Mal J Nutr 20(3): 317 - 326, 2014

Sodium Intake among Normotensive Health Staff Assessed by 24-Hour Urinary Excretion: A Cross-sectional Study

Rashidah A[1*], Yeo PS[2], Noor Ani A[3], Muhammad Fadhli MY[4], Tahir A[5], Feisul Idzwan M[6], Ahmad Ali Z[2], Suhaila AG[2], Azli B[2], Viola M[6], Zainal AO[6], Ruhaya S[6] & Madihah M[6]

[1] *Training Section, Institute for Public Health, Ministry of Health, Kuala Lumpur*
[2] *Centre for Nutrition Epidemiology Research, Institute for Public Health, Ministry of Health, Kuala Lumpur*
[3] *Center for Family Health Research, Institute for Public Health, Ministry of Health, Kuala Lumpur*
[4] *Center for Non-Communicable Disease Research, Institute for Public Health, Ministry of Health, Kuala Lumpur*
[5] *Director Office, Institute for Public Health, Ministry of Health, Kuala Lumpur*
[6] *Disease Control Division, Ministry of Health Malaysia, Putrajaya*

ABSTRACT

Introduction: High sodium consumption over an extended period of time has been associated with hypertension, stroke, cardiovascular disease, renal damage, and other adverse health effects. This study aimed to determine urinary sodium excretion and consequently estimate dietary sodium consumption among normotensive health staff in Malaysia. **Methods:** A cross-sectional study was conducted to acquire data on sodium excretion among normotensive Ministry of Health staff aged 20 – 56 years (mean age 35.08, SD 9.78) in 14 states and a research institute. Respondents were recruited using quota sampling. Data collection was conducted from December 2011 to February 2012. A single urine sample was collected over 24 hours for sodium concentrations and calculated as 95.0% of total daily sodium intake. **Results:** Among the 471 enrolled respondents, 445 (94.0%) provided complete information on socio-demography and urine samples. Mean urine sodium excretion was 142.0 mmol/day (SD 71.7), which is equivalent to 3429 mg sodium/day or 8.7 gm of salt intake (1.75 teaspoon, which exceeds the Malaysian recommendation of 2000 mg sodium/day by 1.7 times. About 79.0% (n=353) of respondents (88.0% male and 73.0% female) had daily sodium consumption that was above the recommendation. Excretion was significantly higher among males at 161.7 mmol/day (SD 78.1) (3726 mg sodium/day) than females, 125.3 mmol/day (SD 61.1) (2875 mg/day). There was a positive, low correlation between BMI and sodium intake ($r=0.216$, $p<0.001$) and between age and sodium intake ($r=0.083$, $p=0.040$) **Conclusion:** Daily sodium intake among health staff studied was much higher than the current recommendation. A more comprehensive educational programme should be implemented to positively influence staff towards the need to reduce sodium consumption.

Key words: 24-h urine sodium, dietary sodium, salt intake, sodium intake, urinary sodium excretion

* Correspondence: Rashidah Ambak; Email: *rashidaha@moh.gov.my* / *rashidah662009@yahoo.com*

INTRODUCTION

High sodium consumption over an extended period of time has been associated with major risk factors for hypertension and other related non-communicable diseases such as stroke, cardiovascular diseases, renal damage, heart failure and other adverse health effects (Chappius *et al.*, 2011, Hajjar *et al.*, 2001, Ortega *et al.*, 2011). The Malaysian National Health and Morbidity Surveys in 1996, 2006 and 2011 have stated the prevalence of hypertension among Malaysian adults aged more than 18 years as 20.7% (Institute for Public Health, 1997), 32.2% (Institute for Public Health, 2008) and 32.7% (Institute for Public Health, 2011) respectively.

Sodium consumption needs to be monitored in the population and one way of monitoring is to determine sodium intake. There are several dietary survey methods to measure sodium intake such as food diary, dietary recall and food frequency questionnaire but they are prone to bias, under-reporting and under-estimation during dietary analysis (Reinivuo *et al.*, 2006; Vandevijvere *et al.*, 2010; WHO, 2007). More than 90.0% of the daily sodium intake is excreted through urine, hence analysis of sodium in 24-hour urine excretion is considered a gold standard to measure dietary sodium intake. As with other methods, repeated urine measurements are suggested to estimate intra-individual variability compared to a single measurement (Espeland *et al.*, 2001).

There have been various studies conducted in the Asian population to determine sodium intake using 24-hour urinary analysis (Batcagan-Abueg *et al.*, 2013). In Malaysia, Maryam, Nani & Rahman (2009) conducted a study among healthy young adults to determine sodium consumption using 24-hour urine samples. They reported a high sodium consumption of 157 mmol/day (3611 mg/day) among the subjects, compared to the recommended 2000 mg. Apart from this study, there is little evidence to determine sodium or salt intake in Malaysia using 24-hour urine sodium excretion (Batcagan-Abueg *et al.*, 2013). Hence, this study was undertaken as a step to obtain preliminary data on urinary sodium excretion and consequently to estimate dietary sodium consumption among normotensive health staff in Malaysia.

METHODS

This cross-sectional study was conducted among Ministry of Health staff at 14 state health departments and a research institute. The respondents were recruited using quota sampling. Data collection was undertaken from November 2011 to February 2012. Inclusion criteria were normotensive respondents aged 18 years and older, without a history of heart failure, kidney failure or liver disease, not on diuretic therapy, not pregnant and having any other condition which would affect urine excretion. Respondents with a 24-hour urine volume of less than 500 ml were excluded from the study. A self-administered questionnaire was utilised to collect data on socio-demographic profile such as sex, age, ethnicity, marital status, academic achievement and health information.

Anthropometric data on weight (kg), height (m) and waist circumference (WC) (cm) were collected by the nursing staff of each institution. Body mass index (BMI), defined as ratio of weight in kilogram to the square of height in meter, was expressed as kg/m^2. BMI classification was based on WHO (2000) guideline (WHO, 2000) of underweight (BMI < 18.5 kg/m^2), normal (BMI 18.5 - 24.9 kg/m^2), overweight (BMI 25.0 - 29.9 kg/m^2) and obese (BMI > 30.0 kg/m^2). WC guideline used was according to the International Obesity Task Force, International Association for the Study of Obesity (WHO/ IOTF /IASO, 2000) with normal circumference of < 90 cm for male and < 80 cm for female.

Respondents were instructed to collect a single 24-hour urine. There was no clinical method implemented to determine the completeness of the 24-hour urine collection. Hence, the emphasis was on instructions to respondents to strictly follow urine collection procedures. Further, printed instructions on urine collection procedures were given to every respondent along with advice to avoid contamination of the sample. They were taught to void the first urine in the morning, begin collection with the following urination and to end with the first urination of the next day. On the same morning, samples were sent to the nearest hospital's biochemical laboratory for analysis. In accordance with standard laboratory procedures, sodium concentrations and the 24-hour sodium excretion were analysed using ion selective electrodes by an indirect (dilution) method where urine samples were automatically diluted at 1:46 ratio with a diluent using COBAS 8000 analyser.

The total sodium excretion in 24-hour urine was used as an estimate of total sodium intake per day. Considering that about 95% of sodium from foods is excreted in urine (another 5% is excreted through the skin and faeces), estimation of daily sodium intake from foods was done by multiplying 24-hour sodium excretion (mmol/day) with a factor of 100/95 (Vandevijvere *et al.*, 2010). Daily sodium intake (mg/day) was then calculated by multiplying the daily sodium intake (expressed in mmol) with the molecular mass of sodium, 23 g/mol. Hence, in this study, the urinary sodium excretion of 82.8 mmol/day corresponds to the Malaysian recommended intake of 2000 mg/day sodium, which will be used to compare results. The term 'sodium' used in this paper refers to all dietary sources in the diet including sodium chloride (cooking/table salt), sodium added in food processing and manufacturing, other sodium additives, taste enhancers such as monosodium glutamate and naturally occurring sodium.

The study was approved by the National Institutes of Health and Medical Research Ethics Committee, Ministry of Health of Malaysia. Study purposes were explained to the eligible respondents and written informed consent was obtained prior to initiating the urine collection and interview.

Statistical analyses were conducted using the SPSS version 20.0 using descriptive statistics and inferential statistical methods. Descriptive statistics such as frequencies, percentages, means and standard deviations were computed for socio-demographic and other variables. Analysis of variance (ANOVA) and independent sample *t*-test were used to assess differences between group means. Pearson correlation was conducted to assess correlations between continuous variables. Significance was set at 95% confidence interval. For analysis purposes, the states were grouped into five zones, i.e. North (Penang, Kedah, Perak and Perlis), West (Malacca, Johor and Negeri Sembilan), Central (Kuala Lumpur and Selangor), East Coast (Terengganu, Kelantan and Pahang), and Sabah & Sarawak.

RESULTS

Among the 471 enrolled respondents, data of 445 respondents with complete information on socio-demography and urine sample were analysed (94.0% inclusion rate). The respondents were aged between 20 – 56 years with a mean age of 35.1 years (SD 9.8) (Table 1) and a mean BMI of 25.4 kg/m2 (SD 5.1). Almost half of the males and females had high waist circumference compared to the recommendation. Mean urine sodium excretion was 142.0 mmol/day (SD 71.7). About 79.0% (n=353) (88.0% male and 73.0% female) had a daily intake of sodium that was higher than the recommendation of 2000 mg/day.

Mean urine sodium excretion results of all zones exceeded the daily sodium recommendation figures. Comparison

Table 1. Mean of 24-hour urinary sodium excretion by study characteristics

	Frequency	*Percentage (%)*	*Urine sodium (mmol/day) Mean (SD)*	*Test statistic*	*p-value*
Overall	445	-	142.0 (71.7)	-	-
Zone					
North	110	24	158.4 (77.3)	$F_{(4,440)} = 4.322$	0.002*
West	91	21	142.6 (63.6)		
East Coast	91	21	137.2 (68.7)		
Central	94	21	119.7 (58.4)		
Sabah and Sarawak	59	13	153.3 (86.6)		
Sex					
Male	204	46	161.7 (78.1)	$t_{(381.5)} = 5.407$	<0.001[a]
Female	241	54	125.3 (61.1)		
Age (years)					
20 – 29	174	39	135.1 (72.0)	$F_{(2,442)} = 1.439$	0.238
30 – 39	136	31	144.4 (73.4)		
40 and above	135	30	148.5 (69.2)		
Academic qualifications					
Secondary	139	31	153.7 (77.0)	$F_{(2,439)} = 4.120$	0.017[a]
Form 6/ Matriculation	178	40	141.4 (71.7)		
College/ University	125	28	128.8 (60.6)		
BMI (kg/m^2)					
< 18.5 (Underweight)	25	6	95.7 (59.5)	$F_{(3,434)} = 8.252$	<0.001[a]
18.5 - 24.9 (Normal)	201	46	133.4 (63.1)		
25.0 - 29.9 (Overweight)	134	31	152.7 (74.2)		
> 30.0 (Obese)	78	18	164.1 (82.6)		
Male waist circumference					
Normal (< 90 cm)	104	53	151.2 (83.1)	$t_{(195)} = -2.344$	0.020[a]
High (≥ 90 cm)	93	47	177.2 (71.2)		
Female waist circumference					
Normal (<80 cm)	124	53	121.2 (59.7)	$t_{(230)} = -1.539$	0.176
High (≥80 cm)	108	47	132.2 (63.3)		

[a]Significant at $p<0.05$.

across the zones showed that the Northern Zone had the highest mean sodium excretion, while the Central Zone showed the lowest urinary sodium excretion (Table 1). There was a significant difference in the mean urinary sodium excretion among zones (p=0.002). Further analysis using Tukey post-hoc test suggested significant differences in mean urinary sodium excretion when comparisons were made between the North Zone and Central Zone (p=0.001), and between Sabah & Sarawak Zone and the Central Zone (p=0.035).

Urinary sodium excretion was significantly higher in males compared to females but both groups showed high sodium intake. There was no significant difference in urinary sodium excretion between the age groups. However, further analysis found a positive low correlation between urinary sodium excretion and age, with r = 0.083 (p = 0.040) (Figure 1).

Mean sodium excretion decreased significantly with higher academic achievements (p=0.017) but all categories represented an intake that exceeded the recommendation (Table 1). Tukey post-hoc test showed a significant difference

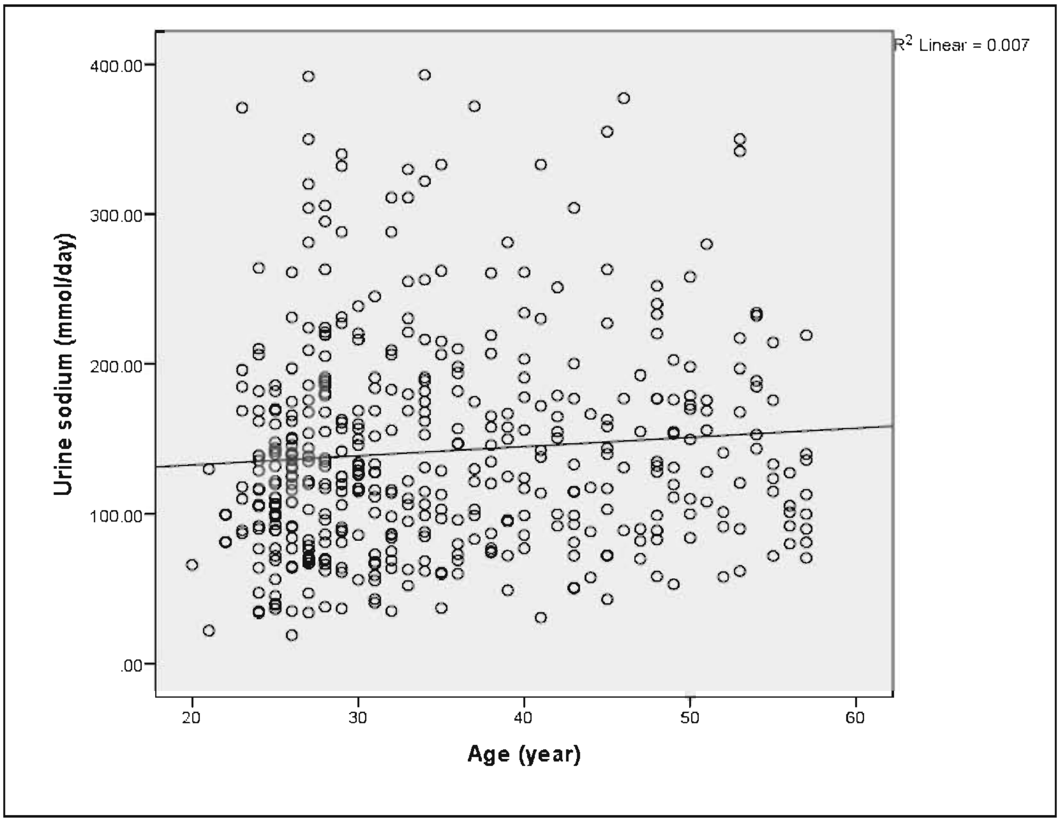

Figure 1. Correlation between urinary sodium excretion and age among health staff

between the secondary level and the college / university level respondents (p = 0.012) in terms of sodium intake

Table 1 also shows that the mean urinary sodium excretions increased significantly with higher BMI and all urinary sodium excretion values exceeded the sodium recommendation (p<0.001). Further analysis using post-hoc test (Dunnett C procedure) showed differences between all BMI groups except for the obese versus the overweight group, and overweight versus the normal group. Correlation analysis showed a positive low correlation between urinary sodium excretion and BMI with r = 0.216, p<0.001 (Figure 2).

Measurement results of the WC of the respondents showed that 47.0% of both males and females exceeded the normal WC cut-off points of 90 cm for males and 80 cm for females. Pertaining to the mean urinary sodium excretion, all groups of normal and high WC by sex denoted high excretions. Male respondents who exceeded the normal cut-off points for WC excreted significantly higher sodium compared to their counterparts with normal WC (p=0.020). In contrast, there was no significant difference in urinary sodium excretion among females with high WC compared to their counterparts with normal WC (Table 1).

DISCUSSION

Urinary sodium excretion and intake in the diet

This study presented 24-hour urinary sodium excretion results as a proxy to

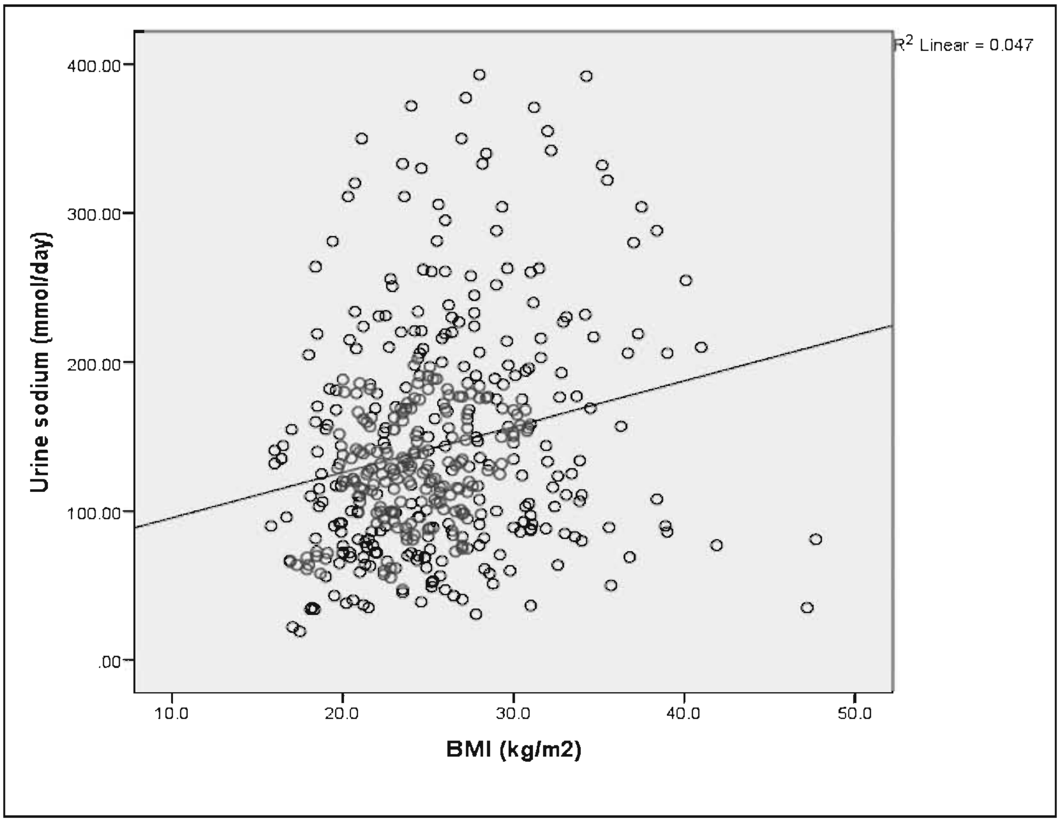

Figure 2. Correlation between urinary sodium excretion and BMI among health staffs

daily sodium consumption among the health staff. Taking into considerations that 95% of sodium consumed is excreted in the urine, the mean urinary sodium excretion of 142 mmol/day corresponds to a consumption of 149 mmol sodium/day. This is equivalent to an intake of 3429 mg sodium/day or 8.0 gm of salt/day (1.75 teaspoon). Thus, the intake of sodium in foods has exceeded the Malaysian daily recommendation of 2000 mg by 1.7 times. A previous smaller study among 37 university students in Malaysia showed an even higher urinary sodium intake (157 mmol/day). A possible explanation could be that the higher food intake and energy requirements of younger respondents may have contributed to a higher consumption of sodium (Maryam *et al.*, 2009). Our findings indicate that sodium consumption is substantially higher than previously analysed using 24-hour dietary recall (2575 mg/day) in the Malaysian Adult Nutrition Survey (Mirnalini *et al.*, 2008). Difference in sodium consumption describes the likelihood of under-reporting of consumption during interview and under-estimation in quantification of sodium during analysis of the 24-hour dietary recall (WHO/PAHO, 2010). Under-estimation might also occur due to incomplete sodium information in the food composition database used to analyse sodium intake (Reinivuo *et al.*, 2006, WHO/PAHO, 2010).

The consumption of sodium among respondents in this study is almost similar to the Singaporean results (8.3 gm) reported by the Health Promotion Board Singapore(2011). Similarity in the sodium consumption to neighboring country Singapore might reflect the excessive intake of sodium primarily from sodium chloride (during cooking and at the table), sauces and processed foods among the Asian population (Elliot & Brown, 2007; Health Promotion Board Singapore, 2011). Our results are also similar to a population survey in England where the mean sodium intake was 8.1 gm, (Sadler *et al.*, 2011). Though a similar figure was reported by Sadler *et al.* (2011), it is observed that England being a developed country, the dominant source of sodium consumption originated from sodium added during commercial food processing (75.0%). Sodium chloride as a table and cooking salt accounted for 15.0% of daily consumption while 10.0% was contributed by naturally occurring sodium in foods consumed by the people in England (Elliot & Brown, 2007).

About 79.0% (88.0% males and 73.0% females) of the health staff in this study consumed sodium excessively; a figure similar to the 80.0% for Singapore (Health Promotion Board of Singapore, 2011). The sodium intake figures for Switzerland and Spain are much higher at 86.0% (94.0% males and 77.0% females) for the Swiss (Chappius *et al.*, 2011) and 88.0% (93.0% males and 84.0% females) (Ortega *et al.*, 2011) for the Spanish. However, the UK population presented a lower percentage, of 70.0% (80.0% males and 58.0% females) exceeding their sodium recommendation (Sadler *et al.*, 2011). This could be attributed to a salt reduction programme implemented in the UK in 2003 which has led to a significant reduction in salt intake from 9.5 gm to 8.1 gm as indicated by the National Diet and Nutrition Surveys in 2000/2001 (Sadler *et al.*, 2011).

Urinary sodium excretion by socio-economic variables

No previous study has been conducted using urinary sodium excretion to determine sodium intake across the zones in Malaysia. However, the Malaysian Adult Nutrition Survey (2006) which applied dietary survey method (single 24-hour dietary recall) demonstrated that the population in Sabah and Sarawak had the highest sodium intake while the Southern Zone had the least intake (Mirnalini *et al.*, 2008). Otherwise, the present study showed that the Northern Zone had the highest sodium intake with the Central Zone having the least intake. The differences in findings of both studies could be attributed to the differences in methods used to quantify sodium intake and the category of respondents.

As expected, mean sodium excretion was significantly higher in males compared to females ($p<0.001$) in parallel with the findings of INTERMAP, INTERSALT and various other studies (Adam & Walter, 2012; Chappius *et al.*, 2011; Hyun *et al.*, 2007; Brown *et al.*, 2009; Intersalt Cooperative Research Group, 1988; Reinivuo *et al.*, 2006; Ortega *et al.*, 2011). This could be explained by the fact that males generally require higher intake of calories due to overall larger body size and bigger muscle mass compared to females. Hence, higher caloric intake and higher food consumption will consequently increase sodium consumption among males (Ortega *et al.*, 2011, Vandevijvere *et al.*, 2010).

This study showed no significant increase in sodium excretion with increasing age categories. The coefficient of determination as measured by the regression of sodium excretion and age suggested only 0.7% of the variability of sodium consumption being explained by an increase in age. However, the increase in age has been related to a decrease in salt taste acuity (Mojet, Christ-Hazelhof & Herdema, 2001) thus leading to preferences for salty foods and an increase in salt usage. This has resulted in greater daily sodium consumption in the older age groups. In contrast, for Singapore, the highest sodium excretion (as explained by intake of sodium) was reported for the age category of 30 - 49 years with the intake decreasing by the age of 50 years and above (Health

Promotion Board, 2011). Studies in US and Spain have also demonstrated lower excretion of sodium in the age group of 50 - 60 years (Adam & Walter, 2012; Ortega *et al.*, 2011). This could also be attributed to a decline in food requirement and energy intake with age, thus contributing to the lower intake of sodium compared to the younger respondents (Reinivio *et al.*, 2006). As for our study, it is more likely that the sample size is not sufficiently big to postulate on low sodium intake among respondents aged 50 and above.

An inverse relationship between academic achievements and sodium intake was seen in this study as in the case of Britain (Chen & Cappuccio, 2014). In contrast, the Malaysian Adult Nutrition Survey indicated the highest sodium intake in the college / university group, while the least intake was among the least educated respondents (Mirnalini *et al.*, 2008). Overall, in this study, all respondents had a high intake of sodium in the diet regardless of academic achievement. This indicates an increased likelihood of high blood pressure among the health staff.

Previous studies confirm that urinary sodium excretion is significantly higher among those with problems of overweight, obesity and high waist circumference (Adam & Walter, 2012; Ortega *et al.*, 2011). Accordingly, we found a positive low association between BMI and sodium intake, which is similar to the results of the Belgium study by Vandevijvere *et al.* (2010). The coefficient of determination as measured by the regression of sodium excretion and BMI suggests that only 5% of the variability of the sodium consumption is explained by BMI. Further, Keskitalo *et al.* (2008) suggest that a higher BMI is linked to the liking and high consumption of salty-and-fatty foods resulting in the consumption of energy-dense foods and sodium. Donaldson *et al.* (2009) also described a diminished taste perception of salt among the obese adults. This condition will affect food intake as they will consume more sodium in their daily diet. An association between the taste enhancer, monosodium glutamate (MSG) and obese women was also found by Donaldson *et al.* (2009) who observed a desire for a high concentrations of MSG among obsese women due to a lower taste sensitivity. MSG is a taste enhancer added to foods to increase palatability but it is also a sodium source. Findings in both studies suggest that it could be the reason for a larger intake of sodium and a higher food intake among the respondents in this study. This consequently could lead to weight gain (Ortega *et al.*, 2011) and high waist circumference.

This study has its limitation. The completeness of the 24-hour urine collection was not verified by an objective marker, such as the analysis of creatinine clearance. This may alter the results of sodium excretion.

CONCLUSION

In conclusion, daily sodium intake was much higher than the current recommendation as simulated by the excessive urinary sodium excretion. Although findings relate only to the normotensive health staff, it can be used to design policies and programmes to reduce sodium consumption. A more comprehensive educational programme should be implemented to positively influence staff and public towards the need to reduce sodium consumption. Further studies on the general population are needed to determine the sodium intake of the Malaysian population.

ACKNOWLEDGEMENTS

The authors would like to extend their grateful thanks to the Director General of Health, Malaysia for permission to publish this paper. The support given by the respective State Health Departments, Pathology Departments of each state, data collectors and all staff who contributed to this study is gratefully acknowledged.

Conflict of interest

The authors have no potential conflict of interest to declare.

REFERENCES

Adam MB & Walter CW (2012). Trends in 24-h urinary excretion in the United States, 1957 - 2003: a systematic review. *Am J Clin Nutr.* 92: 1172 – 80 doi:10.3945/ajcn.2010.29367.

Batcagan-Abueg APM, Lee JJM, Chan P, Rebello SA & Amarra MSV (2013). Salt intakes and salt reduction initiatives in South-east Asia: a review. *Asia Pac J Clin Nutr* 22(4):683-697.

Brown IJ, Tzoulaki I, Candeias V & Elliot P (2009). Salt intakes around the world: implications for public health. *Int J Epidemiol* 38: 791 - 813 doi:10.1093/ije/dyp139

Chappius A, Bochud M, Glatz N, Vuistiner P, Paccaud F & Burnier M (2011). Swiss survey on salt intake: main results. Centre Hospitalier Universitaire Vaudois, Switzerland.

Chen J & Cappuccio FP (2014). Public health socio-economic inequality in salt intake in Britain 10 years after a national salt reduction programme. *BMJ* 14; 4. doi:10.1136/bmjopen-2014-005683

Donaldson LF, Bennett L, Baic S & Melichar JK (2009). Taste and weight: is there a link?. *Am J Clin Nutr* 90: 800S–803S. doi: 10.3945/ajcn.2009.27462Q.

Elliott P & Brown I (2007). Sodium intakes around the world. Background document prepared for the forum and technical meeting on reducing salt intake in populations (5 - 7 October, Paris 2006). Geneva, World Health Organisation.

Espeland MA, Shiriki Kumanyika S, Wilson AC, Reboussin M, Easter L, Self M, Robertson J, Brown WM & McFarlane M (2001). Statistical issues in analyzing 24-hour dietary recall and 24-hour urine collection data for sodium and potassium intakes. *Am J Epidemiol* 153(10): 996 – 1006.

Hajjar IM, Grim CE, George V & Kotchen TA (2001). Impact of diet on blood pressure and age-related changes in blood pressure in the US population analysis of NHANES III. *Arch Intern Med* 161: 589-593.

Health Promotion Board Singapore (HPB) (2011). HPB declares war on salt: Singapore residents exceed daily recommended salt consumption by 60%. From *http://www.worldactiononsalt.com/worldaction/asia/75286.pdf* [Accessed 1 September 2012].

Hyun JK, Hee YP, Sim YL, Jae ES & Young SK (2007). Salt usage behaviours are related to urinary sodium excretion in normotensive Korean adults. *Asia Pac J Clin Nutr* 16(1): 122 - 128.

Institute for Public Health (1997). Nutritional Status. The Second National Health and Morbidity Survey (NHMS II) 1996. Vol I. Ministry of Health, Malaysia.

Institute for Public Health (2008). Nutritional Status. The Third National Health and Morbidity Survey 2006. Ministry of Health, Malaysia.

Institute for Public Health (2011). National Health and Morbidity Survey 2011 – Non Communicable Disease (Vol II). Ministry of Health, Malaysia.

Intersalt Cooperative Research Group (1988). Intersalt: an International Study of Electrolyte Excretion and Blood Pressure. Results for 24-h Urinary Sodium and Potassium Excretion. Intersalt Cooperative Research Group. British Med J 297: 316. From *http://dx.org/10.1136/bmj. 297.6644.319*

Keskitalo K, Tuorila H, Spector TD, Cherkas LF, Knaapila A, Kaprio J, Silventoinen K & Perola M (2008). The three-factor testing questionnaire, body mass index, and reponses to sweet and salty fatty foods: a twin study of genetic and environmental associations. *Am J Clin Nutr* 88:263 - 271.

Maryam KJ, Nani N & Rahman AR (2009). Correlation between spot urine sodium, 24-hour urinary sodium and food frequency questionnaire in estimation of salt intake in healthy individuals. From *http://emobilise.com.au/files/programs/46/abstracts/9568.pdf* [Assessed 20 February 2013].

Mojet J, Christ-Hazelhof E, Heidema J (2001). Taste perception with age: generic or specific losses in threshold sensitivity to the five basic tastes? *Chem Senses* 26: 845 – 860.

Mirnalini K, Zalilah MS, Safiah MY, Tahir A, Siti Haslinda MD, Siti Rohana D, Khairul

Zarina MY, Mohd Hasyami S & Normah H (2008). Energy and nutrient intakes: findings from the Malaysian Adult Nutrition Survey (MANS). *Mal J Nutr* 14 (1): 1 – 24.

Ortega RM, Lo´pez-Sobaler AM, Ballesteros JM, Pe´rez-Farino N, Rodrı´guez-Rodrı´guez E, Aparicio A, Perea JM & Andre´s P (2011). Estimation of salt intake by 24-hour urinary sodium excretion in a representative sample of Spanish adults. *Brit J Nutr* 105: 787–794 doi:10.1017/S000711451000423X.

Reinivuo H, Valsta LM, Laatikainen T, Tuomilehto J & Poetinen P (2006). Sodium intake in the Finnish diet: II Trends in dietary sodium intake and comparison between intake and 24-h excretion of sodium. *Eur J Clin Nutr* 60: 1160 – 1167.

Sadler S, Nicholson S, Steer T, Gill V, Bates B, Tipping S, Cox L, Lennox A & Prentice A (2011). National Diet and Nutrition Survey - Assessment of dietary sodium in adults (aged 19 to 64 years) in England. From *https://www.wp.dh.gov.uk/transparency/files/2012/06/Sodium-Survey-England-2011_Text_to-DH_FINAL1.pdf* [Accessed 19 February 2013].

Vandevijvere S, Keyzer WD, Chapelle JP, Jeanne D, Huybrechts I, Hulshof P & Van Oyen H. (2010). Estimate of total salt intake in two regions of Belgium through analysis of sodium in 24-h urine samples. *Eur J Clin Nutr* 64:1260 - 1265.

World Health Organisation (2000). Obesity: Preventing and managing the global epidemic. WHO Obesity Technical Report Series No. 894.World Health Organization, Geneva.

WHO/IOTF/IASO (2000). The Asia-Pacific perspective: Redefining obesity and its treatment. International Obesity Task Force, International Association for the Study of Obesity. Hong Kong, World Health Organisation.

World Health Organisation (2007). Reducing Salt Intake in Populations: Report of a WHO Forum and Technical Meeting, 5 – 7 October 2006, Paris, France. World Health Organization, Geneva.

World Health Organisation / Pan American Health Organisation (2010). Regional Expert Group for cardiovascular disease prevention through population-wide dietary salt reduction. A review on methods to determine the main sources of salt in the diet. PAHO, Washington DC [Assessed 29 January 2013].