Review

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

Ada Portia M Batcagan-Abueg MD, MPH[1], Jeanette JM Lee MBBS[1], Pauline Chan MS[2], Salome A Rebello PhD[1], Maria Sofia V Amarra PhD[2]

[1]*Saw Swee Hock School of Public Health, National University of Singapore, Singapore*
[2]*International 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
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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 Science, 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 ≥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 study [27] had total sodium intake data for both adults and children, 19 studies had data for adults only, and 3 studies [31-33] 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

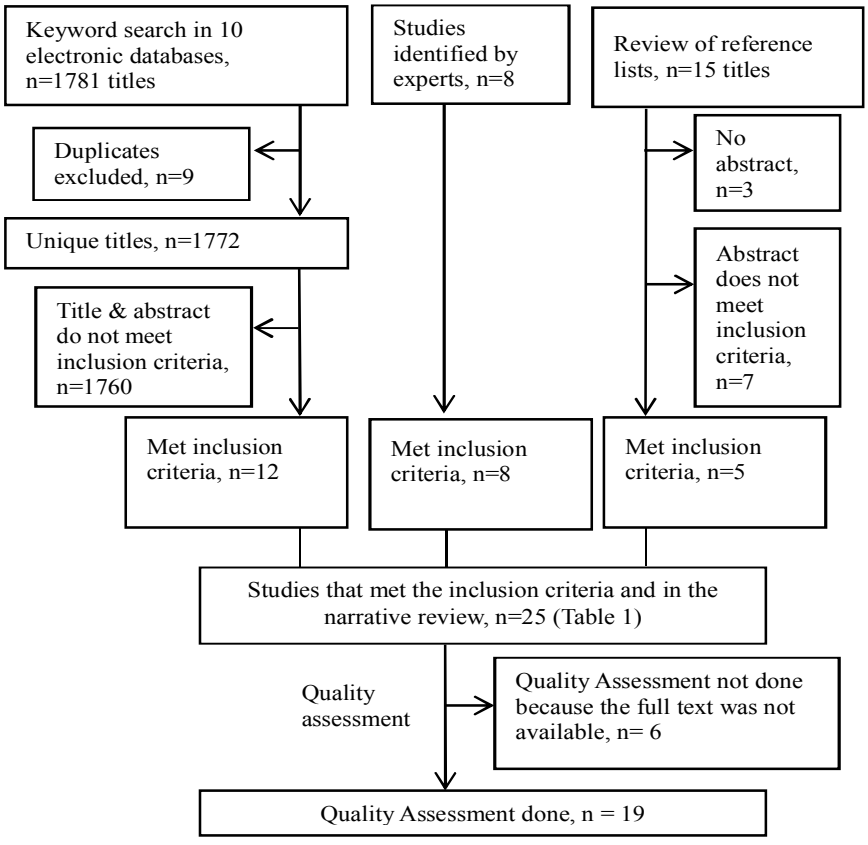

Figure 1. Process of inclusion of the studies for review and analysis

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	Kamso 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 multistage 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 2nd 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 232females	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 ±SD (g/day)			
		Age (yrs)	Males	Females	Both sexes
A. Adults					
Indonesia	Kamso S et al, 2007[35]	55-80	0.20±0.02†	0.16±0.01†	--
	Mustafa A et al, 2006[27]	--	--	2.28±0.67	--
Malaysia	Gan et al., 2011[55]	18-24	2.97±1.27	2.32±0.96	--
	Mirnalini K et al, 2008[56]	18-59	2.82±0.03	2.32±0.03	2.58±0.02
	Shimbo S et al, 1999[89]	33.2±6.9	--	F: 1.22±0.70 M: 1.28±0.60	--
	Shimbo S et al, 1996[90]	33.2±6.9	--	1.21±0.70	--
Philippines	Lee N, 2009[39]	35-68	--	2.90‡	--
	Natera E et al, 2002[91]	--	--	--	1.25±0.5
Singapore	Health Promotion Board, 2011[28]	18-79	3.78‡	2.80‡	3.26‡
	Ministry of Health, 1998[44]	18-69	3.58±0.05	3.06±0.4	3.53±0.03
	Ministry of Health, 1994[45]	18-69	3.94±0.13	3.05±0.09	3.50±0.08
	Lee HP et al, 1983[29]	>20	--	--	3.81±0.38
	Whittow GC, 1956[30]	18-27	--	--	3.52±0.14
Thailand	Saiwongse N, 2010[57]	--	--	--	4.25‡
	Pavadhgul P et.al, 2009[40]	17-20	5.22±2.23	4.50±2.09	4.85±2.18
	Kwanmaung K, 2001[58]	20-30	--	--	3.05±1.03
		60-81			3.30±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±0.83	--	--
Thailand	Leelajaratkoon W et al, 2010[32]	1-3	--	--	1.30±0.41
		4-5	--	--	1.45±0.52
	Klunklin S et al, 2006[33]	2-3	--	--	0.54±0.11
		4-6	--	--	0.58±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±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±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 infants[36] 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 implementation[78] 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*'s[93] 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, Ekinci *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 Cohen[98] 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 report[99] 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 intake[100] 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.

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Review

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

Ada Portia M Batcagan-Abueg MD, MPH[1], Jeanette JM Lee MBBS[1], Pauline Chan MS[2], Salome A Rebello PhD[1], Maria Sofia V Amarra PhD[2]

[1]*Saw Swee Hock School of Public Health, National University of Singapore, Singapore*
[2]*International 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