role of dietary salt in the development / prevention of blood pressure, diabetes mellitus and cholesterol levels in Nepalese population taking considerations of different measures of population characteristics.
This study has several strengths, first of all it analyzed the salt intake in community level in Nepalese population, and is not limited to any particular region, caste, sex, and age. Second, to our best knowledge, this is the first study in Nepalese population which demonstrated the association of salt intake with different characteristics. However, this study has also few major limitations; being a cross-sectional study, it cannot attribute the causality from the association of estimated salt intake and BMI and blood pressure. Second, the use of spot urine sample for the estimation of salt intake instead of its gold standard method 24-h urine sample. Therefore, its validation study in small Nepalese population is recommended. However, many large epidemiological studies have already adopted the estimation of salt intake using spot urine sample instead of 24-h urine sample because of the ease of urine sample collection and participant enrollment. Third, this study has included hypertensive individual but their detailed information on antihypertensive drug was not inclusively collected via a questionnaire. It is postulated that some antihypertensive drugs with natriuretic properties could be a confounder, but the other antihypertensive drug could not be the confounder. To be sure about the confounding factor, a correlation study with exposure namely salt intake in this study is required. Fourth, we have not focused on status of renal function tests (RFT) of the participants which might have influence on estimation of salt intake.

WHO is now considering using spot urine samples to assess population salt intake as part of STEPS in order to monitor progress toward the global targets. Several equations have been developed and tested and proven potentially useful for estimating mean population 24-hour salt intake from spot urine samples [21,24,25,27]. However, they have yet to be tested and evaluated in Nepalese population. The estimation of salt intake using spot urine samples is likely to
discriminate that salt intakes are well above the WHO recommendations and may provide a benchmark to assess the impact of salt reduction efforts in Nepal [19].

Conclusions

Our study finding suggested that higher estimated daily salt intake, approximately double than the limit recommended by WHO. A total of 69.4% of the population had a salt intake >5 g/d. This study demonstrated the association of high salt intake with different health indicators and documented the importance of lifestyle modification on health indicators. These findings suggest a need of urgent actions to reduce salt consumption in Nepal to achieve the global target of a 30% reduction in population salt intake by 2025. Population-based salt reduction strategies are cost-effective and cost-saving in most of the settings for prevention of non-communicable diseases.

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