Urinary sodium excretion and determinates among adults in Ethiopia: Findings from National STEPS survey

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Abstract

Background: There is strong and consistent evidence indicating high salt intake is one of the risk factors for non-communicable diseases (NCDs). The global target is to reduce population salt intake by 30% by 2025. This study was conducted with the aim of determining the level of urinary sodium excretion and determinates among adults in Ethiopia.

Methods: A nation-wide cross-sectional survey on NCD risk factors was carried out using the WHO STEPS survey during April and June 2015. A total of 6761 spot urine samples representative of all the regions of the country including the cities of Addis Ababa and Dire Dawa city administration were collected. The level of sodium and creatinine excretion was determined using Cobas Integra 400 Plus. INTERSALT equation was used to calculate population salt intake. Logistic regression analysis was used to assess the independent predictors of salt intake.

Results: Among 6761 study participants included in this study, 3979 (58%) were female, 2653 (39.2%) of the study participants aged between 15-29 years. The mean estimated salt intake (g/day) in Ethiopia population using random spot urine was 8.3 (95% CI 8.2-8.4) where the average salt intake among male was 9.0 (95% CI 8.9-9.1) and 7.4 (95% CI 7.3-7.4) among female. Those aged 30-34 [AOR and (95%CI)] [2.89 (1.81-4.57)] and male [AOR and (95%CI)] [2.34 (1.65-3.30)] were more likely to have high sodium intake than their counterparts.

Conclusion and recommendation: Salt consumption in Ethiopia is higher than the WHO recommendations of 5 g/day. Being male and in the thirties was a strong determinant influencing the sodium intake in our study. Population based strategies to reduce salt intake must be implemented and also factors associated with high salt intake should be considered as one of the strategies used in community interventions directed to reduce salt intake to prevent death and disability from NCDs. (Ethiop. J. Health Dev. 2017;34(Special issue):370-377)

Key words: Sodium excretion, Salt intake, Spot Urine, Ethiopia

Introduction

Non-communicable diseases (NCDs) are receiving increasing attention globally because of the recognition that NCDs have now overtaken infectious diseases as the major causes of morbidity and mortality (1). According to World Health Organization (WHO), each year 15 million people die from NCDs among person between ages 30-70 years; from this over 80% of this "premature" mortality occur in low and middle-income countries (LMICs) (2).

Key risk factors for the development NCDs and mortality worldwide are insufficient physical activity and poor dietary quality (especially high saturated and trans-fatty acid intake, low fruit and vegetable consumption and high salt intake) (3). There are strong and consistent evidence indicating that high salt intake is one of the major risk factors for NCDs diseases such as hypertension (4), cardiovascular diseases (CVD) (5), renal diseases (6), and stomach cancer (7).

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The physiological requirement for sodium is likely to be less than 1 gram per day (2.5 g salt). However, globally most adult population consumes between 9 to 12 grams of salt which exceeds the maximum recommended daily salt intake of 5 g salt/day by WHO (8). In Africa, particularly in Sub-Saharan, studies indicated that daily intake among adult population is above the upper limit of WHO (9).

In 2011, the *United Nations (UN) and WHO global action plan for the prevention and control of NCDs 2013-2020* identifies nine voluntary global targets for the prevention and control of NCDs including reduction of population mean salt intake by 30% by 2025 (10). In 2012, a technical workshop was conducted in Mauritius, '*creating an enabling for population-based salt reduction strategies in the African Region'. The focus of this workshop was to sensitize WHO member states and other stakeholders on the strategies for salt reduction to implement* WHO NCD action Plan 2011(11).

Population–based surveys are required to monitor population sodium intake thereby introducing measures to reduce salt intake to recommended levels as an important step to reduce the burden of NCDs and to assess progress against the WHO target for the reduction of salt intake. Estimation of salt intake using dietary recall survey, and 24-hour collection of urines for measurement of urinary sodium excretion is difficult, expensive and cumbersome to carry out. Estimating sodium excretion from random urine specimens is cheaper and is easy to conduct in population surveys to determine salt intake (12). There is no national data on the level of salt intake in the Ethiopian population. In this study, we investigated the level of salt intake and factors associated with high salt intake based on the estimated spot urinary sodium excretion, using 2015 Ethiopia National Steps survey for NCDs.

Methods

***Study design and sample size**:* A community based cross sectional study was carried out in 2015 using a WHO STEP-wise approach to surveillance (13). A national representative sample of all regions of the country including the cities of Addis Ababa and Dire Dawa city administration was collected with the sampling frame based on the population and housing census conducted for Ethiopia in 2007 by the Central Statistical Agency (14). Study participants who are 15-69 years of age and with more than 6 months of residential history in the study area were involved in the study. Tourists/visitors, individuals who are not regular residents in the area, those in military camps, dormitories, nursing homes, refugee camps, and pregnant women were excluded from the study. Eligible adults age 15-69 years old in each household were selected using kish method (15). Only one eligible participant was selected in the survey from selected household. A total of 6761 study participants were included in the national NCDs survey for salt study.

Survey Instrument: The survey was conducted using the WHO NCD STEPS instrument version 3.1. The questionnaire consisted of three STEPS for measuring the NCD risk factors. STEP I included demographic and behavioral questionnaires, STEPS II included physical measurements, and STEP III included biochemical measurements. Each step consisted of a number of core, expanded and optional questions. The questionnaire was modified with expanded and optional questions to suit local needs. All the modifications were done in accordance with the STEPs manual (13).

Data Collection: The survey data were collected between April and June, 2015. Survey data collection was carried out by 35 teams with three people in each team, a supervisor and two data collectors who were trained extensively prior to data collection.

Demographic and lifestyle data collection, Anthropometric measurements, and biochemical measurements: The data collection process included three steps. Step 1: This step comprised a questionnaire to gather demographic and behavioral characteristics of the study population, such as tobacco use status, physical activity; Khat use, and history of raised blood pressure. In step 2: Blood pressure was measured for all survey participants whereas body weight, height, waist circumference, and hip circumference were measured for all survey participants other than pregnant women. Body weight and height was measured with the electronic Growth Management Scale. This is a device suitable for measuring a combination of factors (body scale with height gauge) with laser. It measures body weight and height, and calculates body mass index (BMI). BMI is a ratio of body weight in kilograms to the square of body height in meters. Step 3: Biochemical measurements were undertaken to build on the core data in Step 1 and Step 2 to measure proportion of the study population with diabetes, raised blood glucose and abnormal lipid level. In addition to core and expanded modules, some optional modules were included in each of the three steps.

Salt intake study: Dietary recall and measurement of 24-hour sodium excretion are the current method to assess sodium intake (16). Dietary recall is often inaccurate, and 24-hour urine collection to measure sodium excretion is considered as the gold standard for the assessment of salt consumption in populations based study. The collection of 24-hour urine is cumbersome, inconvenient in a field survey particularly in area where resources are constrained. Spot urine is preferable method (low-burden, low-cost), even though it has inherent limitations, to estimate 24-hour urinary sodium excretion and explored in many studies including INTERSALT method (17).

In this study, to estimate daily salt intake 10ml of random (spot) urine sample was taken from study participants. The urine sample was transported to National References Laboratory for Clinical Chemistry, Ethiopian Public Health Institute (EPHI) and stored at -20°c until analysis. Both urinary Sodium and Creatinine were measured using COBAS Integra 400 plus, Clinical Chemistry analyzer, (Roche Diagnostic GmbH, Manneheim, Germany), which uses Ion selective electrode (ISE) method and enzymatic method for sodium (18) and creatinine (19) respectively.

Estimating the 24 Hour Urinary Sodium Excretion from spot Urine: The 24-hour urinary sodium excretion was estimated from spot urine measurement of sodium and creatinine using INTERSALT equation. This equation was selected because it was developed using large heterogeneous population sample and published both including and excluding potassium concentration from spot urine (20).

Equation for predication 24-hour urinary sodium excretion from casual urine sample in mmol/L

1. Estimated 24-hour urinary Na excretion for Male = 23.51 + (0.45 x spot Na (mmol/L)) – (3.09 x spot Cr (mmol/L)) + (4.16 x BMI (kg/m2)) + (0.22 x age (in years))
2. Estimated 24-hour urinary Na excretion for Female = 3.74 + (0.33 x spot Na (mmol/L)) - 2.44 x spot Cr (mmol/L)) + (2.42 x BMI (kg/m2)) + (2.34 x age (in years)) – (0.03 x age 2 (years))

The main sodium eliminated in the urine comes from the diet, the excretion would correspond to the dietary salt (NaCI) intake. According to the internationally established protocol and in line with WHO recommendations, the amount of salt intake per day is estimated by dividing the sodium excreted per day in mmol by a conversion factor of 17.1 (1 g NaC1 is equivalent to 17.1 mmol of sodium or 393.4 mg of sodium) (21, 22).

Data Analysis*:* Statistical analyses were performed using SPSS (version 20). The mean salt intake was estimated. Logistic regression analysis was used to obtain associations between salt intake and the independent variables. All factors with a p-value < 0.05 in a bivariate analysis were further entered into the multivariable model to control confounding effects. Odds ratio with 95% CI were estimated to identify the independent predictors of high salt intake.

Ethical considerations: Ethical clearance was obtained first from the EPHI Institutional review board (IRB) and then from National research and Ethics review committee. Furthermore, official letter was produced and delivered to the respective regional health bureaus by EPHI during fieldwork. Principles of ethics were considered. Before administering questions/collecting urine sample, informed consent was obtained from the study participants and objectives of the study was explained to the participants by the data collectors. For under eighteen children (age <18 years) survey participants assent and consent from their parents or guardians was obtained.

Results

Demographic Characteristics: In the present study a total of 6761 study participants were included. Of these, about 3750 (58%) were female. More than 70% (n=4937) were rural residents, and more than 75% (n=5084) of the study participants were in the age group between 15-44 years (Table 1). Finding shows that, 4509 (67%) of the study participants had normal BMI (18.5-24.99 kg/m^2), 4614 (68%) of the study participants during study period were married or cohabiting. 3324 (49%) of the study participants had no formal education, 5414 (80%) had normal waist circumference, 4370 (65%) of the study participant had high level physical activity, and 5462 (80.8%) of the study participants had normal blood pressure.

Estimated Salt Consumption: Estimated mean salt intake in Ethiopia population based on the estimation of 24 hour urinary excretion using spot urine was 8.3 g/day (95% CI 8.2-8.4). Salt intake was higher among men (9.0 grams daily, 95% CI 8.9-9.1) than in female. There was no significant differences in the average salt intake among urban and rural residents (Table 2). Overall, 96.2% of the study participants (97.5% of men and 95.3% of the women) had more salt intake than the WHO recommendations (5g/day).

Table 1: **Socio demographic characteristics of the study population, Ethiopia NCD STEPS, 2015**

Characteristics		**Total N (%)**
Age group	15-29	2653 (39.2)
	30-44	2431 (36.0)
	45-59	1209 (17.9)
	60-69	468 (6.92)
Gender	Male	2824 (41.8)
	Female	3937 (58.2)
BMI(Kg/m2) ς	Low BMI	1574 (23.3)
	Normal BMI	4509 (66.8)
	High BMI	666 (9.9)
Residence area	Urban	1824 (27.0)
	Rural	4937(73.0)
Regions	Tigray	825 (12.2)
	Afar	194 (2.87)
	Amhara	1371 (20.3)
	Oromiya	1563 (23.1)
	Somali	22 (3.28)
	B. Gumuz	139 (2.06)
	SNNPR	1354 (20.0)
	Gambela	260 (3.85)
	Harari	168 (2.48)
	Dire Dawa	73 (1.08)
	Addis Ababa	592 (8.76)
Marital status	Single	2144 (31.7)
	Married or cohabiting	4614 (68.3)
Occupational status	Employed	677 (10.1)
	Skilled Worker	3528 (52.8)
	Housewife/Homemaker	1642 (24.6)
	Unemployed	835 (12.5)
Level of Education	No Formal Education	3324 (49)
	Primary Education	2608 (39)
	Secondary Education	485 (7.2)
	College and above	344 (5.1)
Quartiles of income	Quintile 1	1168 (24.3)
	Quintile 2	1269 (26.4)
	Quintile 3	1137 (23.7)
	Quintile 4	1224 (25.5)
Waist circumference	Normal	5414 (80.1)
	Raised	1345 (19.9)
Physical Activity Level Φ	Low level	1176 (18)
	Moderate Level	1150 (17)
	High Level	4370 (65)
Current smoker	Yes	323 (5)
	No	6438 (95)
Current Chewing Khat Δ	Yes	1019 (81.3)
	No	235 (18.7)
Blood Pressure in mmHg Ψ	Normal range	5462 (80.8)
	Raised (>=140/>=90)	1299 (19.2)

ςBMI=Body mass Index, It measures body weight and height, and calculates body mass index (BMI) (Body weight (kg)/ Body height/(m2)). Low BMI= <18.5 kg/m^2, Normal BMI= 18.5-24.99 kg/m^2, High BMI= >25 kg/m^2

Ψ SBP= Systolic blood pressure, DBP= Diastolic blood pressure, Raised blood pressure (SBP ≥140 and/or DBP ≥ 90 mmHg

ΦPhysical activity Level

- High-level physical activity involves a person reaching any of the following criteria: vigorous-intensity activity at least three days per week, achieving at least 1500 metabolic equivalent time (MET) minutes per week; or seven or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a at least 3000 MET-minutes per week.
- Moderate level physical activity involves a person not meeting the criteria for the high-level category, but meeting any of the following criteria: Three or more days of vigorous-intensity activity of at least 20 minutes per day; or five or more days of moderate-intensity activity or walking for at least 30 minutes per day; or Five or more days of any combination of walking, moderate- or vigorous-intensity activities achieving at least 600 MET-minutes per week.
- Low level physical activity involves a person not meeting any of the above-mentioned criteria for the moderate- or high-level categories.

Δ Khat=Khat (Catha edulis) is an evergreen plant that grows mainly in Yemen, Kenya, Ethiopia, and at high attitudes in South Africa and Madagascar.

ΛInformation sheets are incomplete because study participants were unwilling to give the response for the particular questions

Table 2: **Mean salt intake (g/day), by sex, age, and area of residence, 2015 Ethiopia NCDs Step survey**

Variables	n (%)	Mean salt intake (g/day) (95% CI)
Age group		
15-29	2653 (39.2)	8.1 (8.0-8.2)
30-44	2431 (36.0)	8.4 (8.3-8.5)
45-59	1209 (17.9)	8.5 (8.3-8.6)
60-69	468 (6.92)	8.4 (8.1-8.0)
Gender		
Men	2824 (41.8)	9.0 (8.9-9.1)
Women	3937(58.2)	7.4 (7.3-7.4)
Residence		
Urban	1824 (27.0)	8.3 (8.2-8.4)
Rural	4937 (73.0)	8.0 (7.8-8.1)
Total	**6761**	**8.3 (8.2-8.4)**

Factors associated with high salt Intake: A logistic regression analysis for daily salt intake $\geq$ 5g/day using age, gender, BMI, residence area, regions, marital status, occupation status, level of education, household income, waist circumference, physical activity, current status of chewing khat, and blood pressure as covariates was performed (Table 3).

The odd of high salt intake was 1.76 times among men group compared to women. Using subject aged 60 to 65 years as a control, age groups of 15-29, 30-44 and 45-59 years old were [AOR and (95% CI)] [2.19 (1.38 – 3.47)], [AOR and (95% CI)] [2.89 (1.81-4.57)] and [AOR and (95% CI)] [2.76 (1.66 – 4.59)] times more likely to have high level salt intake ($\geq$ 5gm/day) respectively.

Study participants with low BMI and normal BMI were less likely to take more than the recommended salt intake per day than high BMI i.e. 83% and 68%, respectively. There were also significant differences across area of regions in the level of salt intake. In multivariate regression analysis for regions using Addis Ababa city administration as control, it was noted that those living in Afar, Somali, Benishangul – Gumuz, and Gambela regional states were less likely to take more than the recommended salt amount per day by 64%, 86%, 79% and 77%, respectively compared to Addis Ababa city administration. Study participant from Addis Ababa city administration consumed high salt intake per day compared to individuals from Afar, Somali, Benishangul-Gumuz, and Gambela regional states. However, using high physical activities as a control, low level of physical activity [AOR and (95% CI)] 0.61, (0.44 – 0.86)] was associated with a low salt intake. There were no associations with marital status, level of education, blood pressure, and waist circumference on the level of salt intake.

Table 3: **Multivariate analysis of salt intake level by respondent background characteristics, 2015 Ethiopia NCDs Step survey**

Variables	Total N (%)	Salt Intake Elevated from WHO cutoff		Adjusted* OR(95% CI)	P-value
		< 5 gm N	≥5 gm N		
Age group					
15-29	2653 (39.2)	116	2537	2.19 (1.38-3.47)	< 0.001
30-44	2431 (36.0)	69	2362	2.89 (1.81-4.57)	<0.001
45-59	1209 (17.9)	33	1176	2.76 (1.66-4.59)	<0.001
60-69	468 (6.92)	39	429	1	
Gender					
Male	2824 (41.8)	70	2754	2.34 (1.65-3.30)	<0.001
Female	3937 (58.2)	187	3750	1	
BMI(Kg/m2)					
Low BMI	1574 (23.3)	105	1469	0.17 (0.074-0.39)	<0.001
Normal BMI	4509 (66.8)	145	4364	0.32 (0.14-0.72)	0.006
High BMI	666 (9.9)	7	659	1	
Geographic Regions					
Tigray	825 (12.2)	25	800	0.954 (0.47-1.93)	0.896
Afar	194 (2.87)	16	178	0.34 (0.15-0.77)	0.010
Amhara	1371 (20.3)	36	1335	0.91 (0.47-1.78)	0.788
Oromiya	1563 (23.1)	39	1524	0.9 (0.47-1.71)	0.739
Somali	22 (3.28)	33	189	0.14 (0.07-0.29)	<0.001
B. Gumuz	139 (2.06)	11	128	0.21 (0.09-0.49)	<0.001
SNNPR	1354 (20.0)	54	1300	0.06 (0.54-0.29)	0.056
Gambela	260 (3.85)	22	238	0.23 (0.11-0.48)	<0.001
Harari	168 (2.48)	3	165	1.13 (0.31-4.12)	0.858
Dire Dawa	73 (1.08)	3	70	0.65 (0.18-2.39)	0.515
Addis Ababa	592 (8.76)	15	577	1	
Marital status					
Single	2144 (31.7)	110	2034	0.75 (0.55-1.01)	0.055
Married or cohabiting	4614 (68.3)	147	4467	1	
Occupational status					
Employed	677 (10.1)	25	652	0.79 (0.43-1.45)	0.450
Skilled Worker	3528 (52.8)	108	3420	1.16 (0.75-1.80)	0.499
Housewife/Homemaker	1642 (24.6)	71	1571	1.29 (0.8-2.07)	0.300
Unemployed	835 (12.5)	45	790	1`	
Level of Education					
No Formal Education	3324 (49)	148	3176	1.01 (0.47_2.17)	0.983
Primary Education	2608 (39)	85	2523	1.18 (0.57-2.44)	0.648
Secondary Education	485 (7.2)	11	474	1.76 (0.73-4.25)	0.210
College and above	344 (5.1)	13	331	1	
Waist circumference					
Normal	5414 (80.1)	220	5194	0.72 (0.48-1.07)	0.107
Raised	1345 (19.9)	37	1308	1	
Physical Activity Level					
Low level	1176 (18)	67	1109	0.61 (0.44-0.86)	0.004
Moderate Level	1150 (17)	50	1100	0.82 (0.57-1.17)	0.271
High Level	4370 (65)	139	4231	1	

BMI=Body mass Index, SBP= systolic blood pressure, DBP= Diastolic blood pressure, OR=odds ratio; CI, confidence interval

*Adjusted for age group, gender, BMI, geographic regions, marital status, occupational status, level of education, raised waist circumferences, physical activity level.

Discussion

The mean salt intake among the adult Ethiopia population age 15-69 is 8.3 g per day and the majority of the study participants (96.2%) consumed more than the maximum recommended daily salt intake of 5 g salt/day.

Worldwide, the average national intake of sodium is near to 10g per day (23). Huang et al. conducted a systematic review and meta-analysis to quantify the population mean salt intake using 24 hour and spot urine samples. In this study, the overall mean salt intake was 9.3 g/day based on 24 hour urine sample and 9.0 g/day using spot urine samples (24).

Salt intake was also estimated from two regions of north India (Delhi and Haryana) and south India (Andhra Pradesh) population using spot and 24 hour urine collection method. Based on the 24 hour urine collection, salt intake was 8.59 g/day and 9.46 g/day both in Delhi and Haryana and Andhra Pradesh population respectively, whereas using INTERSALT equation for spot urine, the corresponding salt intake estimates was 7.99 g/day and 8.64 g/day both in Delhi and Haryana and Andhra Pradesh population respectively (25,26).

Our results is in concordances with the previous study conducted in Ethiopia, using 24-hour dietary recall method. In this study, the mean salt consumption was 8.4 ± 5.9 g per person per day with the highest in Southern Nations, Nationalities, and Peoples' Region, 17.2 g/day, and the lowest in Tigray with 4.6 g/day (27). It is assumed that Ethiopia Population consume excessive salt from their traditional food such as *genfo*, *beso* , *dabo*, *kinche, kita* and *chuko* also from spices (*berbere*, *mitmita*, *awaze*), and hot beverages like coffee (28).

Our study suggests, both age and gender was the strongest determinate factor influencing the sodium intake in the Ethiopia adult population. Being male and younger age group related to excess levels of salt intake which similar to previous studies (20-31). In contrast to this, previous studies have shown that older age group related to high salt intake than younger age group (32, 33). This result can be explained by differences in the dietary source of salt among countries.

Unlike other studies conducted elsewhere (34, 35), we didn't find any association between salt intake and hypertension. Hypertension treatment status may be significantly affected sodium intake. As expected, those who had hypertension and currently on treatment consumed less sodium than those who were normotensive. A possible reason for this is that patient with raised blood pressure and under medication advice to restrict sodium intake.

One of the limitations of this study is formulae-derived estimate of 24 hour sodium excretion conducted from spot urine. Nowadays, there are at least six equations established to estimate 24-hour urine excretion from a spot urine sample and there is no clear cut which equation to be used (36). In this study, we used INTERSALT equation, which were developed from the western population using heterogeneous population samples provided the least biased estimates of 24 hour sodium excretion when compared to other equations (37, 38).

Even though INTERSALT equation gives better results to estimate 24 hour sodium excretion, it is not yet evaluated in Ethiopia population. Estimation of salt intake using 24 hour urine sample reflects an ingested sodium intake with a 24 hour period of time and considered as a gold standard. However, a collection of 24 hour urine sample for the direct estimation of salt intake for the large-scale survey will be impractical and imposes a high burden on the participants and results in a low response rate (12). The major strength of our study is the large, nationally representative sample of adult Ethiopia population.

Conclusions:

Salt consumption in Ethiopia population is high and both gender and age were shown to be the major determinant factor for consumption of high salt intake. Population-based strategies to reduce salt intake must be implemented to prevent death and disability from NCDs.

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