The association of urinary sodium excretion with dietary sodium intake among selected low-income urban households

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

INTRODUCTION

Sodium chloride or dietary salt is significantly associated with hypertension[1-3] because higher salt intake could lead to hypertension.[4] Elevated blood pressure (BP) is responsible for up to 13% of global deaths.[5] It is a significant disease in Malaysia, with a prevalence of 32.7% in 2011 and 39.3% in 2014.[6] Hypertension is one of the main risk factors for cardiovascular disease (contribution of 39.3%),[7] and is present in 35% of the adult population in Southeast Asia.[8]

Dietary sodium consumption among the general population is high despite the known risks to health.[9] The average sodium intake among the adult population in most countries is more than 100 mmol/day (~6 g of salt per day), and in many Asian countries, the mean intake is more than 200 mmol/day (~12 g of salt per day).[10] These levels of sodium intake exceed the World Health Organization (WHO) recommendation of 2 g of sodium per day (~5 g of salt per day).[11]

Measuring the level of sodium intake in a population is crucial for salt reduction strategies that encompass proactive health promotion at the individual level[12] because reducing sodium intake could help reduce the prevalence of chronic diseases.[13] Several studies on the Asian population have sought to determine sodium intake through 24-hour urine samples,[14] but there is a paucity of research to determine the relationship between sodium intake and urinary sodium excretion in the context of Malaysia. Determining 24-hour urinary sodium excretion is considered to be the reference standard for estimating salt intake[12] because a 24-hour urine collection is required to capture the marked diurnal variations in sodium, chloride and water excretion. Electrolyte excretion in healthy individuals reaches a maximum at or before midday, and a minimum at night towards the end of sleep.[15] It has been found that factors such as urbanisation[16] and low socio-economic status[17] are associated with higher sodium consumption due to high intake of processed food. Therefore, this study aimed to determine the amount of dietary sodium intake and urinary sodium excretion among low-income city dwellers and to investigate factors associated with it.

METHODS

Study design and study population

This was a cross-sectional study among the residents of two randomly selected low-income community housings (flats) under the People's Housing Project, locally known as *Program Perumahan Rakyat* (PPR), located within metropolitan Kuala Lumpur Malaysia. Participants were adults (aged 18 years and above) without a history of chronic disease (diagnosed by healthcare professionals) such as hypertension, diabetes mellitus, heart and/or renal disease (chronic kidney disease) or mental illness, who agreed to provide urine collected over 24 hours and who had resided in the area of study for at least 6 months.

Data collection

Household visits were conducted at each flat (PPR), and all adult residents were invited to participate in this study. Those who agreed to participate were asked for verbal consent for a brief interview to screen whether they met the inclusion criteria. Recruitment was only finalised after written consent was obtained, and appointments were given for the participants to attend the actual interview and provide urine at a study station set up near their flats.

For the actual data collection at the study station, a face-to-face interview guided by questionnaires was conducted by a trained dietitian, and the information obtained was recorded on a form. Information on demographic variables, socio-economic data, smoking habits, hypertension history and the usage of medication, and a 3-day dietary recall was collected. Height and weight were measured by the interviewers, whereas BP was measured by medical doctors.

Three-day dietary recall[18] data — information about dietary intake and other dietary practices over the past 3 days (2 weekdays and 1 day of the weekend) — were obtained to capture the participants' habitual dietary intake. This method is appropriate for low-income and low-literacy populations because it does not require participants to read or write to complete the recall.[19]

For the 24-hour urine collection, participants were asked to void the first urine in the morning into a provided container after discarding the initial flow of urine, after which all urine for the following 24 hours was collected. The last collection was the first urination on the second day of collection.[20,21] The participants recorded the start and end of the 24-hour urine collection and were instructed to notify the data collectors if any collection was missed. They were reminded that it was important to stick to their normal diet and activities during the period of urine collection[22] to ensure that the dietary intake was related to the 24-hour urine samples.

© 2023 Singapore Medical Journal | Published by Wolters Kluwer - Medknow

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

Study tools and measurement protocol

Weight was measured using a SECA 813 weight scale (SECA, Birmingham, UK), and height was measured using a SECA Portable 217 stadiometer (SECA, Birmingham, UK). Both tools were calibrated. The weight and height were measured according to a standardised protocol and recorded to the nearest 0.1 kg and 0.1 cm, respectively. BP levels were measured using the OMRON Automated Blood Pressure Monitor HEM-7211, with participants in a sitting position, and their right arm bared, supported and positioned at heart level. Three readings were taken with at least a 1-minute interval, and subsequently increased to 5 minutes if the first reading was too high.

The 3-day dietary recall interview[18] was conducted within 30 minutes to avoid sufficing behaviour.[23] The participants were asked about their usual dietary intake in the past 3 days with the help of a flip chart and measurement tools such as scoops and cups. In addition, they were asked about the estimated frequency of consuming high-sodium foods such as sauces and fast food. The 24-hour urine collection was normally completed within 48 hours after the 3-day dietary recall was taken. Urine samples were sent to the accredited University of Malaya Medical Centre (UMMC) Laboratory (MS: ISO 15189:2014 by the Department of Standard Malaysia) for analysis on the same day that they were returned. Participants who collected less than 250 ml of urine and/or whose time collection was outside the 20- to 28-hour range were excluded from this study.[24]

Data analysis

Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in metres. For analysis, BMI was categorised according to Asia-specific criteria[25] because Asians are known to have a higher amount of fat as compared to their Western counterparts with the same BMI.[26] BP was categorised according to the Clinical Practice Guidelines for Management of Hypertension (4th edition).[27]

Dietary data were then analysed using Nutritionist Pro™ Dietary Analysis software (Axxya Systems, Redmond, WA, US). Data cleaning and quality checks were conducted before analysis. Participants whose ratio of total energy intake (EI) to basal metabolic rate (BMR) was less than 1.2 were considered to have under-reported their dietary intake (a ratio of 1.2 is considered the minimum ratio to maintain body weight),[28] and were excluded from the analysis. BMR was determined using the Henry equation.[29]

Statistical analyses were carried out using the IBM SPSS Statistics version 20.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics were computed for socio-demographic, anthropometric, BP, BMI, urinary sodium excretion and dietary sodium intake variables. An independent *t*-test and Mann-Whitney *U* test were conducted to compare the 2 independent groups. Pearson and Spearman correlations were used to show the association between 2 variables.

Ethical approval

This study obtained ethical approval from the UMMC Medical Ethics Committee and was conducted in accordance with the ethical standards of the Helsinki Declaration. Written informed consent was obtained prior to the interview session (referral number: MEC ID: 20144_157).

RESULTS

Among the 437 residents who were approached, 237 agreed to participate in the study, making the response rate 54.2%. Only 180 participants completed the interview, attended the anthropometric measurements, gave enough urine and reported that they were free from diseases, making the completion rate 75.9%. However, only 147 participants were included in the analysis because 33 of them had known hypertension and were excluded. Table 1 shows the socio-demographic, anthropometric, clinical and biochemical profiles of the participants.

A further 46 participants (31.3%) were excluded because their dietary intake was under-reported. The final data for analysis was from 101 participants. The energy and dietary sodium intake of these participants are shown in Table 2.

Further analysis using Pearson correlation found a good, positive correlation between dietary sodium intake and EI ($r = 0.58$; $P < 0.001$) [Figure 1]. Partial correlation after controlling for age, gender, BMI and smoking status indicated that dietary sodium intake was significantly associated with EI ($r = 0.51$; $P < 0.001$) and BMI ($r = 0.30$; $P < 0.05$) but not with systolic BP (SBP). There was also a significant association between BMI and EI ($r = 0.30$; $P < 0.05$).

The association between urinary sodium excretion and dietary sodium intake was established with rs (99) = 0.27, where $P < 0.05$. There was also a significant association between urinary sodium excretion and EI, rs (99) = 0.33, and between

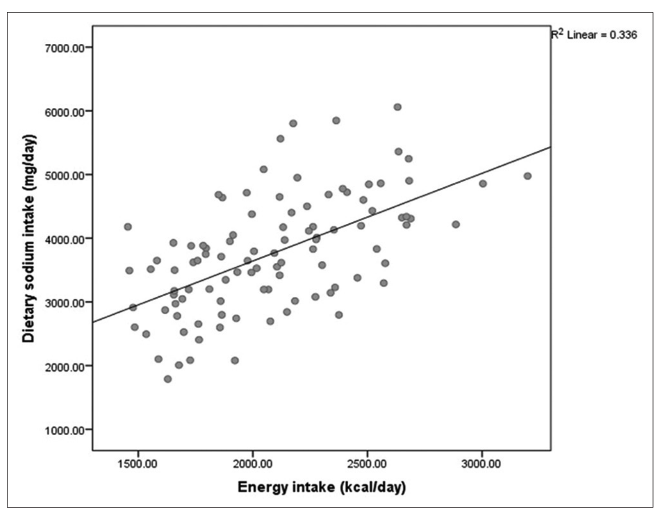

Figure 1: Graph shows the correlation between dietary sodium intake (mg/day) and energy intake (kcal/day) among participants.

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

urinary sodium excretion and BMI, rs (145) = 0.31 ($P < 0.001$ for both). After controlling for age, gender, BMI and smoking status, the associations between urinary sodium excretion and dietary sodium intake and between EI and BMI were still significant: rs (99) = 0.20, EI, rs (99) = 0.27 and BMI, rs (99) = 0.32; $P < 0.05$.

Using the linear regression model, it was shown that those with high BMI were 5.40 times more likely to have higher urinary sodium excretion than those with low BMI (95% CI 2.860–7.936; $P < 0.001$).

DISCUSSION

A previous local study had reported that unhealthy dietary practices were common among the low-income urban community. However, they did not use sodium levels in urine collected over 24 hours as the biomarker assessment.[30] Sodium intake can be estimated indirectly from the dietary survey method or directly by using the urinary collection method.[12] Hence, the current study is the first local study on the estimation of sodium intake among adults in the community that uses both the dietary history of sodium intake and urinary excretion of sodium.

In this study, the median urinary sodium excretion of the participants was 90.0 mmol/24h, which was equivalent to 2070.0 mg of sodium per day or 5.2 g of salt per day. Considering that 95.0% of the dietary sodium will be excreted in the urine[31] and the intake of sodium estimated from the sodium excretion in urine can be calculated by multiplying by the factor 100/95, we can say that the dietary sodium intake of the participants was high. The estimated sodium intake from urinary sodium excretion was 2178.9 mg or equivalent to 5.4 g of salt per day. Meanwhile, the estimated mean dietary sodium intake of the participants was 3759.7 mg/day (standard deviation = 899.6) or equivalent to 9.4 g of salt per day. By comparison, the dietary intake of sodium in this study population was almost twice the WHO recommendation of 2 g of sodium per day (5 g of salt per day).[11]

The high intake of sodium in Asian countries can be attributed to the salt present in sauces and seasonings, and the salt added during preparation and consumption of food.[14] Malaysia underwent rapid urbanisation over 5 decades (1970–2010).[32] It is well known that urbanisation is associated with sedentary behaviour, which affects food consumption due to changing dietary behaviour, leading to increased consumption of saturated fats and sugar.[33] The fast food industry has exploited this niche by providing convenient and affordable takeaway meals. These meals also satisfy the consumers' demand for food high in salt, fat and sugar.[34] According to the Centers for Disease Control and Prevention,[35] sodium intake increases when the EI increases because energy-dense foods have a higher sodium content. In addition, sodium intake is likely to increase in Southeast Asia as people eat out more frequently and consume more processed food.[14]

Although sodium intake using the dietary survey method (3-day dietary recall) could be underestimated, dietary sodium intake was higher compared to urinary sodium excretion in this study. A possible explanation is that the dietary survey method requires participants to recall and recount all the different food and drinks they had consumed over the past 3 days; this could lead to inaccurate reporting as a result of forgetfulness and omissions. In addition, the interview conditions could also contribute to inaccurate reporting.[36] This issue was minimised because the dietary assessment was done by a qualified health professional using visual aids to estimate the serving portions.[37] However, participants could still under- or over-report their dietary intake.[38]

This study also found that when dietary sodium intake is increased, urinary sodium excretion also increases, similar to findings reported in previous studies.[39-41] Given that around 95.0% of sodium consumed is excreted in urine,[31] urinary sodium excretion naturally increases when sodium consumption increases. However, because of the extensive use of sodium in food and widespread use of sodium or salt in food processing,[42] it is difficult to quantify discretionary salt intake,[41] leading to inaccurate sodium measurements by the dietary method.

The results from this study provide beneficial insights for government agencies and other stakeholders. Policies can be developed to educate the public regarding the health effects of high sodium intake and work with the food industries to minimise sodium content in food.[43] Such policies will assist in preventing chronic non-communicable diseases (NCDs) from escalating in Malaysia. He *et al.*[44] found that a modest reduction in salt intake has an essential effect on lowering BP in both hypertensive and normotensive individuals. Azizan *et al.*[45] found a reduction of 2.96 mmHg in SBP when salt intake was reduced, after controlling for physical activity.

Based on the findings of this study and the established relationship between sodium level and hypertension, there is a need to promote low intake of dietary sodium among people. There are various strategies to do this, and a good example is the 'Pick the Tick' programme established in New Zealand, which helps consumers identify foods with nutrition profiles that are more consistent with a 'heart-healthy diet' by means of their logo. The food industries then came on board to voluntarily reduce the sodium content in their processed foods.[46] It is important to take some action, not just for the benefit of adults, but also for the younger population because studies among adolescents have shown that their levels of sodium consumption are higher than the recommended value.[47]

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

Table 1. Socio-demographic, anthropometric, clinical and biochemical profiles of the participants.

Variable	n (%)			P
	Total (n=147)	Male (n=54)	Female (n=93)	
Socio-demographic profile				
Age (yr)*	47.67±11.71	49.54±13.08	46.59±10.76	0.142[a]
18–29	10 (6.8)	5 (3.4)	5 (3.4)	
30–39	22 (15.0)	7 (4.8)	15 (10.2)	
40–49	49 (33.3)	12 (8.2)	37 (15.2)	
50–59	42 (28.6)	17 (11.6)	25 (17.0)	
>60	24 (16.3)	13 (8.8)	11 (7.5)	
Race				0.407[b]
Malay	133 (90.5)	49 (33.3)	84 (57.1)	
Chinese	8 (5.4)	3 (2.0)	5 (3.4)	
Indian	3 (2.0)	2 (1.4)	1 (0.7)	
Others	3 (2.0)	0	3 (2.0)	
Religion				0.854[b]
Islam	135 (91.8)	49 (33.3)	86 (58.5)	
Hindu	4 (2.7)	2 (1.4)	2 (1.4)	
Buddhist	8 (5.4)	3 (2.0)	5 (3.4)	
Marital status				0.055[b]
Single	10 (6.8)	6 (4.1)	4 (2.7)	
Married	131 (89.1)	48 (32.7)	83 (56.5)	
Divorced	6 (4.1)	0	6 (4.1)	
Level of education				0.287[b]
No formal education	6 (4.1)	0	6 (4.1)	
Primary	20 (13.6)	10 (6.8)	10 (6.8)	
Lower secondary	31 (21.1)	11 (7.5)	20 (13.6)	
Upper secondary	70 (47.6)	26 (17.7)	44 (29.9)	
STPM/diploma	11 (7.5)	5 (3.4)	6 (4.1)	
Don't know	9 (6.1)	2 (1.4)	7 (4.8)	
Type of work				<0.001[b]
Government	8 (5.4)	4 (2.7)	4 (2.7)	
Private sector	46 (31.3)	27 (18.4)	19 (12.9)	
Self-employed	23 (15.6)	12 (8.2)	11 (7.5)	
Pensioner	8 (5.4)	6 (4.1)	2 (1.4)	
Unemployed	56 (38.1)	4 (2.7)	52 (35.4)	
Don't know	6 (4.1)	1 (0.7)	5 (3.4)	
Smoking				<0.001[c]
Yes	37 (25.2)	35 (23.8)	2 (1.4)	
No	110 (74.8)	19 (12.9)	91 (61.9)	
Anthropometric profile				
BMI (kg/m^2)*	26.22±5.41	24.56±4.57	27.17±5.65	<0.05[a]
Underweight (<18.5)	11 (7.5)	5 (3.4)	6 (4.1)	
Normal (18.5–22.9)	27 (18.4)	14 (9.5)	13 (8.8)	
Overweight (23.0–24.9)	23 (15.6)	8 (5.4)	15 (10.2)	
Obese I (25.0–29.9)	52 (35.4)	21 (14.3)	31 (21.1)	
Obese II (≥30.0)	34 (23.1)	6 (4.1)	28 (19.0)	
Clinical profile				
SBP (mmHg)*	120.00±11.66	122.88±10.22	118.32±12.16	0.022[a]
Optimal (<120)	61 (41.5)	15 (10.2)	46 (21.3)	
Normal (<130)	53 (36.1)	25 (17.0)	28 (19.0)	
High normal (130–139)	33 (22.4)	14 (9.5)	19 (12.9)	
DBP (mmHg)*	70.87±8.45	70.91±8.16	70.84±8.66	0.959[a]

Contd...

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

Table 1. Contd...

Variable	n (%)			P
	Total (n=147)	Male (n=54)	Female (n=93)	
Optimal (<80)	117 (79.6)	44 (29.9)	73 (49.7)	
Normal (<85)	22 (15.0)	7 (4.8)	15 (10.2)	
High normal (85–89)	8 (5.4)	3 (2.0)	5 (3.4)	
Biochemical profile				
Urinary sodium excretion (mmol/24h)†	90.00 (55.00)	92.00 (57.00)	87.00 (61.00)	0.389[d]

*Data presented as mean±standard deviation. †Data presented as median (interquartile range). [a]*t*-test; [b]Fisher's exact test; [c]Chi-square test; [d]Mann-Whitney *U* test. BMI: body mass index, DBP: diastolic blood pressure, SBP: systolic blood pressure

Table 2. Dietary intake of the participants.

Dietary intake	Mean±standard deviation			P
	Total (n=101)	Male (n=34)	Female (n=67)	
Energy intake (kcal/day)	2084.93±379.01	2275.78±373.89	1988.08±345.64	<0.001*
Sodium intake (mg/day)	3759.70±899.56	4068.03±874.70	3603.23±877.33	<0.05*

*Data between groups compared using *t*-test.

This is the first study conducted in Malaysia that used both dietary recall and 24-hour urine collection to determine the level of sodium intake in low-income urban populations. Although the Food Frequency Questionnaire (FFQ) could provide better information on habitual dietary intake, this method was more practical for our study group. With the FFQ, individuals have to remember their intake over the past 6 months, which may lead to inaccuracy in food quantification. The FFQ also slightly underestimates environmental impacts.[48] In addition, the 3-day dietary recall still provides sufficient information on energy, carbohydrate, protein, fat and sodium intake,[49] and there is a decreased impact of seasonal variation or variation by day of the week.[50] Furthermore, it does not require literacy; thus, the burden on the participants is relatively small compared to that of the 3-day dietary record.[49,50] In addition, it was shown in a systematic review that using multiple 24-hour dietary recalls increases correlation with 'true' intake and substantially decreases attenuation of relative risk estimates.[37]

The findings of this study can provide some suggestions for further intervention to reduce sodium intake in the low-income population, although several limitations need to be acknowledged. Firstly, our results may not be applicable to the wider population because this study represents only the urban low-income population. In addition, it would have been better if para-amino benzoic acid or measurement of the creatinine output was used in this study as a marker to check for completeness of 24-hour urine collection.

This study shows that the sodium intake, as measured by dietary recall and measurement of sodium in the urine, among low-income city dwellers exceeded the sodium intake recommendation by the WHO, and established the association between urinary sodium excretion and dietary sodium intake. Overweight and obese populations seem to be at a higher risk of high dietary sodium intake. This reiterates the importance of emphasising a healthy diet and lifestyle when developing health promotion programmes to combat NCDs in this low-income group.

Acknowledgements

We would like to acknowledge the Kuala Lumpur City Hall (DBKL), data collectors, committee and all participants from PPR Kg.Limau and PPR Seri Anggerik for their commitment to this study.

Financial support and sponsorship

This work was supported by the University of Malaya Flagship Priority Funding [Grant Number FL009-2011] and the Ministry of Higher Education, which granted a 1-year scholarship (MyBrain).

Conflicts of interest

There are no conflicts of interest.

Ameera Abdullah Thani[1], BHSc, Maznah Dahlui[1,2], MPH, PhD, Tin Tin Su[1,3], MSc CHHM, MD, Hazreen Abd Majid[1], MND, PhD

[1]Centre for Population Health and Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia, [2]Department of Health Policy Administration, Faculty of Public Health, University of Airlangga, Surabaya, Indonesia, [3]South East Asia Community Observatory (SEACO), Jeffery Cheah School of Medicine and Health Sciences, Monash University Malaysia, Bandar Sunway, Malaysia

Correspondence: Prof. Maznah Dahlui,
Centre for Population Health and Department of Social and Preventive Medicine, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia.
E-mail: maznahd@ummc.edu.my

Received: 14 Jul 2020 **Accepted:** 27 Sep 2021 **Published:** 01 Feb 2023

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023

REFERENCES

1. Kim HJ, Paik HY, Lee SY, Shim JE, Kim YS. Salt usage behaviours are related to urinary sodium excretion in normotensive Korean adults. Asia Pac J Clin Nutr 2007;16:122-8.
2. Radhika G, Sathya RM, Sudha V, Ganesan A, Mohan V. Dietary salt intake and hypertension in an urban South Indian Population-[CURES-53]. J Assoc Physicians India 2007;55:405-11.
3. Sun Z, Zheng L, Detrano R, Zhang X, Xu C, Li J, *et al*. Incidence and predictors of hypertension among rural Chinese adults: Results from Liaoning province. Ann Fam Med 2010;8:19-24.
4. He FJ, Campbell NR, MacGregor GA. Reducing salt intake to prevent hypertension and cardiovascular disease. Rev Panam Salud Pública 2012;32:293-300.
5. WHO. Global Status Report on Noncommunicable Diseases 2010. 2010.
6. Institute for Public Health. National Health and Morbidity Survey 2011- Non Communicable Disease. Malaysia: Institute for Public Health, Ministry of Health; 2011.
7. Amiri M, Majid HA, Hairi F, Thangiah N, Bulgiba A, Su TT. Prevalence and determinants of cardiovascular disease risk factors among the residents of urban community housing projects in Malaysia. BMC Public Health 2014:14(Suppl 3):S3. doi: 10.1186/1471-2458-14-S3-S3.
8. WHO. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risk. Geneva: WHO; 2009.
9. Institute for Public Health. Determination of dietary sodium intake among the Ministry of Health Staff 2015 (MySalt 2015). 2016.
10. Brown IJ, Tzoulaki I, Candeias V, Elliott P. Salt intakes around the world: Implications for public health. Int J Epidemiol 2009;38:791-813.
11. WHO. Guideline: Sodium Intake for Adults and Children. Geneva: World Health Organization; 2012.
12. Rhee MY, Shin SJ, Park SH, Kim SW. Sodium intake of a city population in Korea estimated by 24-h urine collection method. Eur J Clin Nutr 2013;67:875-80.
13. Charlton K, Yeatman H, Houweling F, Guenon S. Urinary sodium excretion, dietary sources of sodium intake and knowledge and practices around salt use in a group of healthy Australian women. Aust N Z J Public Health 2010;34:356-63.
14. Batcagan-Abueg AP, Lee JJ, Chan P, Rebello SA, Amarra MS. Salt intakes and salt reduction initiatives in Southeast Asia: A review. Asia Pac J Clin Nutr 2013;22:490-504.
15. Wesson LG Jr. Electrolyte excretion in relation to diurnal cycles of renal function: Plasma electrolyte concentrations and aldosterone secretion before and during salt and water balance changes in normotensive subjects. Medicine (Baltimore) 1964;43:547-92.
16. Ibrahim MM, Damasceno A. Hypertension in developing countries. Lancet 2012;380:611-9.
17. de Mestral C, Mayén AL, Petrovic D, Marques-Vidal P, Bochud M, Stringhini S. Socioeconomic determinants of sodium intake in adult populations of high-income countries: A systematic review and meta-analysis. Am J Public Health 2017;107:e1-12.
18. Ma Y, Olendzki BC, Pagoto SL, Hurley TG, Magner RP, Ockene IS, *et al*. Number of 24-hour diet recalls needed to estimate energy intake. Ann Epidemiol 2009;19:553-9.
19. Johnson RK, Soultanakis RP, Matthews DE. Literacy and body fatness are associated with underreporting of energy intake in US low-income women using the multiple-pass 24-hour recall: A doubly labeled water study. J Am Diet Assoc 1998;98:1136-40.
20. Campbell N, Cappuccio F, Hennis A, Barquera S, Rotter RC, Dary O, *et al*. Protocol for population level sodium determination in 24-hour urine samples. 2010.
21. NCCLS. Urinalysis and Collection, Transportation, and Preservation of Urine Specimens; Approved Guideline—Second Edition, NCCLS document GP16-A2 [ISBN 1-56238-448-1]. 2001.
22. Corder CJ, Rathi BM, Sharif S, Leslie SW. 24-Hour Urine Collection. StatPearls [Internet]: StatPearls Publishing; 2019.
23. Remler DK, Van Ryzin GG. Research Methods in Practice: Strategies for Description and Causation. Sage Publications; 2014.
24. Brown IJ, Dyer AR, Chan Q, Cogswell ME, Ueshima H, Stamler J, *et al*. Estimating 24-hour urinary sodium excretion from casual urinary sodium concentrations in western populations: The INTERSALT study. Am J Epidemiol 2013;177:1180-92.
25. WHO. The Asia-Pacific Perspective: Redefining obesity and its treatment. 2000. Contract No.: 0957708211.
26. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157-63.
27. Ministry of Health. Clinical Practice Guidelines Management of Hypertension. 4th ed. 2013.
28. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, *et al*. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. Eur J Clin Nutr 1991;45:569-81.
29. Henry CJ. Basal metabolic rate studies in humans: Measurement and development of new equations. Public Health Nutr 2005;8:1133-52.
30. Azizan NA, Thangiah N, Su TT, Majid HA. Does a low-income urban population practise healthy dietary habits? Int Health 2018;10:108-15.
31. Vandevijvere S, De Keyzer W, Chapelle JP, Jeanne D, Mouillet G, Huybrechts I, *et al*. Estimate of total salt intake in two regions of Belgium through analysis of sodium in 24-h urine samples. Eur J Clin Nutr 2010;64:1260-5.
32. Hasan AR, Nair PL. Urbanisation and growth of metropolitan centres in Malaysia. Malays J Econ Stud 2017;51:87-101.
33. Ebrahim S, Kinra S, Bowen L, Andersen E, Ben-Shlomo Y, Lyngdoh T, *et al*. The effect of rural-to-urban migration on obesity and diabetes in India: A cross-sectional study. PLoS Med 2010;7:e1000268. doi: 10.1371/journal.pmed.1000268.
34. Smil V. Feeding the World: A Challenge for the Twenty-First Century. MIT Press; 2001.
35. Center for Disease Control and Prevention. Sodium intake among adults-United States, 2005-2006. 2010. Report No.: 1545-861X Contract No.: 24.
36. Thompson FE, Subar AF, Coulston A, Boushey C. Dietary assessment methodology. Nutrition in the Prevention and Treatment of Disease 2008;2:3-39.
37. Freedman LS, Commins JM, Moler JE, Willett W, Tinker LF, Subar AF, *et al*. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for potassium and sodium intake. Am J Epidemiol 2015;181:473-87.
38. Madden JP, Goodman SJ, Guthrie HA. Validity of the 24-hr. recall. Analysis of data obtained from elderly subjects. J Am Diet Assoc 1976;68:143-7.
39. Reinivuo H, Valsta LM, Laatikainen T, Tuomilehto J, Pietinen P. Sodium in the Finnish diet: II trends in dietary sodium intake and comparison between intake and 24-h excretion of sodium. Eur J Clin Nutr 2006;60:1160-7.
40. Lee J, Hwang Y, Kim KN, Ahn C, Sung HK, Ko KP, *et al*. Associations of urinary sodium levels with overweight and central obesity in a population with a sodium intake. BMC Nutr 2018;4:47.
41. Charlton KE, Steyn K, Levitt NS, Jonathan D, Zulu JV, Nel JH. Development and validation of a short questionnaire to assess sodium intake. Public Health Nutr 2008;11:83-94.
42. Sanchez-Castillo CP, Warrender S, Whitehead TP, James WP. An assessment of the sources of dietary salt in a British population. Clin Sci (Lond) 1987;72:95-102.
43. Webb M, Fahimi S, Singh GM, Khatibzadeh S, Micha R, Powles J, *et al*. Cost effectiveness of a government supported policy strategy to decrease sodium intake: Global analysis across 183 nations. BMJ 2017;356:i6699. doi: 10.1136/bmj.i6699.
44. He FJ, MacGregor GA. Reducing population salt intake worldwide: From evidence to implementation. Prog Cardiovasc Dis 2010;52:363-82.
45. Azizan NA, Majid HA, Nahar Mohamed A, Su TT. Improvement of nutritional intake for the low-income urban dwellers with hypertension in Malaysia. SAGE Open Med 2020;8:2050312120960563.
46. Ning SX, Mainvil LA, Thomson RK, McLean RM. Dietary sodium reduction in New Zealand: Influence of the'Tick'label. Asia Pac J Clin Nutr 2017;26:1133-8.
47. Abdl Majid H, Ramli L, Ying SP, Su TT, Jalaludin MY, Abdul Mohsein NA. Dietary intake among adolescents in a middle-income country: An outcome from the malaysian health and

adolescents longitudinal research team study (the MyHeARTs Study). PLoS One 2016;11:e0155447.
48. Mertens E, Kuijsten A, Geleijnse JM, Boshuizen HC, Feskens EJM, van't Veer P. FFQ versus repeated 24-h recalls for estimating diet-related environmental impact. Nutr J 2019;18:2.
49. Shim JS, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiol Health 2014;36:e2014009. doi: 10.4178/epih/e2014009.
50. Ralph JL, Von Ah D, Scheett AJ, Hoverson BS, Anderson CM. Diet assessment methods. Clin J Oncol Nurs 2011;15:E114-21.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/SMJ/pages/default.aspx
	DOI: 10.4103/singaporemedj.SMJ-2020-363

How to cite this article: Thani AA, Dahlui M, Su TT, Majid HA. The association of urinary sodium excretion with dietary sodium intake among selected low-income urban households. Singapore Med J 0;0:0.

Downloaded from http://journals.lww.com/smj by BhDMf5ePHKav1zEoum1tQfN4a+kJLhEZgbsIHo4XMi0hCywCX1AWnYQp/IlQrHD3i3D0OdRyi7TvSFl4Cf3VC1y0abggQZXdtwnfKZBYtws= on 12/14/2023