

Review

Salt intakes and salt reduction initiatives in Southeast Asia: a review

Ada Portia M Batcagan-Abueg MD, MPH¹, Jeanette JM Lee MBBS¹, Pauline Chan MS²,
Salome A Rebello PhD¹, Maria Sofia V Amarra PhD²

¹Saw Swee Hock School of Public Health, National University of Singapore, Singapore

²International Life Sciences Institute Southeast Asia (ILSI SEA) Region, Singapore

Increased dietary sodium intake is a modifiable risk factor for cardiovascular disease. The monitoring of population sodium intake is a key part of any salt reduction intervention. However, the extent and methods used for assessment of sodium intake in Southeast Asia is currently unclear. This paper provides a narrative synthesis of the best available evidence regarding levels of sodium intake in six Southeast Asian countries: Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam, and describes salt reduction measures being undertaken in these countries. Electronic databases were screened to identify relevant articles for inclusion up to 29 February 2012. Reference lists of included studies and conference proceedings were also examined. Local experts and researchers in nutrition and public health were consulted. Quality of studies was assessed using a modified version of the Downs and Black Checklist. Twenty-five studies fulfilled the inclusion criteria and were included in this review. Full texts of 19 studies including government reports were retrieved, with most studies being of good quality. Insufficient evidence exists regarding salt intakes in Southeast Asia. Dietary data suggest that sodium intake in most SEA countries exceeded the WHO recommendation of 2 g/day. Studies are needed that estimate sodium intake using the gold standard 24-hour urinary sodium excretion. The greatest proportion of dietary sodium came from added salt and sauces. Data on children were limited. The six countries had salt reduction initiatives that differed in specificity and extent, with greater emphasis on consumer education.

Key Words: sodium chloride, dietary, nutrition policy, sodium intake, salt

INTRODUCTION

High dietary sodium consumption is associated with high blood pressure,^{1,2} which is a major risk factor for cardiovascular disease (CVD).^{3,4} Animal studies, genetic studies, epidemiologic studies and interventional studies have provided evidence for a causal relationship between sodium intake and CVD.² There is also increasing evidence that salt intake is associated with increased risk of renal stones and osteoporosis, and may be a major cause of stomach cancer.^{2,5,6}

The body's physiological need for sodium is 0.23 to 0.46 g/day (0.58 to 1.17 g/day salt), but sodium intakes around the world exceed this figure.⁷ Most adult populations have mean sodium intakes >2.3 g/day (>5.85 g/day salt). In many Asian countries, mean sodium intakes are >4.6 g/day (>11.7 g/day salt).⁷ The 1988 INTERSALT study examined 24-hour urine sodium excretion of 52 sample populations in 32 different countries. Sodium excretion ranged from 0.01 g/day (0.03 g/day salt) among Yanomamo Indians in Brazil to 14.15 g/day (35.98 g/day salt) in north China.⁸ The INTERMAP study showed that sodium consumption was highest in China compared with Japan, UK and USA.^{7,9}

Increased dietary sodium intake is a modifiable risk factor and the efficacy of lowering blood pressure via reduction of salt intake is established.¹⁰⁻¹⁴ Two WHO expert consultations in 1983 and 2003 recommended that

the population average for sodium consumption should be <2 g/day of sodium (<5 g/day salt).¹ The recommended daily sodium intake in children 1 to 13 years is below 1.5 g/day, but sodium intake in children is far in excess of the recommended level.¹⁵

Measuring sodium intake at the population level is challenging. The 24-hour urine collection which is considered the "gold standard" to measure sodium intake captures 85-90% of ingested sodium.^{1,16} However, its high cost and participant burden may render it a less feasible option. Other urine collection procedures (e.g. spot (casual) urine collection, overnight urine collection) and analytical methods (e.g. prediction and estimation methods) are alternative techniques that may be adapted to the needs of specific countries,^{1,17,18} but these are less accurate than 24-hour urine collection procedures. Studies show large variations in the degree of correlations between sodium excretion in 24-hour- and spot- urine col-

Corresponding Author: Dr Maria Sofia V. Amarra, International Life Sciences Institute Southeast Asia (ILSI SEA) Region, 9 Mohamed Sultan Road #02-01, Singapore 238959.

Tel: +65 6352 5220; Fax: +65 6352 5536

Email: sofiaamarra@ilsisea.org.sg; amarra.sofia@gmail.com

Manuscript received 11 December 2012. Initial review completed 27 April 2013. Revision accepted 18 June 2013.

doi: 10.6133/apjcn.2013.22.4.04

lections, with correlations ranging from $r = -0.01$ to 0.86 .^{19,20}

Sodium intake may also be estimated indirectly from questionnaire or food consumption data.²⁰ Measures of food consumption include 24-hour food recalls, food diaries, duplicates of food collection, and food frequency questionnaires.¹⁷ Sodium intake is then assessed by linking food intake information to a food composition database. Measurement errors with these instruments arise as these methods are subject to participant bias and usually rely on memory to estimate food intake. The accuracy of the data also depends on the quality of the database which must be updated with a wide-array of ever-changing food products available at the market place. Discretionary (added) salt during cooking or at the table is also difficult to estimate, and may not be adequately captured by questionnaires.²⁰ Literature reveal that indirect methods underestimate urinary sodium excretion,^{20,21} and correlations between dietary survey and urine collection ranges from $r = 0.09$ to 0.30 .^{22,23}

Identifying major dietary sources of sodium in the population is usually determined via surveys on dietary habits such as discretionary salt or sauces during cooking or at the table.^{9,17} This information is important because this can help identify interventional targets and develop public health recommendations.

The WHO has recommended interventions to reduce salt intake based on three main pillars, namely: *product reformulation* (reducing the salt content of commercialized foods and meals), *consumer education* (raising awareness on the harmful effects of excessive salt consumption and educating consumers with regards to reading food labels and choosing healthier options), and *environmental change* (building an environment where choosing the healthiest foods is the easiest and most affordable option, e.g. through pricing strategies and development of clear labelling systems).¹

The Southeast Asia (SEA) region is faced with a growing prevalence of CVD, which can impose a significant burden on the healthcare system.²⁴ Reviewing the amount and sources of dietary sodium intake in these populations, as well as policy guidelines to limit sodium intake, can help identify knowledge-gaps and provide directions for future research and policy recommendations. This review examines sodium intake in Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. The objectives are to 1) evaluate measurements of population salt/sodium intake in available studies and identify sources of salt/sodium in the diet; and 2) describe current approaches to reduce salt/sodium intake in the region

MATERIALS AND METHODS

The study is composed of two parts: 1) a narrative synthesis of population-level studies that assessed dietary sodium intake and sources of sodium in the diet; and 2) a description of initiatives to reduce salt intake in SEA.

Studies that assess dietary sodium intake and sources in the diet

Search strategy

Databases searched were PubMed, Cochrane Library, PERIND, Science Direct, Access Medicine, Web of Sci-

ence, Scopus, ProQuest Dissertations and Theses database, Faculty of 1000 and OpenSIGLE. Search terms used were “sodium chloride”, “salt”, “sodium”, “Indonesia”, “Malaysia”, “Philippines”, “Singapore”, “Thailand” or “Vietnam”. Conference proceedings and reference lists of published literature were hand-searched for relevant information. Studies identified by local experts and researchers in the fields of public health and nutrition were obtained.

Inclusion criteria

Studies were selected for inclusion based on the following criteria: 1) measured or estimated total sodium intake and/or dietary sources of sodium; 2) conducted on humans (children or adults); 3) among populations in Singapore, Malaysia, Philippines, Indonesia, Thailand or Vietnam; and 4) published in English up to 29 February 2012. Studies done in subsets of the population such as pregnant women or institutionalised individuals, case studies and case series were excluded.

Quality assessment of literature using a modified Downs and Black Checklist

The Downs and Black Checklist is recommended for use in reviews of non-randomised studies.²⁵ Since not all items in the Downs and Black Checklist were applicable for this particular review, a modified version called the Modified Downs and Black Checklist for Salt Intake (MDBSI) was developed. Seventeen items in the original checklist were omitted as they were not suitable for the type of studies being reviewed.²⁶ The studies were evaluated in terms of quality of reporting, internal validity and external validity. A subscale on “Salt Intake Assessment” was created to evaluate individual studies according to 1) the method used to measure salt intake, wherein higher scores were given to studies which made use of more precise methods, and 2) the method of assessing salt sources. A higher score indicated higher quality. All studies with available full texts were assessed for quality using the MDBSI by two reviewers (APMBA and SAR). A copy of the modified instrument can be requested from the authors.

Data synthesis

For each country, information relating to salt intake measurements was extracted. The information included age of subjects, sampling method, sample size, instrument or measurement used, and mean sodium intake or excretion.

Sodium intake is usually reported as either mass or millimolar amounts of sodium, or as mass of sodium chloride (salt).⁷ For ease of comparison, all dietary and urinary estimates of salt intake were converted and reported as mass of sodium per day (g/day) where 1 g sodium chloride = 17.1 mmol sodium or 393.4 mg sodium.^{7,20}

Description of initiatives to reduce salt intake in SEA

Data on current approaches to reduce salt intake in the region were obtained by searching the internet for country information and by communicating with local experts. National-level policies, strategies and programmes that sought to achieve population-wide salt intake reduction

were charted based on WHO's three pillars of intervention.¹

Identification of salt reduction initiatives

Factiva and Business Source Premier (databases for news articles) were explored in addition to the databases mentioned in the review of salt intake. Similar keywords were used during the search. Government websites from local health authorities were visited, and experts/researchers in the fields of public health and nutrition were contacted. Other web-based resources were identified using Google and Google Scholar.

Contact with experts

Public health and nutrition experts from Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam were consulted, with the help of International Life Sciences Institute Southeast Asia (ILSI SEA) Region. Emails were sent asking for information regarding salt reduction policies and programs in their respective countries.

RESULTS

Studies that assess dietary sodium intake and sources in the diet

Selection process

The search strategy yielded 1804 potentially relevant articles. After reviewing the titles and abstracts, 25 studies (including government reports such as press releases and presentation slides) fulfilled the inclusion criteria, and are included in this narrative synthesis (Figure 1). Out of the 25, only 19 studies were included in the quality assessment as full texts of 6 studies were not accessible to the

authors.

Characteristics of included studies

The characteristics of the 25 included studies and reports are presented in Table 1, grouped by country and sorted by year of publication. An arbitrary quality score of $\geq 70\%$ was defined as "good" quality. Among the 19 studies assessed for quality, 18 (95%) studies were judged as good quality, while 1 (5%) study had a score below 70%.

Among the 22 studies that measured sodium consumption, only 4 (18%)²⁷⁻³⁰ used the gold standard 24-hour urine collection. Sources of sodium were assessed most commonly using dietary intake measures, such as dietary practices questionnaire and/or food frequency questionnaire.

Sodium intake estimates across countries

Estimates of sodium intake based on dietary intakes or urinary sodium excretion in adults and children from different Southeast Asian countries are shown in table 2. National nutrition survey data were available from Malaysia, Philippines, and Singapore. Smaller studies were available from Indonesia, Malaysia, Philippines and Thailand. Of these, one study²⁷ had total sodium intake data for both adults and children, 19 studies had data for adults only, and 3 studies³¹⁻³³ had data exclusively for children. We were unable to find sodium consumption estimates for Vietnam.

Sodium intakes of adults

Data for adults indicate that, in the five countries examined, sodium intake is generally greater than the WHO recommended amount of 2 g/day (Table 2). The highest

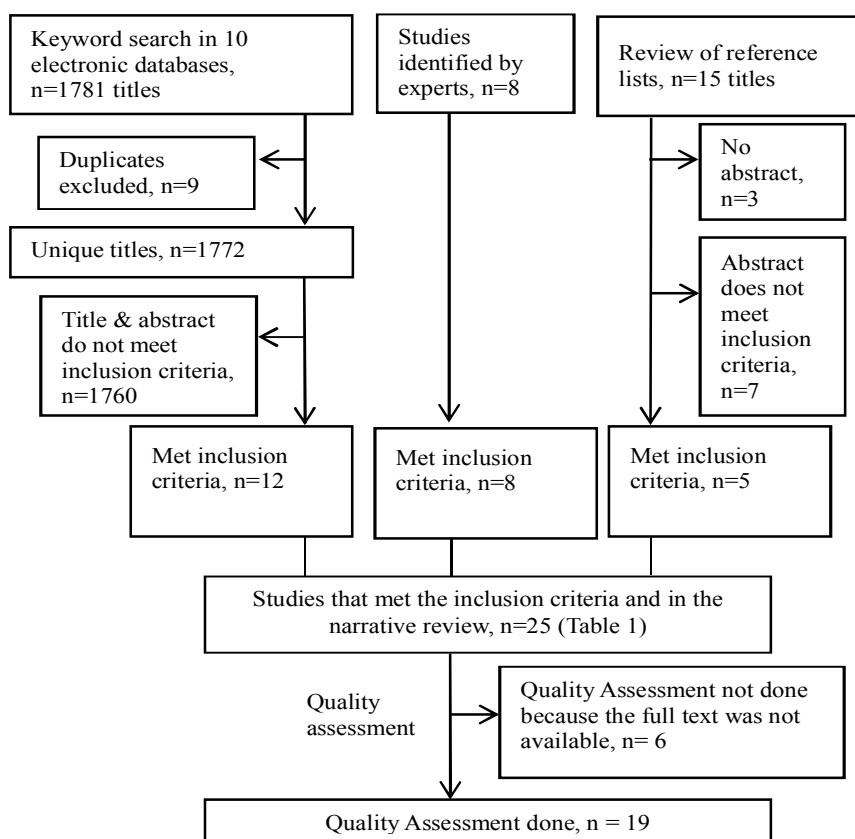


Figure 1. Process of inclusion of the studies for review and analysis

Table 1. Characteristics of studies that examined sodium intake and dietary sources of sodium (n=25)

Country (Study name, study year)	Author, year published	Sampling	Age (years)	Measurement	Sample size	Sodium intake was estimated	Food sources of sodium were identified	Quality Score
Indonesia	Wijayanti E et al, 2010 ³¹	Proportional systematic random sampling	--	Direct food analysis by atomic absorption spectroscopy (AAS)	68 school-aged children	Yes	No	None†
Indonesia	Kamsu S et al, 2007 ³⁵	Multi-stage random sampling	55 to 80	24-hour dietary recall method	556 adults	Yes	No	73%
Indonesia	Mustafa A et al, 2006 ²⁷	--	Men: 8.7±0.6 Women: 33.2±4.0	Lithium-marker technique for 24-hr urine collection	15 school-aged males, 15 adult females	Yes	No	82%
Malaysia	Gan WY et al 2011 ⁵⁵	Multistage stratified random sampling of universities in the Klang Valley	18 to 22	Two-day dietary intake recall	584 university students (59.4% females and 40.6% males)	Yes	No	73%
Malaysia (Malaysian Adult Nutrition Survey, 2003)	Mirnalini K et al, 2008 ⁵⁶	Stratified random sampling of Sabah, Sarawak and Peninsular Malaysia (national representative)	18 to 59	One day 24-hour dietary recall	7349 adults (51% males and 49% females)	Yes	No	82%
Malaysia	Shimbo S et al, 1999 ⁸⁹	--	33.2±6.9	24-h food duplicate samples were subjected to estimation (E) by use of food composition tables established in Malaysia, and to measurement (M) by inductively-coupled plasma mass spectrometry	49 females, ethnically Malay	Yes	No	73%
Malaysia	Khor GL et al, 1998 ³⁸	Convenience sampling	Mean: 36-37	Food frequency questionnaire	147 males 187 females	No	Yes	71%
Malaysia	Shimbo S et al, 1996 ⁹⁰	--	33.2±6.9	24-h food duplicate samples were subjected to estimation by use of food composition tables	49 females, ethnically Malay	Yes	No	82%
Philippines (National Nutrition Survey)	Capanzana M , Food and Nutrition Research Institute (FNRI) 2010 ³⁷	Nationwide multi-stage stratified sampling of households	--	Secondary analysis of data from National Nutrition Surveys done in 1978, 1987, 1993, 2003, 2008 was done. Measurement done in the surveys was by one-day household food weighing where mean one-day per capita discretionary sodium consumption was computed.	--	Yes	No	None†

† Quality Assessment was not done because either the study's full text or related literature describing the methodology were not available; -- Information not available; NA, Not applicable

Table 1. Characteristics of studies that examined sodium intake and dietary sources of sodium (n=25) (cont.)

Country (Study name, study year)	Author, year published	Sampling	Age (years)	Measurement	Sample size	Sodium intake was estimated	Food sources of sodium were identified	Quality Score
Philippines (Cebu Longitudinal Health and Nutrition Survey, 2005)	Lee N 2009 ³⁹	Stratified, single stage sampling design	35 to 68	Two 24-hour dietary recalls and a semi-structured questionnaire on salty condiments added during cooking or at the table were utilised; food composition tables were used to calculate estimates.	1776 females	Yes	Yes	71%
Philippines	Natera E et al, 2002 ⁹¹	--	NA	One-day diet samples (purchased regional cooked meals [duplicate diets] and samples of commonly eaten food [total diet]) were each weighed and nutrient estimates were determined by chemical analysis and spectrometry	19 regional diet samples	Yes	No	73%
Philippines	Corpus VA et al, 1988 ⁹²	Nationwide stratified sampling	--	Mineral contents (including sodium) of average Filipino diet were approximated based on food composition values and consumption data of food groups from the 2 nd Nationwide Nutrition Survey 1982	--	Yes	No	None †
Singapore (National Nutrition Survey, 2010)	Health Promotion Board, 2011 ²⁸	Subsample of the National Health Survey 2010 participants	18 to 79	24-hr urine collection; Dietary Practices Questionnaire, Food Frequency Questionnaire	800	Yes	Yes	None †
Singapore (National Nutrition Survey, 2004)	Health Promotion Board, 2004 ⁴³	Subsample of NHS 2004 participants, stratified sampling	18 to 69	Dietary Practices Questionnaire, Food Frequency Questionnaire	1381	No	Yes	90%
Singapore (National Nutrition Survey, 1998)	Ministry of Health, Department of Nutrition 1998 ⁴⁴	Subsample of NHS 1998 participants, systematic sampling	18 to 69	Dietary Practices Questionnaire, Food Frequency Questionnaire, 24-Hour Food Intake Questionnaire	2400	Yes	No	79%
Singapore (Food Consumption Study, 1993)	Ministry of Health, Food & Nutrition Department 1994 ⁴⁵	Subsample of NHS 1992 participants, systematic sampling	18 to 69	Dietary Practices Questionnaire, 24-hour Food Intake Questionnaire, 3-day food records	460	Yes	No	86%
Singapore	Lee HP et al, 1983 ²⁹	--	>20	Dietary survey, 24-hr urine analysis	30	Yes	No	79%

† Quality Assessment was not done because either the study's full text or related literature describing the methodology were not available; -- Information not available; NA, Not applicable

Table 1. Characteristics of studies that examined sodium intake and dietary sources of sodium (n=25) (cont.)

Country (Study name, study year)	Author, year published	Sampling	Age (years)	Measurement	Sample size	Sodium intake was estimated	Food sources of sodium were identified	Quality Score
Singapore	Whittow GC, 1956 ³⁰	--	18-27	24-hr urine samples; 8-hr urine samples	66 males	Yes	No	82%
Thailand (2009)	Leelajaratkoon W et al, 2010 ³²	Purposive sampling	1-5	Food frequency questionnaire and 24-hr dietary recall	225	Yes	Yes	71%
Thailand (2008-2009)	Saiwongse N, Bureau of Nutrition, Ministry of Public Health 2010 ⁵⁷	--	--	--	--	Yes	Yes	None†
Thailand (2007)	Pavadhgul P et al, 2009 ⁴⁰	2 dormitories selected by simple random sampling of 11 dormitories. Sampling of students unable to determine	17-20	Semi-quantitative food frequency	83 males 87 females	Yes	Yes	71%
Thailand (2001)	Klunklin S and K Channoonmuang 2006 ³³	--	2-6	5-day food record (3 working days and a weekend)	85 normal-weight subjects	Yes	No	64%
Thailand (2001)	Kwanmaung K 2001 ⁵⁸	--	Group 1: 20-30 Group 2: 60-81	48-hour urine sodium determination (i.e. 2 12-hour daytime periods and 2 12-hour night-time periods)	Group 1: 20 Group 2: 18	Yes	No	82%
Thailand (1960)	Interdepartmental Committee on Nutrition for National Defense 1962 ³⁴	--	--	Food composite analysis	--	Yes	No	None†
Vietnam	Duong DN et al, 2003 ⁴²	Convenience sampling	19 to 85	Interviewer-administered questionnaire on family cardiovascular risk, personal health, habits associated with cardiovascular risk and knowledge about hypertension	125 males 232 females	No	Yes	70%

† Quality Assessment was not done because either the study's full text or related literature describing the methodology were not available; -- Information not available; NA, Not applicable

Table 2. Estimated total sodium intake levels among adults and children in Southeast Asia

Country	Reference	Mean sodium \pm SD (g/day)			
		Age (yrs)	Males	Females	Both sexes
A. Adults					
Indonesia	Kamso S et al, 2007 ³⁵	55-80	0.20 \pm 0.02 [†]	0.16 \pm 0.01 [†]	--
	Mustafa A et al, 2006 ²⁷	--	--	2.28 \pm 0.67	--
Malaysia	Gan et al., 2011 ⁵⁵	18-24	2.97 \pm 1.27	2.32 \pm 0.96	--
	Mirmalini K et al, 2008 ⁵⁶	18-59	2.82 \pm 0.03	2.32 \pm 0.03	2.58 \pm 0.02
	Shimbo S et al, 1999 ⁸⁹	33.2 \pm 6.9	--	F: 1.22 \pm 0.70 M: 1.28 \pm 0.60	--
Philippines	Shimbo S et al, 1996 ⁹⁰	33.2 \pm 6.9	--	1.21 \pm 0.70	--
	Lee N, 2009 ³⁹	35-68	--	2.90 [‡]	--
Singapore	Natera E et al, 2002 ⁹¹	--	--	--	1.25 \pm 0.5
	Health Promotion Board, 2011 ²⁸	18-79	3.78 [‡]	2.80 [‡]	3.26 [‡]
	Ministry of Health, 1998 ⁴⁴	18-69	3.58 \pm 0.05	3.06 \pm 0.4	3.53 \pm 0.03
	Ministry of Health, 1994 ⁴⁵	18-69	3.94 \pm 0.13	3.05 \pm 0.09	3.50 \pm 0.08
	Lee HP et al, 1983 ²⁹	>20	--	--	3.81 \pm 0.38
Thailand	Whittow GC, 1956 ³⁰	18-27	--	--	3.52 \pm 0.14
	Saiwongse N, 2010 ⁵⁷	--	--	--	4.25 [‡]
	Pavadhgul P et al, 2009 ⁴⁰	17-20	5.22 \pm 2.23	4.50 \pm 2.09	4.85 \pm 2.18
	Kwanmaung K, 2001 ⁵⁸	20-30	--	--	3.05 \pm 1.03
		60-81	--	--	3.30 \pm 1.74
	Interdepartmental Committee on Nutrition for National Defense, 1962 ³⁴	--	7.12 (range:2.95-10.81, Military)	--	3.58 (range: 1.61-6.69, Civilians)
B. Children					
Indonesia	Wijayanti E et al, 2010 ³¹	--	--	--	3.58 [‡]
	Mustafa A et al, 2006 ²⁷	7-10	2.12 \pm 0.83	--	--
Thailand	Leelajaratkoon W et al, 2010 ³²	1-3	--	--	1.30 \pm 0.41
		4-5	--	--	1.45 \pm 0.52
	Klunklin S et al, 2006 ³³	2-3	--	--	0.54 \pm 0.11
		4-6	--	--	0.58 \pm 0.15

[†]text does not indicate whether mean or median; [‡] measure of variability not available; E, Estimation using food composition table; M, Measurement using spectrometry; SD, standard deviation; -- No data

total sodium intake was recorded among Thai military men with a mean of 7.12 (range 2.95-10.81) g of sodium consumed per day,³⁴ while the lowest intake was recorded among Indonesian women with a daily sodium intake of 0.16 \pm 0.01 g.³⁵ The low estimates of sodium intake in Indonesian women and men in this study is possibly related to the characteristics of this sample which was comprised of older adults with less than the recommended energy intake, and to the imperfect dietary assessment method which did not capture discretionary sodium consumption.³⁵ In a younger, but smaller sample of women, estimated mean sodium intakes were considerably higher at 2.28 \pm 0.67 g per day.²⁷ Studies with data on both men and women showed that men consistently had higher intakes than women.

Sodium intakes of children

Indonesia and Thailand were the only countries with data on children. The few available studies suggested that older children had higher sodium intakes than younger children. The IOM Food and Nutrition Board recommended the following adequate intake (AI) levels of sodium per day: 1.0 g (age 1-3 years); 1.2 g (age 4-8 years); 1.5 g (9-18 years).³⁴ When compared with AI levels for their respective age groups, sodium intakes among Indonesian schoolchildren exceeded the recommended amounts. Findings for Thai pre-school children were inconsistent although more recent findings showed the same trend of exceeding recommended amounts (Table 2).

Per capita sodium intake (Philippines data)

The Philippines' National Nutrition Surveys reported mean one-day per capita sodium intakes based on household food weighing, rather than age- and sex-specific intakes. Consumption figures given in per capita averages assume equal shares for household members including infants³⁶ and do not show existing variations in intake among different groups. Data from the nutrition surveys of 1978, 1987, 1993, 2003 and 2008 showed that discretionary (ie, salt added during cooking or at the table) use of salt declined over the years.³⁷ Still, the 2008 data suggest that levels of intake exceeded the recommended amount and that more than half of ingested sodium was accounted for by discretionary use of salt (Table 3).

Food sources of sodium across countries

Few studies exist on the dietary sources of sodium. The available data suggest that, in addition to added sodium in processed foods, condiments and sauces contribute significantly to sodium intakes of Southeast Asian populations.

Sources of sodium among adults

In Malaysia, a study on dietary practices among 334 adults showed that 83% of respondents always added salt or salty sauce to foods during cooking, while almost half (49%) said they rarely or never added salt to cooked food before eating.³⁸

In the Philippines, the 2003 and 2008 National Nutrition Surveys showed that the major sources of sodium in

Table 3. Estimated per capita sodium intakes based on national surveys – Philippines

National Nutrition Survey year from which data was taken	Mean per capita sodium intake (g/day) [†]	
	Discretionary intake (salt added at the table or during cooking) ³⁷	Total intake
2008	1.57	2.29 [‡]
2003	1.57	NA
1993	1.97	NA
1987	2.36	NA
1982	4.63 ⁹²	NA
1978	2.36	--

[†] measure of variability not available; [‡] personal communication with Barba CVC and Tanchoco C; NA, not applicable; --No data

the diet were condiments such as table salt (coarse and iodized forms) and soy sauce.³⁷ An analysis of the diets of 1776 women also showed that the major source (76.3%) of sodium was added condiments (salt 58%, soy sauce 14%, fish sauce 1.4%, monosodium glutamate 2.4%, other flavourings 0.6%), while whole foods contributed only 23.7% of total sodium intake.³⁹

In Thailand, a study among young adults aged 17-20 years showed that common sources of sodium were one-plate meals, meat products, flour, nut, and seed products, seasoning added during consumption, snacks and desserts, beverages, and fast food.⁴⁰ A report by the country's Department of Health showed that the major source of sodium was condiments, especially table salt and fish sauce.⁴¹

In Vietnam, a survey among adults showed that 98% of respondents cooked with salt, 5% added salt regularly when eating, and 81% said that they 'always' or 'occasionally' ate canned salty foods.⁴²

The Singapore national nutrition surveys in 1993, 1998

and 2004 suggested that 40-69% of respondents rarely or never added salt or sauces to their food.⁴³⁻⁴⁵ The Salt Intake Study in 2010 showed that processed foods accounted for 37% of sodium sources in Singapore.²⁸ Almost two-thirds of dietary salt intake in Singapore was consumed outside the home. Fish balls, fish cakes, breads and noodles were the major sources of salt.²⁸

No study was identified for Indonesia regarding salt use or sources of sodium in the diet.

Sources of sodium among children

Leelajaratkoon *et al*³² found that high-sodium foods frequently consumed by Thai pre-schoolers aged 1-5 years included fish sauce or soy sauce, seasoning sauce, bread and bakery products, mackerel, fried rice, fast food (fried prawn/chicken/fish balls), fried seaweed snack, potatoes/potatoes flour chips, fish minced strips, noodles and one-plate meals. Except for Thailand, no studies from other SEA countries regarding food sources of sodium among children were identified.

Approaches to reduce salt intake

Table 4 shows national salt reduction strategies of the different countries. Among the three pillars of intervention advocated by WHO, the "consumer" pillar is commonly employed by all six countries. There were fewer efforts targeting food production and the environment. Singapore employs all three pillars and has the most number of salt-specific programmes. Vietnam has the least number of salt reduction approaches.

Consumer awareness and education

As shown in Table 4, the common components of consumer interventions were dietary guidelines to reduce salt intake, the promotion of diet or lifestyle changes (eg, increase exercise), and communications to increase aware-

Table 4. Approaches to reduce population salt intake in Southeast Asian countries classified by WHO's three pillars of intervention

Country	WHO pillars of intervention for salt reduction		
	Product Reformulation	Consumer awareness	Environmental change
Indonesia	--	Dietary guidelines ⁶³ NGOs [†] conduct educational activities ⁶⁴	Government regulations requiring food manufacturers and restaurants to label the amount of salt in their products by 2012 ⁵⁰
Malaysia	Voluntary food reformulation ⁴⁶	Dietary guidelines; ⁶⁵ Government's national policy to promote healthy eating and active lifestyle; ⁶⁶ NGO [†] -led annual consumer nutrition promotion campaign and production of educational materials ^{67,68}	--
Philippines	--	Dietary guidelines; ⁶⁹ Government and NGO [†] -led campaigns to create awareness of hypertension and to promote healthy lifestyle ^{70,71}	--
Singapore	Voluntary food reformulation; ⁴⁶ Government equips small and medium enterprises with knowledge and skills to develop healthier products	Dietary guidelines; ⁷² Government and NGO [†] -led campaigns to promote healthy lifestyle ^{47,75}	Front-of-pack labelling; ⁵² Government-led programmes to promote healthier food in restaurants, eateries, and schools ^{48,49}
Thailand	--	Dietary guidelines; ⁷⁴ Government-led public awareness campaigns ⁵¹	Front-of-pack labelling ^{51,57}
Vietnam	--	Dietary guidelines ⁷⁵	--

[†] Nongovernmental organization, -- No data found

ness of hypertension. Some interventions focused specifically on salt and sodium intake while others were part of broader health and lifestyle programs. Programmes were led by government or non-government organizations.

Product reformulation

Malaysia and Singapore encourage voluntary product reformulation by the food and restaurant industry, as a way of reducing the salt content of processed and prepared foods.⁴⁶ In Singapore, the Health Promotion Board is working with industry partners to lower the sodium content of packaged foods, and to develop a "healthier salt" containing 25% less sodium than regular salt.⁴⁶ This salt will be promoted for use in food establishments.

Environmental changes

Indonesia, Singapore, and Thailand have implemented regulations to reduce the amount of salt in restaurants and street foods. In Singapore, regulations are implemented in the Healthier Restaurant Programme, Model School TuckShop Programme, and Healthier Hawker Programme.⁴⁷⁻⁴⁹ In Indonesia, regulations on salt content are planned to be enforced among franchised fast-food restaurants.⁵⁰ In Thailand, restaurants provide the Healthy Food Menu for Healthier Choice.⁵¹ Both Singapore and Thailand also use "healthy" logos to symbolize products with lower salt content.^{51,52} In Malaysia, the Health Ministry has announced plans for a labelling scheme wherein "items would carry a healthy-choice food logo if their sugar, salt and fat content were at healthy levels".⁴⁶

DISCUSSION

The present review revealed that most of the studies in SEA estimated sodium intake using dietary survey methods rather than the gold-standard 24-hour urinary sodium excretion. Dietary intake methods are not considered very reliable due to associated measurement errors^{53,54} and some may not take discretionary salt intake into account.^{17,20} Since 24-hour urine studies are expensive, countries in the region should be encouraged to validate and use alternative methods such as spot urine analysis supplemented by dietary intake data to identify food sources, and to develop their own cost-effective protocol in order to improve the state of knowledge regarding sodium intake.

Thirteen studies^{27-30,34,39,40,44,45,55-58} estimated that total sodium consumption among adults in SEA is above 2 g/day (>5 g/day salt). Men were more likely to have higher sodium intakes than women, which could be due to their higher food intake.⁷ Indonesia and Thailand were the only countries with data on intake levels of children. Older children had higher sodium intakes than younger children, probably due to differences in overall energy intakes. On the whole, data was limited to establish secular changes over time.

Mean daily sodium consumption in Singapore which has data from a nationally representative sample is comparable to estimated sodium intakes in US (mean±SD estimated sodium intake derived from 24-hour dietary recall: 3.21±1.61 g/day)⁵⁹ and UK (mean±SE estimated sodium intake from urinary sodium excretion: 3.39±0.07 g/day).⁶⁰ Estimated mean sodium intakes in Malaysia

which also has nationally representative data are somewhat lower than those of the US and the UK. Sodium intake estimates from a number of studies in China (range 2.9-6.7 g/day) and Japan (range 4.3-5.2 g/day)⁷ are generally higher than those reported for SEA.

This review suggests that a high proportion of dietary sodium comes from salt added at the table or during cooking, and from condiments such as soy sauce and fish sauce. This finding is consistent with that of other Asian countries (China and Japan) where a large proportion of ingested sodium comes from salt added when cooking as well as sauces and seasonings.⁹ The customary practice in SEA of discretionary use of salt during cooking or at the table should be addressed in nutrition education programmes. In most western industrialised countries, a large proportion of sodium in the diet is obtained from processed foods and foods eaten outside the home.¹ As eating-out becomes more prevalent in SEA,⁶¹ the contribution of processed and food-service foods to total sodium intake is likely to increase.

It is important to note that studies in the present review, aside from being few in number, were heterogeneous in terms of sample size, age of subjects, methods of estimating sodium consumption, and outcomes measured. Because of this, caution should be exercised when interpreting and comparing sodium consumption figures among countries.

Monitoring population sodium intake over time should be part of any national salt reduction strategy. Information from monitoring activities provide essential information for policymakers and stakeholders regarding the extent of population salt consumption as a public health problem, help set goals to be reached by initiatives, and show progress and limitations of the various approaches on sodium reduction.¹⁷ It is necessary to monitor sodium intakes in both adults and children. Some countries (e.g. Philippines, Singapore) conduct monitoring programs but these focus on adults.^{43,62} It is notable that no large-scale studies on sodium intake in children were identified in this review. Children with high sodium intakes may be predisposed to develop hypertension in adulthood.⁶³ Also, high sodium intake suppresses salt taste receptors that may cause children to prefer food with higher salt content in adulthood.⁶⁴ Data from the US and other regions in the world suggest that sodium consumption among children and adolescents is as high as that of adults.⁷ More studies are needed to determine whether this situation exists in SEA.

While efforts to lower population-level sodium intake have been made in all six countries,^{46, 48-52,57,65-77} data on the effectiveness of salt-reduction programmatic-initiatives are lacking. Evaluations are critical to improve program implementation⁷⁸ and help identify programs that are effective. Also, ongoing efforts in most countries have focused on increasing consumer awareness.^{51,65-77} Simulation studies have suggested that strategies such as voluntary or mandatory reductions of sodium content of packaged foods are particularly cost-effective.⁷⁹ These studies showed that even modest reductions in population level sodium intake accomplished gradually over several years is more cost-effective than pharmacological control of hypertension.⁸⁰ Thus, as recommended by WHO,^{1,51}

environmental and product reformulation measures are important components that should be considered in the development of sodium-reduction initiatives in this region.

Overall, the results of this review indicate that insufficient evidence exists regarding sodium intakes in Southeast Asia and that sodium reduction initiatives in the region are limited. Dietary intake studies suggest that intake exceeds recommended levels but more studies using urinary sodium excretion measures are needed in order to verify levels of sodium intake in most countries. Reducing dietary salt intake can lower blood pressure,⁸¹ and even modest reductions in blood pressure applied across the population can reduce the risk of CVD.⁸² Graudal *et al*'s⁹³ review of randomized trials found that sodium reduction in hypertensive Asians reduced systolic blood pressure by -10.21 mmHg (95% CI: -16.98, -3.44; $p=0.003$) and diastolic blood pressure by -2.60 mmHg (95%CI: -4.03, -1.16; $p=0.0004$). Since the prevalence of hypertension in SEA is significant,⁸³⁻⁸⁷ initiatives to reduce salt in the food supply will most likely benefit the region.

Knowledge gaps and future research needs

While lower sodium consumption for the general public is advocated, certain groups such as athletes may require more sodium than ordinary individuals due to sweat losses.⁸⁸ This may also apply to certain occupational groups that undertake heavy manual labour in hot tropical environments. Recent studies have also suggested that low sodium intakes may lead to higher risk of adverse events in patients with established cardiovascular disease or diabetes mellitus. O'Donnell *et al*⁹⁴ examined data from two observational cohorts – the Ongoing Telmisartan Alone and in combination with Ramipril Global Endpoint Trial (ONTARGET) and the Telmisartan Randomized Assessment Study in ACE Intolerant Subjects with Cardiovascular Disease (TRANSCEND). They found a J-shaped association between urinary Na excretion and adverse cardiovascular (CV) events such as CV death, myocardial infarction, stroke and hospitalization for heart failure. Baseline sodium excretion of less than 3 grams per day was associated with increased risk of cardiovascular mortality and hospitalization for congestive heart failure, while baseline excretion of greater than 7 grams per day was associated with an increased risk of all adverse CV events. The lowest risk occurred at baseline Na excretion of 4 to 5.99 g/day. Among patients with type 2 diabetes, Ekinçi *et al*⁹⁵ found a significant inverse association between urinary Na excretion and mortality, wherein for every 100 mmol rise in 24-hour Na, all-cause mortality was 28 percent lower.

A meta-analysis by WHO that summarised information from 14 cohort studies (but excluded studies on unique populations such as patients with heart failure and other acute illnesses) observed no association of sodium consumption with all-cause and cardiovascular mortality. Consistent with its blood-pressure elevating effects, higher sodium consumption was associated with higher risk of stroke, stroke mortality and coronary heart disease mortality in non-acutely ill adults.⁹⁶

Further studies are needed to determine the need for sodium of various groups depending on age, race, level of

activity, environmental conditions and pre-existing diseases, particularly among Asians. Adverse effects of low Na intakes in high-risk populations have been associated with activation of metabolic and neurohormonal pathways, particularly the renin-angiotensin-aldosterone system (RAAS).⁹⁷ In animal studies, activation of these pathways was shown to result in increased total and LDL cholesterol, and reduced insulin sensitivity. Tikellis *et al*⁹⁷ showed that a low salt diet in *apolipoprotein E* knockout mice resulted in plaque accumulation associated with activation of the RAAS and increased vascular adhesion molecules and inflammatory cytokines.

Alderman and Cohen⁹⁸ put forward the view that the body of evidence does not support universal reduction of sodium intake. Their review showed that while sodium reduction lowers blood pressure on one hand, similar reductions increased plasma renin activity and aldosterone secretion, insulin resistance, sympathetic nerve activity, serum cholesterol and triglycerides, and increased risk of mortality among heart patients. The authors suggested that “the health consequences of reducing sodium cannot be predicted by its impact on any single physiologic characteristic but will reflect the net of conflicting effects.” Thus, a recent IOM report⁹⁹ identified a need for more randomized clinical trial (RCT) research, observational and mechanistic studies in population subgroups to examine the effects of a range of sodium levels on risk of cardiovascular events, stroke and mortality among patients receiving therapeutic treatment as well as among individuals as part of natural experiments, such as those in other countries where policies affecting sodium consumption are in effect.

Future studies also need to take into consideration the interaction of sodium with other nutrients such as potassium. The recently released WHO guidelines on potassium intake¹⁰⁰ recommends increased potassium intake from food to reduce blood pressure. It stated that increased potassium intake should complement the WHO guidelines on Na intake and that a Na:K ratio of 1:1 is necessary in order to achieve optimal health.

While there is an on-going debate on the lower limit of the recommended sodium intake, both the WHO and Institute of Medicine recognize that excessive sodium consumption is associated with increased cardiovascular risk.^{99,101}

Limitations of the review

Despite efforts to conduct a thorough search, full texts for some relevant studies were inaccessible to the authors (unpublished or not available from the contacted libraries). The review was also limited to studies written in English. This may have resulted in exclusion of other relevant research written in a different language that would have otherwise been appropriate for review.

Summary

Information on salt intakes in Southeast Asia is limited. Malaysia, Philippines and Singapore have salt intake data from nationally representative samples, while data for Indonesia and Thailand were based on non-representative samples. There was no data for Vietnam. Among all countries, only Singapore used the gold standard 24-hr

urinary sodium excretion to estimate intakes. The rest of the countries used less reliable dietary assessment methods. Available information focused on adults and very little on children. Dietary sources of sodium are salt and sauces added to food during cooking, condiments added at the table, store-bought and processed foods and snacks (fish balls, fish cakes, bread, noodles), and beverages. Salt reduction initiatives exist in all countries but in the absence of reliable baseline measures of salt intake, it is difficult to evaluate the effectiveness of such initiatives or to monitor changes in salt consumption over time. Future priorities should include developing alternative methods to 24-hr urinary sodium excretion, motivating SEA countries to collect baseline measures of salt intake using more accurate and reliable methods, promoting the establishment of national sodium reduction initiatives that include environmental measures and product reformulation, and developing programs to monitor and evaluate salt reduction initiatives.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the following individuals who provided information for the review: Mrs Yeong Boon Yee (ILSI SEAR), Prof Corazon VC Barba (College of Human Ecology, University of the Philippines), Dr Mario Capanzana and Dr Celeste Tanchoco (Food and Nutrition Research Institute, Philippines), Dr Siti Muslimatun (Resource Management and Marketing, SEAMEO RECFON, Indonesia), Dr Tee E Siong (TES NutriHealth Strategic Consultancy, Malaysia), Singapore Health Promotion Board, Prof Khor Geok Lin (International Medical University, Malaysia), Prof Pattanee Winichagoon (Mahidol University, Thailand), and Ms Steffiana Wijaya (ILSI SEAR).

AUTHOR DISCLOSURE

The first author (APMBA) received honorarium from ILSI SEA Region for write-up and costs associated with presentations at conferences. The remaining authors have no conflict of interest.

REFERENCES

- World Health Organization. Reducing salt intake in populations: report of a WHO forum and technical meeting, 5-7 October 2006, Paris. Geneva, Switzerland: WHO Press; 2007. pp 1-59.
- He FJ, MacGregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. *J Hum Hypertens.* 2009;23:363-84. doi: 10.1038/jhh.2008.144
- World Health Organization. Global health observatory. Raised blood pressure: situation and trends. 2012 [cited 2012/4/26]. Available from: http://www.who.int/gho/ncd/risk_factors/blood_pressure_prevalence_text/en/index.html
- Centers for Disease Control and Prevention. High blood pressure. 2012 [cited 2012/04/24]; Available from: <http://www.cdc.gov/bloodpressure/>.
- de Wardener HE, MacGregor GA. Harmful effects of dietary salt in addition to hypertension. *J Hum Hypertens.* 2002;16:213-23. doi: 10.1038/sj.jhh.1001374
- Caudarella R, Vescini F, Rizzoli E, Francucci CM. Salt intake, hypertension, and osteoporosis. *J Endocrinol Invest.* 2009;32:15-20.
- Brown IJ, Tzoulaki I, Candeias V, Elliott P. Salt intakes around the world: implications for public health. *Int J Epidemiol.* 2009;38:791-813. doi: 10.1093/ije/dyp139
- INTERSALT Cooperative Group. INTERSALT: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. *BMJ.* 1988;297:319-28. doi: 10.1136/bmj.297.6644.319
- Anderson CA, Appel LJ, Okuda N, Brown IJ, Chan Q, Zhao L et al. Dietary sources of sodium in China, Japan, the United Kingdom, and the United States, women and men aged 40 to 59 years: the INTERMAP study. *J Am Diet Assoc.* 2010;110:736-45. doi: 10.1016/j.jada.2010.02.007
- He FJ, Marciniak M, Visagie E, Markandu ND, Anand V, Dalton RN, MacGregor GA. Effect of modest salt reduction on blood pressure, urinary albumin, and pulse wave velocity in white, black, and Asian mild hypertensives. *Hypertension.* 2009;54:482-8. doi: 10.1161/HYPERTENSIONAHA.109.133223
- Klaus D, Hoyer J, Middeke M. Salt restriction for the prevention of cardiovascular disease. *Dtsch Arztebl Int.* 2010;107:457-62.
- He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. *J Hum Hypertens.* 2002;16:761-70. doi: 10.1038/sj.jhh.1001459
- Strazzullo P, D'Elia L, Kandala NB, Cappuccio FP. Salt intake, stroke, and cardiovascular disease: meta-analysis of prospective studies. *BMJ.* 2009;339:b4567. doi: 10.1136/bmj.b4567
- He FJ, MacGregor GA. Effect of longer-term modest salt reduction on blood pressure. *Cochrane Database Syst Rev.* 2004:CD004937.
- Gidding SS, Dennison BA, Birch LL, Daniels SR, Gillman MW, Lichtenstein AH, Rattay KT, Steinberger J, Stettler N, Van Horn L. Dietary recommendations for children and adolescents: a guide for practitioners: consensus statement from the American Heart Association. *Circulation.* 2005;112:2061-75. doi: 10.1161/CIRCULATIONAHA.105.169251
- Brewster L, Bohte E, van Montfrans G. Systematic Review of the use of spot and overnight urine for assessment of sodium excretion: 5D. 05. *J Hyperten.* 2010;28:e230. doi: 10.1097/01.hjh.0000378892.59718.c0
- World Health Organization. Strategies to monitor and evaluate population sodium consumption and sources of sodium in the diet: report of a joint technical meeting convened by WHO and the Government of Canada [Internet]. 2010 [cited 2012/4/26]; Available from: http://whqlibdoc.who.int/publications/2011/9789241501699_eng.pdf.
- Hawkes C, Webster J. National approaches to monitoring population salt intake: a trade-off between accuracy and practicality? *PLoS One.* 2012;7:e46727. doi: 10.1371/journal.pone.0046727
- Mann SJ, Gerber LM. Estimation of 24-hour sodium excretion from spot urine samples. *J Clin Hypertens (Greenwich).* 2010;12:174-80. doi: 10.1111/j.1751-7176.2009.00241.x
- Elliott P, Brown IJ. Sodium intakes around the world. Background document prepared for the Forum and Technical meeting on Reducing Salt Intake in Populations (Paris 5-7th October 2006). Geneva Switzerland: WHO Press; 2007.
- National Centre for Social Research. A survey of 24 hour and spot urinary sodium and potassium excretion in a representative sample of the Scottish population 2007 [cited 2012/12/7]; Available from: <http://www.food.gov.uk/multi-media/pdfs/scotlandsodiumreport.pdf>.

22. Sasaki S, Yanagibori R, Amano K. Validity of a self-administered diet history questionnaire for assessment of sodium and potassium: comparison with single 24-hour urinary excretion. *Jpn Circ J*. 1998;62:431-5. doi: 10.1253/jcj.62.431
23. Espeland MA, Kumanyika S, Wilson AC, Reboussin DM, Easter L, Self M, Robertson J, Brown WM, McFarlane M. Statistical issues in analyzing 24-hour dietary recall and 24-hour urine collection data for sodium and potassium intakes. *Am J Epidemiol*. 2001;153:996-1006. doi: 10.1093/aje/153.10.996
24. Dans A, Ng N, Varghese C, Tai ES, Firestone R, Bonita R. The rise of chronic non-communicable diseases in southeast Asia: time for action. *Lancet*. 2011;377:680-9. doi: 10.1016/S0140-6736(10)61506-1
25. Gorber SC, Tremblay M, Moher D, Gorber B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review. *Obes Rev*. 2007;8:307-26. doi: 10.1111/j.1467-789X.2007.00347.x
26. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health*. 1998;52:377-84. doi: 10.1136/jech.52.6.377
27. Mustafa A, Muslimatun S, Untoro J, Lan MC, Kristianto Y. Determination of discretionary salt intake in an iodine deficient area of East Java-Indonesia using three different methods. *Asia Pac J Clin Nutr*. 2006;15:362-7.
28. Health Promotion Board. HPB declares war on salt: Singapore residents exceed daily recommended salt consumption by 60% 2011 [cited 2012/4]; Available from: http://www.news.gov.sg/public/sppc/en/media_releases/agencies/hpb/press_release/P-20111003-1/AttachmentPar/0/file/Salt%20and%20FINEST%20Press%20release%20%28FINAL%29.pdf
29. Lee HP, Ong CN, Chia CB. An estimation of sodium chloride intake by adults in Singapore. *Singapore Med J*. 1983;24:346-9.
30. Whittow GC. Renal excretion of water and salt by healthy people in Singapore. *Med J Malaya*. 1956;11:126-33.
31. Wijayanti E, Muis SF. Sodium intake from foods and snacks and blood pressure of elementary students: Study at SDN Petompon 06. [dissertation]: Diponegoro University, Semarang; 2010.
32. Leelajaratkoon W, Pavadhgul P, Temcharoen P, Sawaddiworn S. Sodium consumption behavior and related factors among preschool children in Well Child Clinic. The 2nd International Conference on Humanities and Social Sciences, Faculty of Liberal Arts, Prince of Songkla University. 2010. [cited 2012/06/20]; Available from: <http://www.libarts-conference.psu.ac.th/proceedings/Proceedings2/article/8pdf/002.pdf>
33. Klunklin S, Channoonmuang K. Snack consumption in normal and undernourished preschool children in Northeastern Thailand. *J Med Assoc Thai*. 2006;89:706-13.
34. United States Interdepartmental Committee on Nutrition for National Defense. The Kingdom of Thailand: Nutrition survey, October-December 1960: a report. Bethesda, Md: National Institutes of Health; 1962.
35. Kamso S, Rumawas JS, Lukito W, Purwastyastuti. Determinants of blood pressure among Indonesian elderly individuals who are of normal and over-weight: a cross sectional study in an urban population. *Asia Pac J Clin Nutr*. 2007;16:546-53.
36. Villavieja G, Cerdana C, Molano W, Luna R, Boquecasa J, Raymundo B, et al. Fourth National Nutrition Survey, Philippines, 1993 Part A Food Consumption Survey. *Philippine Journal of Nutrition*. 1997;44:1-28.
37. Capanzana MV. Salt Consumption in the Philippines: results from the National Nutrition Survey [presentation slides]. Manila, Philippines; 2010.
38. Khor GL, Hsu Hage BH, Wahlqvist ML. Dietary practices in nutritional transition: The case of Malaysian urban Chinese. *Ecol Food Nutr*. 1998;36:463-89. doi: 10.1080/03670244.1998.9991532
39. Lee NR. Estimating the effects of overweight duration, sodium intake and genetic variants on hypertension risk among Filipino women in Cebu, Philippines [dissertation]: The University of North Carolina at Chapel Hill; 2009.
40. Pavadhgul P, Sunthonwaraluk S, Srisorachatr S, Temcharoen P. Dietary sodium intake by semi-quantitative food frequency questionnaire among undergraduate students of Mahidol University. *J Med Assoc Thai*. 2009;92(Suppl 7):S75-82.
41. Williamson C. Synthesis report no. 2: The different uses of food composition databases. [cited 2012/10]. Available from: http://www.eurofir.net/sites/default/files/EuroFIR%20synthesis%20reports/Synthesis%20Report%202_The%20different%20uses%20of%20food%20composition%20database.s.pdf
42. Duong DN, Ryan R, Vo DT, Tran TT. Hypertension screening and cardiovascular risk profiling in Vietnam. *Nurs Health Sci*. 2003;5:269-73. doi: 10.1046/j.1442-2018.2003.00160.x
43. Health Promotion Board, Singapore. Report of the National Nutrition Survey 2004. 2004 [cited 2011/6/20]. Available from: http://www.hpb.gov.sg/data/hpb.home/files/whp/health_fac/resources/NNS%20Report_Final%28Merged%29.pdf
44. Ministry of Health Singapore. National Nutrition Survey 1998. 1998 [cited 2012/6/20]. Available from: http://www.hpb.gov.sg/data/hpb.home/files/whp/health_fac/resources/national%20nutrition%201998.pdf
45. Ministry of Health (MOH) Singapore. Food Consumption Study 1993. Singapore: Food and Nutrition Department, Ministry of Health; 1994.
46. World Action on Salt and Health (WASH). Malaysia and Singapore: salt action summary. 2011. [cited 2012/06/20]; Available from: <http://www.worldactiononsalt.com/worldaction/asia/53960.html>
47. Health Promotion Board. Healthier hawker centre business model catches on as Marine Parade stallowners switch to healthier oil and salt. 2012 [2012/4/2]; Available from: http://www.hpb.gov.sg/HOPPortal/content/conn/HOPUCM/path/Contribution%20Folders/uploadedFiles/HPB_Online/News_and_Events/News/2012/Healthier_Hawker_Marine_Terrace.pdf
48. Health Promotion Board. Healthier restaurant programme. 2012 [cited 2012/06/20]; Available from: <http://www.hpb.gov.sg/HOPPortal/programmes-article/2876>
49. Health Promotion Board. Healthy eating in school programme. 2012 [cited 2012/06/20]; Available from: <http://www.hpb.gov.sg/HOPPortal/health-article/2818>
50. Food and Beverage Reporter. Indonesia eyes salt, sugar and fat limits. 2012 [cited 2012/06/20]; Available from: http://www.fbreporter.com/index.php?option=com_content&view=article&id=26134:indonesia-eyes-salt-sugar-and-fat-limits&catid=1044:news-update-29-august-2012
51. World Health Organization. Creating an enabling environment for population-based salt reduction strategies: report of a joint technical meeting convened by WHO and the Food Standards Agency, United Kingdom July 2010. 2010 [cited 2012/06/20]; Available from: http://whqlibdoc.who.int/publications/2010/9789241500777_eng.pdf

52. Webster JL, Dunford EK, Hawkes C, Neal BC. Salt reduction initiatives around the world. *J Hypertens*. 2011; 29:1043-50. doi: 10.1097/HJH.0b013e328345ed83
53. Plummer M, Clayton D. Measurement error in dietary assessment: an investigation using covariance structure models. Part I. *Stat Med*. 1993;12:925-35. doi: 10.1002/sim.4780121004
54. Prentice RL. Dietary assessment and the reliability of nutritional epidemiology research reports. *J Natl Cancer Inst*. 2010;102:583-5. doi: 10.1093/jnci/djq100
55. Gan WY, Mohd NM, Zalilah MS, Hazizi AS. Differences in eating behaviours, dietary intake and body weight status between male and female Malaysian University students. *Malays J Nutr*. 2011;17:213-28.
56. Mirnalini K, Jr, Zalilah MS, Safiah MY, Tahir A, Siti Haslinda MD, Siti Rohana D, Khairul Zarina MY, Mohd Hasyami S, Normah H. Energy and Nutrient Intakes: Findings from the Malaysian Adult Nutrition Survey (MANS). *Malays J Nutr*. 2008;14:1-24.
57. Saiwongse N. Thailand salt reduction policy 2010. 2010 [cited 2012/6/30]; Available from: <http://nutrition.anamai.moph.go.th/temp/who/files/2.pdf>.
58. Kwanmaung K. Glomerular filtration rate, urine sodium and potassium excretion during the day and night in young and elderly subjects [dissertation]. Thailand: Mahidol University; 2001.
59. Cohen HW, Hailpern SM, Alderman MH. Sodium intake and mortality follow-up in the Third National Health and Nutrition Examination Survey (NHANES III). *J Gen Intern Med*. 2008;23:1297-302. doi: 10.1007/s11606-008-0645-6
60. National Centre for Social Research. An assessment of dietary sodium levels among adults (aged 19-64) in the UK general population in 2008, based on analysis of dietary sodium in 24-hour urine samples. 2008 [cited 2013/5/31]; Available from: <http://www.food.gov.uk/multimedia/pdfs/08sodiumreport.pdf>.
61. Ministry of Health Singapore. Epidemiology and Disease Control Department. National Health Survey 2010, Singapore. Singapore: Epidemiology and Disease Control Division, Ministry of Health; 2011.
62. Department of Health, Philippines. Monitoring System of the Salt Iodization Program in the Philippines. 2004 [cited 2012/8/12]; Available from: <http://home.doh.gov.ph/dm/dm81-04.pdf>.
63. Yang Q, Zhang Z, Kuklina EV, Fang J, Ayala C, Hong Y et al. Sodium intake and blood pressure among US children and adolescents. *Pediatrics*. 2012;130:611-9.
64. World Action on Salt and Health. How does salt affect children? 2012 [cited 2012/10/9]; Available from: <http://www.worldactiononsalt.com/salthealth/children/index.html>.
65. Food and Agriculture Foundation of the United Nations. Food-based Dietary Guidelines: Indonesia. Ministry of Health, Indonesia. 1995 [cited 2012/4/2]; Available from: <http://www.fao.org/ag/humannutrition/nutritioneducation/fbdg/49850/en/idn/>.
66. Indonesian Society of Hypertension. Healthy lifestyle, healthy blood pressure. 2012 [cited 2012/10/2]; Available from: http://www.inash.or.id/news_detail.html?id=42.
67. Ministry of Health Malaysia. Malaysian Dietary Guidelines. 2010 [cited 2012/10/9]; Available from: <http://www.moh.gov.my/images/gallery/Garispanduan/diet/introduction.pdf>.
68. Don R. National Nutrition Policy and Programs - Malaysia. Ministry of Health Malaysia Nutrition Division [presentation slides]. XI Asian Congress of Nutrition, Singapore: 2011.
69. Federation of Malaysian Consumers Association. Bernama - Take Control Of What You And Your Children Eat. 2009 [cited 2012/4/2]. Available from: <http://www.fomca.org.my/v3/index.php/fomca-in-the-news/2010-news/180-bernama-take-control-of-what-you-and-your-children-eat%20>.
70. Ariff MM. Parents: Watch Out For The Snacks, Junk Food. Bernamacom Malaysian National News Agency. 2009 [cited 2012/4/2]; Available from: <http://www.bernama.com/bernama/v3/printable.php?id=396327%20>.
71. National Nutrition Council. 10 Nutritional guidelines for Filipinos. 2012 [cited 2012/10/9]; Available from: http://www.nnc.gov.ph/index.php?option=com_k2&view=item&id=5:10-nutritional-guidelines-for-filipinos-mga-gabay-sa-wastong-nutrisyon-para-sa-pilipino&Itemid=1.
72. Department of Health, Republic of the Philippines. Lifestyle changes can help prevent hypertension – DOH, PSH. 2011 [cited 2012/4/2]; Available from: <http://www.nursedirectory.net/articles/lifestyle-change-can-help-prevent-hypertension/>.
73. Medical Observer. PSH calls for global action to promote lifestyle changes. 2011 [cited 2012/4/2]; Available from: <http://www.medobserver.com/article.php?ArticleID=454>.
74. Lee BL. Dietary guidelines in Singapore. *Asia Pac J Clin Nutr*. 2011;20:472-6.
75. Singapore Heart Foundation. Cardiac rehabilitation and heart wellness. 2012 [cited 2012/4/2]; Available from: <http://www.myheart.org.sg/article/cardiac-rehabilitation-and-heart-wellness/shf-isetan-foundation-heart-wellness-centre/about-us/27>.
76. USDA Global Agricultural Information Network. Thai FDA's new Guideline Daily Amounts (GDA) labeling. 2011 [cited 2012/6/17]; Available from: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Thai%20FDA%E2%80%99s%20New%20Guideline%20Daily%20Amounts%20%28GDA%29%20Labeling%20_Bangkok_Thailand_6-13-2011.pdf.
77. Hop le T, Van TK, Thanh HK. Food based dietary guidelines in Vietnam: progress and lessons learned. *Asia Pac J Clin Nutr*. 2011;20:495-9.
78. Centers for Disease Control and Prevention. Introduction to program evaluation for public health programs: A self-study guide. 2012 [cited 2013/3/13]; Available from: <http://www.cdc.gov/eval/guide/introduction/index.htm>.
79. Murray CJ, Lauer JA, Hutubessy RC, Niessen L, Tomijima N, Rodgers A, Lawes CM, Evans DB. Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. *Lancet*. 2003;361:717-25. doi: 10.1016/S0140-6736(03)12655-4
80. Wang G, Labarthe D. The cost-effectiveness of interventions designed to reduce sodium intake. *J Hypertens*. 2011;29:1693-9. doi: 10.1097/HJH.0b013e328349ba18
81. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. *N Engl J Med*. 2001;344:3-10. doi: 10.1056/NEJM200101043440101
82. Lawes CM, Rodgers A, Bennett DA, Parag V, Suh I, Ueshima H, MacMahon S. Blood pressure and cardiovascular disease in the Asia Pacific region. *J Hypertens*. 2003;21:707-16. doi: 10.1097/00004872-200304000-00013
83. Rashid A, Azizah A. Prevalence of hypertension among the elderly Malays living in rural Malaysia. *Australas Med J*. 2011;4:283-90. doi: 10.4066/AMJ.2011.660

84. Singh RB, Suh IL, Singh VP, Chaithiraphan S, Laothavorn P, Sy RG, et al. Hypertension and stroke in Asia: prevalence, control and strategies in developing countries for prevention. *J Hum Hypertens*. 2000;14:749-63. doi: 10.1038/sj.jhh.1001057
85. Kearney PM, Whelton M, Reynolds K, Whelton PK, He J. Worldwide prevalence of hypertension: a systematic review. *J Hypertens*. 2004;22:11-9. doi: 10.1097/00004872-200401000-00003
86. Van Minh H, Byass P, Chuc NTK, Wall S. Gender differences in prevalence and socioeconomic determinants of hypertension: findings from the WHO STEPs survey in a rural community of Vietnam. *J Human Hypertensi*. 2005;20:109-15. doi: 10.1038/sj.jhh.1001942
87. Ng N, Stenlund H, Bonita R, Hakimi M, Wall S, Weinehall L. Preventable risk factors for noncommunicable diseases in rural Indonesia: prevalence study using WHO STEPS approach. *Bull WHO*. 2006;84:305-13. doi: 10.2471/BLT.05.023721
88. Kenney WL. Dietary water and sodium requirements for active adults. *Sports Sci*. 2004;17:92.
89. Shimbo S, Zhang ZW, Miyake K, Watanabe T, Nakatsuka H, Matsuda-Inoguchi N, Moon CS, Higashikawa K, Ikeda M. Estimates of mineral intakes using food composition tables vs measures by inductively-coupled plasma mass spectrometry: Part 2: sodium, potassium, magnesium, copper, zinc. *Eur J Clin Nutr*. 1999;53:233-8. doi: 10.1038/sj.ejcn.1600709
90. Shimbo S, Moon CS, Zhang ZW, Watanabe T, Ismail NH, Ali RM, Noor I, Nakatsuka H, Ikeda M. Nutritional evaluation of working Malay women in Kuala Lumpur as studied by total food duplicate method. *Tohoku J Exp Med*. 1996;180:99-114. doi: 10.1620/tjem.180.99
91. Natera E, Trinidad T, Valdez D, Kawamura H, Palad L, Shiraishi K. Estimation of daily micronutrient intake of Filipinos. *Food Nutr Bull*. 2002;23:222-7.
92. Corpus VA, Azares F. Macrominerals and some micro-minerals in the average Filipino diet. Food and Nutrition Research Institute, Department of Science and Technology, Taguig, Philippines; 1988.
93. Graudal NA, Hubeck-Graudal T, Jurgens G. Effects of low sodium diet versus high sodium diet on blood pressure, renin, aldosterone, catecholamines, cholesterol, and triglyceride (Cochrane Review). *Am J Hypertens*. 2012;25:1-15. doi: 10.1038/ajh.2011.210
94. O'Donnell MJ, Yusuf S, Mente A, Gao P, Mann JF, Teo K, et al. Urinary sodium and potassium excretion and risk of cardiovascular events. *JAMA*. 2011;306:2229-38. doi: 10.1001/jama.2011.1729
95. Ekinci EI, Clarke S, Thomas MC, Moran JL, Cheong K, Maclsaac RJ, Jerums J. Dietary salt intake and mortality in patients with type 2 diabetes. *Diabetes Care*. 2011;34:703-9. doi: 10.2337/dc10-1723
96. Aburto NJ, Ziolkovska A, Hooper L, Elliott P, Cappuccio FP, Meerpohl JJ. Effect of lower sodium intake on health: systematic review and meta-analyses. *BMJ*. 2013;346:f1326. doi:10.1136/bmj.f1326.
97. Tikellis C, Pickering RJ, Tsorotes D, Huet O, Chin-Dusting J, Cooper ME, Thomas MC. Activation of the renin-angiotensin system mediates the effects of dietary salt intake on atherogenesis in the apolipoprotein E knockout mouse. *Hypertension*. 2012;60:98-105. doi: 10.1161/HYPERTENSIONAHA.112.191767
98. Alderman MH, Cohen HW. Dietary sodium intake and cardiovascular mortality: controversy resolved? *Curr Hypertens Rep*. 2012;14:193-201. doi: 10.1007/s11906-012-0275-6
99. IOM (Institute of Medicine). Sodium intake in populations: Assessment of evidence. Washington DC: The National Academies Press; 2013.
100. WHO. Guideline: Potassium intake for adults and children. Geneva: World Health Organization (WHO); 2012.
101. WHO. Guideline: Sodium intake for adults and children. Geneva: World Health Organization (WHO); 2012.

Review

Salt intakes and salt reduction initiatives in Southeast Asia: a review

Ada Portia M Batcagan-Abueg MD, MPH¹, Jeanette JM Lee MBBS¹, Pauline Chan MS², Salome A Rebello PhD¹, Maria Sofia V Amarra PhD²

¹Saw Swee Hock School of Public Health, National University of Singapore, Singapore

²International Life Sciences Institute Southeast Asia (ILSI SEA) Region, Singapore

回顧東南亞的鹽攝取量及減鹽行動

飲食鹽攝取量增加是心血管疾病一個可修飾危險因子。監測族群鈉攝取量是任何減鹽介入的重要部分。然而，東南亞地區評估鈉攝取的程度及方法目前並不清楚。此篇文章提供六個東南亞國家關於鈉攝取量的最佳可用證據的統整性描述：包括印尼、馬來西亞、菲律賓、新加坡、泰國及越南，並描述在這些國家進行的減鹽措施。篩選電子資料庫以確認至 2012 年 2 月 29 日的相關文章，還檢視參考文獻中所列的研究及研討會報告。諮詢營養及公共衛生背景的當地專家及研究學者。使用 Downs and Black 檢核表修訂版以評估研究品質。計 25 個研究符合納入標準而被描述於本篇回顧文章中。檢索出有全文的 19 個研究，包括政府報告，大部分的研究具有良好的品質。關於東南亞的鹽攝取量證據仍不足。飲食資料顯示，大部分的東南亞國家鹽攝取量超過世界衛生組織建議的每日 2 克。極需要使用 24 小時尿鈉排泄量當作黃金標準以評估鈉攝取量的研究。飲食鈉攝取量大部分是來自於外加鹽及醬汁。兒童的數據極有限。這六個國家著重於消費者教育的減鹽行動，各有不同的特異性及程度。

關鍵字：氯化鈉、飲食、營養政策、鈉攝取、鹽