MALAYSIAN JOURNAL OF NUTRITION

VOL. 29 NO. 2 AUGUST 2023

PP18053/02/2013 (033331)

ISSN 1394-035X

9 771394 035008

Official Publication of the
PERSATUAN PEMAKANAN MALAYSIA
NUTRITION SOCIETY OF MALAYSIA

Malaysian Journal of Nutrition is abstracted/indexed by Google Scholar, the WHO Western Pacific Region Index Medicus, Elsevier databases of the Scopus, EBiology and Ecare, ASEAN Citation Index (ACI), CABI Global Health database and Asian Digital Library (ADL)

MALAYSIAN JOURNAL OF NUTRITION

Peer-reviewed Journal of the Nutrition Society of Malaysia

(http//www.nutriweb.org.my)

The Journal

- Serves as a forum for the sharing of research findings and information across broad areas in nutrition.
- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorials and letters to the editor.
- Welcomes articles in nutrition and related fields such as dietetics, food science, biotechnology, public health and anthropology.

Malaysian Journal of Nutrition
Vol. 29 No. 2, 2023

Contents

Mal J Nutr 29(2): 163-241, 2023

SPECIAL INVITED REVIEW

Review of recommended energy and nutrient intake values in Southeast Asian countries

E Siong Tee[1,2*], Rodolfo F Florentino[1,3], Nalinee Chongviriyaphan[1,4], Hardinsyah Ridwan[1,5], Mahenderan Appukutty [1,2] & Truong Tuyet Mai[1,6]

[1]*Southeast Asia Public Health Nutrition Network;* [2]*Nutrition Society of Malaysia;* [3]*Nutrition Foundation of the Philippines, Inc;* [4]*Nutrition Association of Thailand;* [5]*Food and Nutrition Society of Indonesia;* [6]*Vietnam Nutrition Association*

ABSTRACT

This review summarises the officially published recommended energy and nutrient intake values in five Southeast Asia (SEA) countries namely Indonesia, Malaysia, Philippines, Thailand and Vietnam. The background information, general approaches and references used for setting up recommendations and the recommended intakes levels for energy, protein, fat and carbohydrate, dietary fibre, sugars,14 vitamins and 15 minerals of these countries were tabulated and compared. The recommended intake values show remarkable similarities in terms of approaches and principles taken, as well as references used as the basis for the recommendations development and the application of the recommendations in respective country. There are nevertheless some differences in age groupings, reference height and weight used, as well as the final recommendations of the intake levels for some nutrients, after adjustment to suit local situations. All five countries had provided recommendations in terms of recommended nutrient intakes (RNI) or recommended dietary allowance (RDA) for almost all the nutrients. Due to the limited availability of local data and resources, countries in the region have referred to several references, including those from Food and Agriculture Organization/World Health Organization (FAO/WHO) consultation report and recommendations from research organisations in United States and Europe and adapted the values for local uses. Opportunities should be created to enable closer dialogue and collaboration regarding future developments in nutrient recommendations for populations in the region. These could include consideration of establishing more appropriate nutrient recommendations and the call for setting up harmonised approaches to establishing recommended nutrient intake values for the region.

Keywords: nutrients, recommended energy intake, recommended nutrient intakes, Southeast Asia

INTRODUCTION

The concept of recommended energy and nutrient intake values is widely used by many health authorities around the world. Many countries, including those in Southeast Asia (SEA), have established such recommended values for the populations of their respective

*Corresponding author: Dr Tee E Siong
Chairman
Southeast Asia Public Health Nutrition (SEA-PHN) Network
Email: president@nutriweb.org.my
doi: https://doi.org/10.31246/mjn-2023-29-2-rni-rda-sea-review

country. Such recommendations are important to determine whether the average person's intake of a particular nutrient is adequate. At the population level, these recommended values are also crucial in evaluating the dietary intakes of the population, to identify risk of inadequate nutrient intakes for certain groups, to help reduce the risk of chronic disease as well as for setting up nutrition requirements in nutritional guidelines. These recommendations are also used for planning nutritionally adequate diets for people receiving meals in various institutions and settings.

Countries in SEA have developed their respective national recommended energy and nutrient intake values independently over the years. Each country established its own expert working group within the Ministry of Health or research institution and developed its own national recommended intakes. Various approaches were used in developing these recommendations. These were published at different times over the past decades, for the use of a wide variety of activities related to food and nutrition. The Philippines had their first version of energy and nutrient recommendations 80 years ago.

To understand the status of recommended nutrient intakes in SEA countries, Tee (1998) conducted a review of the recommendations in six countries in the region, including the recommendations for energy, protein, three minerals (calcium, iron and iodine) and six vitamins (vitamin A, thiamin, riboflavin, folic acid, vitamin B_{12}, vitamin C). Tabulations for the recommendations for Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam as well as for World Health Organization (WHO) (1985) and Food and Agriculture Organization (FAO)/WHO (1988) and United States of America (National Research Council, 1989) were presented. The review noted that there were general similarities for the different recommended nutrient intakes, although in some cases a country lists an exceptionally high or low recommendation for particular nutrients for specific groups for specific reasons.

The first regional effort to provide a platform for discussion on recommended dietary allowances (RDAs) in SEA was by the International Life Sciences Institute Southeast Asia Region (ILSI SEA Region). A series of six workshops and one working group meeting was organised between 1997 and 2003, participated by country representatives from Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam, as well as other international and regional nutrition experts and regulators. As a result of these meetings, a harmonised set of RDAs was published in 2005 (Tee & Florentino, 2005). The monograph documents the process of developing and establishing the harmonised RDAs and papers on 14 selected core nutrients prepared by several country representatives. This monograph was to serve as a working document and reference for countries in the region that are formulating or revising their national RDAs.

Recognising the importance of providing a regional perspective of such nutritional recommendations, Southeast Asia Public Health Nutrition (SEA-PHN) Network compiled, reviewed and analysed the official recommendations of five SEA countries who are members of the Network. This publication is an output of this work. It aims to provide an overview of the availability of nutrient recommendations in SEA countries and the approaches and scientific principles undertaken by countries to formulate their own national energy and nutrient recommendations. Additionally, this paper provides an understanding of the similarities and differences of the recommendations among the countries.

The paper also discusses future work on recommended nutrient intakes in the region, including opportunities for collaboration.

METHODS

The official documents of recommended energy and nutrient intake values currently in use in five countries (Indonesia, Malaysia, Philippines, Thailand, Vietnam) were obtained for this review, namely: Regulation of the Ministry of the Republic of Indonesia Number 28 of 2019 Concerning the Nutritional Adequacy Values for Indonesian Population (MOH Indonesia, 2019), Recommended Nutrient Intakes (RNI) for Malaysia (NCCFN, 2017), Philippine Dietary Reference Intakes (PDRI) 2015 (DOST-FNRI, 2017), Dietary Reference Intakes (DRI) for Thais 2020 (MOPH Thailand, 2020), and Nutritional Requirements Recommendations for Vietnamese People (NIN Vietnam, 2016). Several key aspects of these documents were extracted and analysed. These include background of the development of the recommended energy and nutrient intake values in the respective countries, nomenclature used, age-categories and reference weight used, coverage of nutrients, uses of these recommended intake values in each country, and sources of recommended intakes, general principles and approach for setting recommended intakes. The recommendations for energy and all nutrients (macronutrients, vitamins and minerals) were also tabulated according to age and compared for the different countries. Findings from this review are presented based on the key aspects listed above.

RESULTS

Development of recommended energy and nutrient intake values in SEA

The five sets of recommended energy and nutrient intake values have widely differing years of initial establishment, most of which were first introduced in the late 1980s or early 1990s. The oldest is the Philippine's DRIs which was introduced in 1941.

In Malaysia, the first published recommended daily dietary intake was by Teoh (1975) in a simple publication in a medical journal. After close to three decades, a multi-institution Technical Working Group (TWG) on Nutritional Guidelines was established under the National Coordinating Committee on Food and Nutrition (NCCFN), Ministry of Health Malaysia to review this first set of recommendations. A multi-chapter comprehensive 207-page monograph of Recommended Nutrient Intakes (RNI) was published in 2005 (NCCFN 2005). With the developments of scientific knowledge and driven by the deteriorating health status of the population, the RNI was further revised, and an updated Malaysian RNI 2017 was published (NCCFN, 2017). The RNI review process involved writers from multi-institutions including representatives from Ministry of Health, academia, research institutes and professional organisations.

In Indonesia, the first RDAs for Indonesians was formulated at the first National Workshop on Food and Nutrition (*Widyakarya Nasional Pangan dan Gizi,* WNPG) in 1968 and since then has been reviewed and revised every 5 to 10 years. The RDAs were formulated by food, nutrition and health experts from reputable universities, led by the Ministry of Health and the Indonesian Institute of Sciences through the National Workshop on Food and Nutrition. The current version was established based on consultations in the XI National Workshop on Food and Nutrition in 2018 and released as a Ministry of Health decree in 2019. This legal document is known as the

Regulation of the Minister of Health Concerning the Nutritional Adequacy Values for Indonesian Population (MOH Indonesia, 2019).

Recommended energy and nutrient intakes were first developed in the Philippines in 1941. These recommendations have undergone several revisions and expansions in 1953, 1960, 1965, 1970, 1989, and 2002 (Barba & Cabrera, 2008). These revisions were all undertaken by the research agency of the government, now known as the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST). The current version is the PDRI 2015. This edition took on a new nomenclature of dietary reference intakes, to reflect up-to-date concepts on dietary standard-setting and expanding applications. The establishment of this set of DRI went through a comprehensive consultation process led by the PDRI 2015 committee headed by FNRI-DOST, which composed of experts from various disciplines in the field of nutrition research and education (DOST-FNRI, 2017).

In Thailand, the DRI for Thai was first published in 1973. Revised versions were published in 1989, 2003, and 2020. The current 4th edition of DRI 2020 was compiled and developed by a national committee made up of experts specialised in nutrition from multiple institutions including nutritionists, dietitians, clinicians, researchers, and healthcare personnel working in nutrition-related areas. The national committee was led by the Ministry of Public Health, which was responsible for coordinating the contributions among the DRI Technical committee (MOPH Thailand, 2020).

The Vietnamese RDAs was first developed in 1996 by an expert group from the National Institute of Nutrition, following the adoption of the National Plan of Action for Nutrition by the prime minister. Prior to this, Vietnam had only provisional RDAs based on a few international references on nutritional needs. The Vietnamese RDAs 1996 was reprinted in 2003 and later revised in 2007, and in 2015 to provide updates for the recommended nutritional needs that are appropriate for Vietnamese as well as serve as the basis for the National Nutrition Strategy. The revision and formulation of Vietnam's Recommended Nutrition Needs Table was led by the Scientific Council of the Ministry of Health (NIN Vietnam, 2016).

Main components and formats of documents

Most of the sets of recommended energy and nutrient intakes of these countries (Malaysia, Philippines, Thailand and Vietnam) were published as monographs and shared similar structure and organisation of information. These publications generally start with an introduction to the evolution or the concept of the nutrient recommendations in the country, followed by a description of reference height and weight used and the usage of the publication. This is followed by individual chapters or sections describing each nutrient in detail. Information provided for each nutrient includes principles in setting the recommended intakes and summary tables for recommended values for different age groups.

Different from other countries, the Indonesian document was officially released as a Ministry of Health regulation. Much of the background information mentioned above for other countries are not provided in this regulatory document. Nevertheless, appendices in the regulation tabulate the nutritional adequacy values recommended for energy and various nutrients for different age groups, similar to those contained in the monographs of the other four countries.

Nomenclature and definitions used for nutrient recommendations

The publications from the five countries used different terms for the main set of nutrient recommendations published: Nutritional Adequacy Values for the Indonesian Population, Recommended Nutrient Intakes for Malaysia, Philippines Dietary Reference Intakes, Dietary Reference Intake for Thais, and Nutritional Requirements Recommendations for Vietnamese People.

The definitions of the terms used for the associated reference values are shown in Table 1. It can be noted that definitions for the five main values used in the documents of all the countries except for Indonesia are conceptually similar: RNI, RDA, estimated average requirement (EAR), adequate intake (AI) and tolerable upper intake level (UL). In addition to these, the Philippines also included the concept of acceptable macronutrient distribution range (AMDR). At the same time, Vietnam also included the concept of dietary goals (DG), which is the recommended intake levels that the diet should achieve in order to ensure additional health benefits and prevent certain diseases.

Population groups covered and age-categories used

The different national recommended energy and nutrient intake values covered all ages in the entire life cycle, but countries had adopted different age groupings (Table 2). For the infant category, all countries presented energy and nutrient requirements in two separate groups, i.e. 0-5 months and 6-11 months. However, Malaysia's recommended energy requirement for infants were given in four equal age groups of two months each.

The age groupings adopted for children onwards differ widely among countries (Table 2). Malaysia and Indonesia used similar age groupings (1-3, 4-6 and 7-9 years) for children, while the Philippines (1-2, 3-5, and 6-9 years), Thailand (1-3, 4-5, 6-8 years) and Vietnam (1-2, 3-5, 6-7, 8-9 years) adopted different age groupings. In terms of adolescents, most countries used a range from 9 to 18 years old. While Indonesia, Philippines, and Thailand referred to adults as 19 years and above, Malaysia and Vietnam used 18 years old and 20 years old respectively as cut-offs for adults.

There are differences in the way countries categorise nutrient intake recommendations for the elderly group or older adults (Table 2). Except for Vietnam, the other countries further separate the elderly group into two subgroups: 65-80 and >80 years for Indonesia; 60-65 and >65 years for Malaysia; 60-69 and ≥70 years for Philippines; and 61-70 and ≥71 years for Thailand. For Vietnam, recommendations are given for older adults ≥70 years.

Pregnancy and lactation were categorised separately by all the countries. For pregnancy, recommendations were provided for the three trimesters, whereas requirements for lactation were provided for the first and second six months of lactation.

Reference weight and height used

Several countries (Malaysia, Philippines, Thailand, Vietnam) referred to the WHO child growth standard (WHO, 2006) and WHO growth reference (WHO, 2007) respectively for the reference weight of children (below 5 years) and children and adolescents (5-19 years). For adults, countries used median (Malaysia, Philippines) or average height (Vietnam) data obtained from national nutrition surveys [i.e. Malaysia's

Table 1. Nomenclature and definitions used for nutrient recommendations

Terminology used	*Definition*
Recommended Dietary Allowances for Indonesian 2019	A value that indicates the average need for certain nutrient that must be met every day for almost all people with certain characteristics which include age, sex, level of physical activity, and physiological conditions, to live healthy.
Recommended energy intake (REI)	The recommended daily energy intake for energy, set at estimated average requirement (EAR), which meets the nutrient requirement of almost all apparently healthy individuals in an age, sex, level of physical activity, and physiological conditions, to live healthy.
Recommended nutrient intake (RNI)	The recommended daily nutrient intake for certain nutrient, set at estimated average requirement (EAR) plus 2 standard deviations (SD), which meets the nutrient requirement of almost all apparently healthy individuals in an age, sex, level of physical activity, and physiological conditions, to live healthy.
Recommended Nutrient Intakes for Malaysia 2017	
Recommended nutrient intake (RNI)	The daily intake, set at estimated average requirement (EAR) plus 2 standard deviations (SD), which meets the nutrient requirement of almost all apparently healthy individuals in an age- and sex-specific population group.
Estimated average requirement (EAR)	Median intake value that is estimated to meet the requirement, as defined by specified indicator of adequacy, in half of the individuals in a life-stage or sex group.
Adequate intake (AI)	Derived when there is no sufficient scientific evidence to established an EAR and set a RNI, based on experimentally derived intake levels or approximations of observed mean nutrient intakes by groups of healthy people who are maintaining a defined nutritional state.
Tolerable upper intake level (UL)	The highest level of continuing daily nutrient intake that is likely to pose no risk of adverse health effects in almost all individuals in the specified life stage group.

Table 1. Nomenclature and definitions used for nutrient recommendations *(continued)*

Terminology used	*Definition*
Philippines Dietary Reference Intakes 2015	Collective term comprising the set of multi-level reference values for energy and nutrients.
Recommended energy and nutrient intake (RENI)	Specific term describing the intake level needed to meet the requirements of nearly all of the healthy population of individuals.
Estimated average requirement (EAR)	Average intake level estimated to meet the nutrient requirement of half of the healthy individuals in a particular life stage and sex group.
Adequate intake (AI)	Daily nutrient intake level that is based on observed or experimentally-determined approximation of the average nutrient intake or of a group (or groups) of apparently healthy people.
Tolerable upper level of intake (UL)	Highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population.
Acceptable macronurient distribution range (AMDR)	Range of intakes for a particular energy source (carbohydrate, protein, fat) that is associated with a reduced risk of chronic diseases while providing adequate intakes of essential nutrients.
Dietary Reference Intake for Thais 2020	
Recommended dietary allowances (RDAs)	Daily average intakes of nutrients required for almost all healthy people (97-98%) according to gender, age, and/or physiological conditions.
Estimated average requirement (EAR)	Lowest amount of a nutrient to maintain normal nutritional status in a healthy person. It is expected to satisfy the needs of 50% of people who are healthy according to age and gender.
Adequate intake (AI)	For nutrients that have no data of EAR, AI is used when experts have confidence that there is sufficient data for basic requirement of such nutrients; and additional studies are necessary to determine EAR and RDA.
Tolerable upper intake levels (ULs)	ULs are the highest amount of nutrients consumed daily without any risk of detrimental effects in general population.

Table 1. Nomenclature and definitions used for nutrient recommendations *(continued)*

Terminology used	*Definition*
Nutritional Requirements Recommendations for Vietnamese People 2015	
'Recommended Dietary Allowances (RDAs)	Energy and nutrients need that, on the basis of current scientific knowledge, are considered adequate to maintain health and well-being of all normal individuals in a population.
Estimated average requirement (EARs)	The estimated average need represents the average of the nutritional needs that an average group of people by age and sex to maintain in good nutritional status.
Adequate intake (AI)	Average recommended daily intake is believed to be adequate for one or more healthy groups of people based on estimates. observation or experiment, where the RDA cannot be determined.
Dietary goal (DG)	Sufficient scientific evidence to recommend the level of consumption that the diet should achieve to ensure additional health benefits and fight related diseases.

National Health and Morbidity Survey (NHMS) 2015 (IPH, 2015); the 8^{th} National Nutrition Survey (NNS) of Philippines (FNRI-DOST, 2015); Vietnam's National Nutrition Survey 2010] to derive the reference weight based on body mass index (BMI) of 22kg/m^2. The local datasets were also used to derive reference height for the various age categories in Malaysia and Philippines.

Coverage of nutrients

The nutrients included in each of the country's recommended energy and nutrient intakes are shown in Table 3. Indonesia RDAs provide recommendations for a total of 34 nutrients. For Malaysia, recommendations are given for a total of 30 nutrients. A total of 26, 39 and 32 nutrients are listed in Philippines DRI, Thai DRIs and Vietnamese RDAs, respectively. The key nutrients covered in the recommended energy and nutrient intakes of these countries are similar, including energy, carbohydrate, fat, protein, fat-soluble vitamins, water-soluble vitamins, macro minerals calcium, phosphorus, magnesium, trace minerals iron, zinc, iodine, selenium, fluoride, and electrolytes sodium, potassium and chloride.

Thailand also provided recommendations for several other bioactive food components such as polyphenols, lutein, zeaxanthin and isoflavones. There is little or no discussion on recommendations for these non-nutrients in the recommendations of the other four countries.

Uses and applications

The recommended energy and nutrient intakes in the five SEA countries were intended to be used by a wide range of stakeholders including policymakers, food industry, academia and researchers, nutrition and clinical practitioners. In terms of policymaking,

Table 2. Characteristics of age groupings in official documents of recommended energy and nutrient intake values of SEA countries

Country	*Age groupings*				
	Infants	*Children*	*Adolescents*	*Adults*	*Elderly (Older adults)*
Indonesia	0-5months, 6-11months	1-3 years, 4-6 years, 7-9 years	10-12 years, 13-15 years, 16-18 years	19-29 years, 30-49 years, 50-64 years	65-80 years 80+ years
Malaysia	0-5months, 6-11months	1-3 years, 4-6 years, 7-9 years	For energy and protein: 10-12 years, 13-15 years, 16-<18 years	19-29 years, 30-50 years, 51-59 years	60-65 years >65 years
	For energy: 0-2 months, 3-5 months, 6-8 months, 9-11 months For phosphorus, sodium, potassium, magnesium, chromium, copper, manganese, molybdenum, fluoride: 0-6months 7-12months	For phosphorus, sodium, potassium, magnesium, chromium, copper, manganese, molybdenum, fluoride: 1-3 years 4-8 years	For thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, folate, cobalamin, vitamin C, vitamin A, vitamin D, vitamin E, vitamin K, calcium, iodine, selenium, zinc and iron: 10-12 years, 13-14 years, 15 years, 16-18 years For phosphorus, sodium, potassium, magnesium, chromium, copper, manganese, molybdenum, fluoride: 9-13 years, 14-18 years	For energy and protein: ≥18-29 years, 30-59 years, ≥60 years For total fat: 19-29 years 30-59 years	For phosphorus, sodium, potassium, magnesium, chromium, copper, manganese, molybdenum, fluoride: 60-69 years >70years
Philippines	0-5months, 6-11months	1-2 years, 3-5 years, 6-9 years	10-12 years, 13-15 years, 16-18 years	19-29 years, 30-49 years, 50-59 years	60-69 years ≥70 years
Thailand	0-5months, 6-11months	1-3 years, 4-5 years, 6-8 years	9-12 years, 13-15 years, 16-18 years	19-30 years, 31-50 years, 51-60 years	61-70 years ≥71 years
Vietnam	0-5months, 6-11months	1-2 years, 3-5 years, 6-7 years, 8-9 years	10-11 years, 12-14 years, 15-19 years	20-29 years, 30-49 years, 50-69 years	≥70 years

Table 3. Energy and nutrients listed in the recommended intake values of SEA countries

Nutrients	*Covered in the recommendations*				
	Indonesia	*Malaysia*	*Philippines*	*Thailand*	*Vietnam*
Energy	x	x	x	x	x
Macronutrients					
Carbohydrate	x	x	x	x	x
Protein	x	x	x	x	x
Fats	x	x	x	x	x
Dietary fibre	x	x	x	x	x
Water	x		x		
Vitamins					
Thiamin (Vitamin B1)	x	x	x	x	x
Riboflavin (Vitamin B2)	x	x	x	x	x
Niacin (Vitamin B3)	x	x	x	x	x
Pyridoxine (Vitamin B6)	x	x	x	x	x
Folate (Vitamin B9)	x	x	x	x	x
Cobalamin (Vitamin B12)	x	x	x	x	x
Ascorbic Acid (Vitamin C)	x	x	x	x	x
Vitamin A	x	x	x	x	x
Vitamin D	x	x	x	x	x
Vitamin E	x	x	x	x	x
Vitamin K	x	x	x	x	x
Pantothenic Acid (Vitamin B5)	x	x		x	x
Biotin	x			x	x
Choline	x			x	x
Minerals					
Calcium	x	x	x	x	x
Iron	x	x	x	x	x
Iodine	x	x	x	x	x
Zinc	x	x	x	x	x
Selenium	x	x	x	x	x
Phosphorus	x	x	x	x	x
Sodium	x	x	x	x	x
Potassium	x	x	x	x	x
Magnesium	x	x	x	x	x
Chromium	x	x		x	x
Copper	x	x		x	x
Manganese	x	x		x	x
Fluoride	x	x	x		x
Chloride	x		x	x	x
Molybdenum		x		x	

these recommendations were to serve as the blueprint for the development of several national guidelines including dietary and nutrition guidelines, the nutrition action plan, a food balance sheet and also a food production plan to ensure national and local food security. The recommended energy and nutrient intake values were also indicated to be used for the assessment and evaluation of the population's dietary intakes, to ensure nutrient adequacy and to identify the risk of inadequate or potentially excessive usual intakes of a group or population in the country. These recommended values also played important roles in the food industry of these countries as they served as the reference for nutrition labelling and claims, and the development of food products that serve the nutritional requirements for consumer health. Other common applications include being used as educational materials by academia, and as a scientific reference for research involving nutritional needs assessment, food and meal formulation, nutrition interventions, and dietary analysis. Indonesia's DRI has also been used to determine the poverty line and minimum wage for the population. In Vietnam, the RDAs were adopted by an inter-ministerial scientific council as an official document for healthcare and nutrition programmes.

General approach/principles used in setting the recommended values

For the five countries in this review, the general principle for developing national recommendations for energy and nutrients were mainly based on recommendations of several international and renowned research organisations. Table 4 indicates for each of the nutrients the main organisation and reference(s) cited or adapted by each of the countries. The most frequently cited references were publications from WHO/FAO, Food and Nutrition Board of Institutes of Medicine (FNB-IOM) (IOM 1997, 1998, 2000, 2005a, 2018) and European Food Safety Authority (EFSA). Vietnam also referred extensively to the DRI for Japanese 2015 and report by the ILSI SEA region publication on the harmonisation of RDAs in SEA (Tee & Florentino, 2005). Some countries also refer to nutritional requirement documents of neighbouring countries. The outputs of nutrition surveys and related research such as local studies on dietary patterns and diet quality were also being considered and used as background information in setting up the requirements.

For energy requirements, while most countries (Malaysia, Philippines, Vietnam) referred to FAO/WHO/United Nations Organization (UNO) (2004) and IOM (2005a) reports for their recommendation, the data from local studies and national nutrition surveys, i.e. weight, height, physical activity levels were used to derive basal metabolic rate (BMR). In Malaysia's RNI, local median height data from the National Health and Morbidity Surveys (NHMS) (IPH, 2015) were used and BMR for adolescents (13-18 years old) and adults (19-59 years old) were derived from local studies (Ismail *et al.*, 1998; Poh *et al.*, 2004). In Philippines, reference weights from the 8^{th} NNS (FNRI-DOST, 2015) to achieve a BMI of $22 kg/m^2$ was used for BMR calculation. The recommended energy requirements for Vietnamese people by age, sex, type of labour and physiological status were adjusted based on average weight and height, current practices of Vietnamese adults according to the National Nutrition Survey 2010.

The physical activity levels (PAL) of the populations were also being considered in setting the recommendations. Indonesia used PAL 1.1 for children up to the age of 1 year, 1.14 for children 1-3 years, 1.26 for children and adults 4-64 years, and 1.12 for the elderly. For Malaysia RNI 2017 (NCCFN, 2017), energy recommendations for infants were calculated by adding the energy deposited in growing tissues to total energy expenditure (TEE). For the general population, for children 1-6 years PAL 1.4 was recommended for use, whereas for children aged 7 years and above, PAL of 1.6 (i.e. moderately active) was recommended. For individuals, energy recommendation were to be based

Table 4. Main references used for setting recommended intakes of by nutrients and country

Nutrients	*Main references used for recommendations*
Energy	Indonesia: Based on estimated BMR by oxford equation, median healthy body weight of Indonesian based on age and sex groups, physical activity level. Recommendations for pregnant and lactating women are based on IOM (2005a).
	Malaysia: FAO/WHO/UNO (2004); physical activity level values from EFSA (2013a)
	Philippines: IOM (2005a)
	Vietnam: WHO (1985), FAO/WHO/UNU (2004), FAO/WHO/UNU (2007), ILSI SEA-RDAs (Tee & Florentino, 2005), WHO (2006) standard population for children under 5 years old, WHO (2007) reference population for children 5-19 years old.
Carbohydrate	Indonesia: Calculated by difference based on macronutrient distribution ranges.
	Malaysia: FAO/WHO Scientific Update (2007), IOM (2002), IOM (2005a)
	Vietnam: ILSI SEA-RDAs (Tee & Florentino, 2005)
Dietary fibre	Indonesia: ADA (2002); WHO (2003)
	Malaysia: ADA (2002); WHO (2003)
	Philippines: Children intake: American Academy of Pediatrics (Dwyer, 1995); adults: Kranz *et al* (2012); WHO (1990)
	Vietnam: IOM (2005a), DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015)
Sugars	Malaysia: WHO (2015)
Protein	Indonesia: IOM (2005a), FAO/WHO/UNU (2007), and the local study
	Malaysia: References used include Report of DRI committee of IOM (2002, 2005a), FAO/WHO/UNU (2007), scientific report of EFSA (2012); FAO/WHO/UNU (2007) recommendations were adopted in estimating protein requirements for all age groups.
	Philippines: Joint FAO/WHO/UNU (2007) Expert Consultation on Protein and Amino Acid Requirements in human nutrition, in consideration of the protein quality of rice-based Filipino diets.
	Vietnam: WHO (1985), FAO/WHO/UNU (2004), ILSI SEA-RDAs (Tee & Florentino, 2005), WHO/FAO/UNU (2007)

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Fats	Indonesia: IOM (2005a) Malaysia: USDA (2015), PHE (2016), PHC (2016), FAO (2010), Siri-Tarino *et al.* (2010) and Appel *et al.* (2005) Philippines: US IOM-FNB (IOM, 2005a) recommendations were used. Vietnam: FAO (2010) recommendations were adopted, and based on the tradition and actual lipid consumption of Vietnamese people.
Thiamin (Vitamin B1)	Indonesia: IOM (1998) Malaysia: Adapted WHO/FAO (2004) consultation report, IOM (1998) DRI Recommendations were referred, reports of thiamin status of communities in the country were considered. Philippines: Adapted IOM (1998) DRI recommendations; vitamin nutritional status from national nutrition surveys were used as background information. Vietnam: IOM (1997), FAO/WHO (2002), nutritional requirements for regional countries by ILSI (Tee & Florentino, 2005), DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015) were referred.
Riboflavin (Vitamin B2)	Indonesia: IOM (1998) Malaysia: Adopted WHO/FAO (2004) consultation report's values, IOM (1998) DRI recommendations were also referred. Philippines: IOM (1998) recommendations were adopted for infants, children, adults and elderly. Vietnam: ILSI (Tee & Florentino, 2005), DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015) were referred.
Niacin (Vitamin B3)	Indonesia: IOM (1998) Malaysia: Adopted WHO/FAO (2004) consultation report, IOM (1998) DRI recommendations, report of the EFSA (2014a), recommendations by the working group for the harmonisation of RDAs in SEA (Tee & Florentino, 2005) were referred. Philippines: Adopted IOM (1998) DRI recommendations. Vietnam: The recommended requirements are based on US IOM (1998) DRI for niacin.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Pantothenic Acid (Vitamin B5)	Indonesia: IOM (1998) Malaysia: WHO/FAO (2004), IOM (1998) and EFSA (2014b) were referred. The recommendation levels of pantothenic acid by WHO/FAO (2004) were adopted. Vietnam: Recommendations are based on DRI for Japanese (Ministry of Health, Labour & Welfare Japan, 2015) and the US IOM (1998) DRI for pantothenic acid.
Pyridoxine (Vitamin B6)	Indonesia: IOM (1998) Malaysia: WHO/FAO (2004), IOM (1998) and EFSA (2016) were referred. Recommendations are based on WHO/FAO (2004) report. Philippines: Recommendations are based on IOM (1998). The EAR for adults 50 years and above were adopted from IOM (2006). Vietnam: The recommended requirements are based on DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015), and the US IOM (1998) DRI for Vitamin B6.
Folate (Vitamin B9)	Indonesia: IOM (1998) Malaysia: WHO/FAO (2004) consultation report, the IOM (1998) DRI recommendations, EFSA (2014c), and Working group for the harmonisation of RDAs in SEA by ILSI (Tee & Florentino, 2005) were referred. The final recommendation values are adapted from WHO/FAO (2004). Philippines: Folate requirements for Filipinos mostly considered the recommendation of IOM-FNB (IOM, 1998). Newer studies were considered after the recommendation of the 1998 IOM-FNB was published. Vietnam: The recommended requirements are based on the US IOM (1998) Dietary reference intakes for folate.
Cobalamin (Vitamin B12)	Indonesia: IOM (1998) Malaysia: The main references used were the reports from the IOM (1998), WHO/FAO (2004) and the EFSA (EFSA, 2015a), the final recommendations adopted values proposed by EFSA (EFSA, 2015a). Philippines: The recommendations are based on IOM-FNB (IOM, 1998) and FAO/WHO Expert consultation panel (for pregnant women). Vietnam: The recommended requirements are based the US IOM (IOM, 1998) Dietary reference intakes for cobalamin (Vitamin B12).

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Ascorbic Acid (Vitamin C)	Indonesia: IOM (2000) Malaysia: The main references used included WHO/ FAO (2004) consultation report, the IOM (2000) DRI recommendations, recommended intake published by EFSA (2013b), and working group for the harmonisation of RDAs in Southeast Asia (Tee & Florentino, 2005). The final recommendations were adapted from WHO/FAO (2004), with the addition of 25 mg per day for all age groups above 10 years of age, in order to increase absorption or iron in the diet among population of which anaemia is still prevalent. Philippines: IOM (2000) were used as reference for defining vitamin C requirements for adults. Vietnam: The recommendations are based on DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015), Nutritional requirements for regional countries by ILSI (Tee & Florentino, 2005) - Recommended Dietary Allowance: Harmonization in Southeast Asia.
Vitamin A	Indonesia: WHO/FAO (2004), IOM (2001), and the local study. Malaysia: The main references used were WHO/FAO (2004) consultation paper, IOM DRI committee (IOM, 2001), and the EFSA on Dietary Reference Values for vitamin A (EFSA, 2015b). WHO/FAO (2004) recommendations for vitamin A were adopted. Philippines: The main references used were WHO/FAO (2004), IOM-FNB (2001), Olson 1987. Vietnam: The recommendation is based on the DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015).
Vitamin D	Indonesia: IOM (2011) Malaysia: The main references used were WHO/FAO (2004) recommendations & IOM (2011). Numerous studies conducted by various investigators in different part of Malaysia on prevalence of vitamin D deficiency and insufficiency were considered. The IOM (2011) values were adapted. Philippines: The recommendations are based on the IOM (2011). Vietnam: The recommendations are based on the IOM (2011) and the situation of vitamin D deficiency in Vietnamese in recent years.
Vitamin E	Indonesia: IOM (2000) Malaysia: The main references were the reports from the WHO/FAO (2004), IOM (2000) and EFSA (2015c). The dietary pattern of the community was taken into consideration. The final RNI adopted the WHO/FAO (2004) vitamin E intake recommendations.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
	Philippines: The recommendations are based on the IOM (2000) and WHO/FAO (2004).
	Vietnam: The recommendations are based on the DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015).
Vitamin K	Indonesia: IOM (2001)
	Malaysia: The WHO/FAO (2004) consultation report as well as the IOM (2001) DRI recommendations were referred. The WHO/FAO (2004) values were adopted.
	Philippines: The recommendations are based on consultation report WHO/FAO (2004).
	Vietnam: The recommendations are based on the DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015).
Calcium	Indonesia: IOM (2011)
	Malaysia: The main references used were the updated IOM DRI recommendations in 2011 (IOM, 2011) and the existing FAO/WHO (2002) reference.
	Philippines: In the absence of sufficient Philippines data on calcium requirements for different population groups, the FAO/WHO (2004) recommendations were adopted.
	Vietnam: The recommendations by the IOM (2011), and studies in Vietnam and Asian countries (Japan, Malaysia, Singapore) were referred.
Iron	Indonesia: WHO/FAO (2004)
	Malaysia: The RNIs for iron are based on the WHO/FAO (2004) recommendations. Taking into consideration available local reports on iron intake of communities such as Malaysian Adult Nutrition Survey (MANS) (IPH, 2014) and the magnitude of iron deficiency problem in the country, 10% and 15% iron bioavailability levels of WHO/FAO (2004) were adopted.
	Philippines: Philippines adopted 8.5% iron bioavailability levels of WHO/FAO (2004) based on food consumption pattern seen in national nutrition surveys, absorption rates of non-heme iron from local diets at 6.4% (Trinidad *et al.*, 1986) and heme iron at 23% (Monsen *et al.*, 1978).
	Vietnam: The iron requirements applied according to the recommendations of FAO / WHO (2004), SEA-RDAs (Tee & Florentino, 2005), studies in Asia and Vietnam, Needs are calculated based on different levels of dietary iron bioavailability (5%, 10% & 15%) and changes in iron requirements in menstruating women.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Iodine	Indonesia: IOM (2001) Malaysia: The WHO/ FAO (2004) expert consultation and the IOM (2001) reports were the main references used. Several local reports on the magnitude of iodine deficiency disorders and the intervention measures taken were also considered. The approach of the WHO/ FAO (2004) was adapted, based on the mean body weight of Malaysians. Philippines: Prevalence of iodine deficiency from national nutrition surveys were referred. Recommendations for children and adolescents were based on iodine balance studies in children WHO/FAO (2004) and IOM (2001). The recommendation of the WHO/UNICEF/ICCIDD (2001) for children and adolescents were adopted. Vietnam: The recommendations are based on the IOM (2006) report on DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015).
Zinc	Indonesia: IOM (2006) Malaysia: The zinc intake recommendations by WHO/FAO (2004), IOM (2001, 2006), IZiNCG (2004) and EFSA (2014d) were referred and considered. The WHO/FAO (2004) zinc values of diet with zinc absorption of 30% (moderate bioavailability) were adopted but adjusted according to the local reference body weight. Philippines: The recommendations by WHO (1996), WHO/FAO (2004), IOM (2001), IZiNCG (2004) were referred. Philippines' recommendations are based on WHO (1996), WHO/FAO (2004) recommendeds. Studies on the effect of malnutrition concentration of zinc in hair of Filipino children; data on zinc content in breast milk; zinc intake from national surveys were considered. Vietnam: Zinc in the Vietnamese diet (phytate/zinc ratio) is considered. The recommendation is based on the recommendations of WHO/FAO (2004) and SEA-RDAs 2005 (Tee & Florentino, 2005).
Selenium	Indonesia: IOM (2000) Malaysia: The WHO/FAO Expert Consultation report of 2004 (WHO/FAO, 2004), the DRI Committee of IOM (2000) and the the WHO/FAO/IAEA report WHO (1996) were referred. The approach and the recommendations of WHO/FAO (2004) were adapted and adjusted using reference body weights of Malaysians. Philippines: The WHO/FAO/IAEA report (WHO, 1996) recommendations were adapted and adjusted using Filipino reference weight. For pregnant women, WHO/FAO (2004) recommendations of additional +2 µg/day were adapted with higher value (4 µg/day) to allow for build-up of selenium stores.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
	Vietnam: The recommendations are based on IOM (2006), FAO/WHO (2004), DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015), and SEA-RDAs 2005 (Tee & Florentino, 2005).
Phosphorus	Indonesia: IOM (2006)
	Malaysia: The main references used include IOM (2006), National Health and Medical Research Council (NHMRC) for Australia and Ministry of Health New Zealand (NHMRC, 2006), EFSA (2015d). The values from IOM (2006) were adopted.
	Philippines: Phosphorus concentration in breast milk was considered. The IOM (1997) recommendations were adapted.
	Vietnam: References used include IOM (2006), and DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015).
Sodium	Indonesia: WHO (2012a), IOM (2006)
	Malaysia: WHO (2012a), IOM (2006) were referred, the IOM (2006) recommendation for sodium was adapted.
	Philippines: The values adopted were obtained from the 1989 RDA for electrolytes (DOST-FNRI, 1989).
	Vietnam: WHO (2012a) Guideline on sodium intake for adults and children, and DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015) were referred.
Potassium	Indonesia: WHO (2012b), IOM (2006)
	Malaysia: Main references used include National Health and Nutrition Examination Survey (NHANES) study (USDA, 2007); EFSA, (2013c); WHO (2012b); Malaysian Health and Adolescents Longitudinal Research Team Study (Abdul Majid *et al*, 2016); IOM (2006). The recommendations from IOM (2006) were adapted for the RNI values for potassium since it has proposed a set of dietary reference intake values for different age groups as well as pregnant and lactating women.
	Philippines: Holliday & Segar's (1957) recommendation of 78 mg per 100 kcal to maintain potassium balance in children was used for infants, children and adolescents. IOM (2005b) and WHO (2012b) were referred for adults, elderly, pregnancy & lactating women.
	Vietnam: WHO (2012b) Guideline on potassium intake for adults and children, and DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015) were referred.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Magnesium	Indonesia: IOM (2006) Malaysia: The IOM (1997, 2006), WHO /FAO (2004), and EFSA (2015e) were referred. RDA recommendations of IOM (2006) were adopted. Philippines: The recommendations by WHO/FAO (2004) were adopted. Vietnam: DRI for Japanese 2015 (Ministry of Health, Labour & Welfare Japan, 2015) was adopted.
Chromium	Indonesia: IOM (2001) Malaysia: The recommendations by IOM (2001) were adopted. Vietnam: IOM (2006) paper on Dietary Reference Intakes. The essential Guide to Nutrient Requirements was referred.
Copper	Indonesia: IOM (2001) Malaysia: The recommendations by IOM (2001), the National Health and Medical Research Council (NHMRC) for Australia and Ministry of Health New Zealand (NHMRC, 2006), and the European Food Safety Authority (EFSA, 2015f) were referred. IOM (2001) recommendations were adopted. Vietnam: The main reference used for recommendations was IOM (2006) paper on Dietary Reference Intakes: The Essential Guide to Nutrient Requirements.
Manganese	Indonesia: IOM (2006) Malaysia: The main references used were IOM recommendations (2006), EFSA (2013c) and United States Food and Drug Administration Total Diet Study (US TDS) report. The IOM recommendations (2006) for the AI values for manganese were adopted. The median intakes reported from the US TDS was used as the basis to set the AI values for manganese. Vietnam: IOM (2006)
Molydenum	Malaysia: Main references referred include the EFSA (2013d) recommendations and IOM (2006) recommendations. IOM (2006) recommendations were adopted.
Flouride	Indonesia: IOM (2006) Malaysia: IOM (2006) recommendations were adopted.

Table 4. Main references used for setting recommended intakes of by nutrients and country *(continued)*

Nutrients	*Main references used for recommendations*
Chloride	Indonesia: IOM (2006) Philippines: The values adapted were obtained from the 1989 US RDA for electrolytes (National Research Council, 1989). Vietnam: WHO (2012) guidelines on sodium intake for adults and children; and IOM (2006) DRI recommendations on sodium and chloride were referred.

Note: For Indonesia, certain values from the reference or formula were corrected or adjusted according to Indonesians healthy body weight by age and sex groups, as well as by nutrient bio-availability factors

on individual PAL whereby the EFSA recommendations of PAL 1.4, 1.6, 1.8 and 2.0 to reflect sedentary, moderately active, active and very active lifestyles were adopted (EFSA, 2013). In the Philippines' recommendation, the PAL factors used were 1.67 for males from ages 19 to 59 years, 1.55 for females for the same age range, whereas for 60-69 years, PAL values of 1.58 for male and 1.45 for females were used. Vietnam used three PAL namely light, medium and heavy based on the energy demand coefficient of Japan (NIHN Japan, 2010).

For most of the nutrients, recommendations from prevailing resources were either adopted or modified for specific groups or age categories after considering the nutritional status and dietary intake patterns of the local populations. Besides, when data specific for any physiological state were not available to estimate requirements for certain nutrients, extrapolation approach was used. For example, nutrient requirements for children, adolescents, elderly, pregnant and lactating women were extrapolated from the recommendations for adults. For infants, the countries indicated that the recommended values were based on observed mean intake data from infants fed human milk exclusively or extrapolated from the composition of breast milk.

Recommendations for energy

While undernutrition is still a concern in many SEA countries, the problem of overweight, obesity and associated non-communicable diseases (NCDs) have been on the rise. The recommendations for energy requirements are therefore of importance to the population in these countries.

Table 5 shows that the five countries have provided differing daily energy requirements. The daily energy recommendations for males are higher than those for females for all age groups in all countries. In Indonesia, the trend is slightly different in that for infants and children up to 9 years of age, where there is no difference by sex in the daily energy recommendations. It can also be noted that Indonesia recommends higher daily requirements for children aged 1-3 and 4-6 years groups as compared to children of the same age groups in other countries.

In all the countries, the highest recommended energy requirements are for males and females in the 16-18 years group. In Indonesia, it is slightly different in that the highest requirement is for

Table 5. Recommended energy requirements (kcal/day) in SEA countries

Age group	*Indonesia*[†]		*Malaysia*[‡]		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	550[§]		470-540	420-500	620	560	490	460	550	500
6-11 months	800		630-720	570-660	720	630	680	610	650-700	600-650
Children										
1-3 years old	1350		980	900	1000 (1-2yo)	920 (1-2yo)	1050	980	1000 (1-2yo)	950
4-6 years old	1400		1300	1210	1350 (3-5yo)	1260 (3-5yo)	1290 (4-5yo)	1200 (4-5yo)	1320 (3-5yo)	1250
7-9 years old	1650		1750	1610	1600 (6-9yo)	1470 (6-9yo)	1440 (6-8yo)	1320 (6-8yo)	1360 (light labour); 1570 (average labour); 1770 (heavy labour) (6-7yo) 1600 (light labour); 1820 (average labour); 2050 (heavy labour) (8-9yo)	1270 (light labour); 1460 (average labour); 1650 (heavy labour) (6-7yo) 1510 (light labour); 1730 (average labour); 1940 (heavy labour) (8-9yo)
Adolescent										
10-12 years old	2000	1900	1930	1710	2060	1980	1800 (9-12yo)	1650 (9-12yo)	1880 (light labour); 2150 (average labour); 2400 (heavy labour) (10-11yo)	1740 (light labour); 1980 (average labour); 2220 (heavy labour) (10-11yo)
13-15 years old	2400	2050	2210	1810	2700	2170	2200	1860	2200 (light labour); 2500 (average labour); 2790 (heavy labour) (12-14yo)	2040 (light labour); 2310 (average labour); 2580 (heavy labour) (12-14yo)
16-18 years old	2650	2100	2340 (16-<18yo)	1890 (16-<18yo)	3010	2280	2370	1890	2500 (light labour); 2820 (average labour); 3140 (heavy labour) (15-19yo)	2110 (light labour); 2380 (average labour); 2650 (heavy labour) (15-19yo)

Table 5. Recommended energy requirements (kcal/day) in SEA countries (continued)

Age group	*Indonesia*†		*Malaysia*‡		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Adult										
19-29 years old	2650	2250	2240 (≥18-29yo)	1840 (≥18-29yo)	2530	1930	2260 (19-30yo)	1780 (19-30yo)	2200 (light labour); 2570 (average labour); 2940 (heavy labour) (20-29yo)	1760 (light labour); 2050 (average labour); 2340 (heavy labour) (20-29yo)
30-59 years old	2550 (30-49yo) 2150 (50-64yo)	2150 (30-49yo) 1800 (50-64yo)	2190	1900	2420	1870	2190 (31-50yo); 2180 (51-60yo)	1780 (31-50yo); 1770 (51-60yo)	2010 (light labour); 2350 (average labour); 2680 (heavy labour) (30-49yo)	1730 (light labour); 2010 (average labour); 2300 (heavy labour) (30-49yo)
Elderly										
60–69 years old	1800 (65-80yo)	1550 (65-80yo)	2030 (≥60yo)	1770	2140	1610	1790 (61-70yo)	1560	2000 (light labour); 2330 (average labour); 2660 (heavy labour) (50-69yo)	1700 (light labour); 1980(average labour); 2260 (heavy labour) (50-69yo)
≥70 years old	1600 (80+yo)	1400 (80+yo)			1960	1540	1740 (≥71yo)	1540 (≥71yo)	1870 (light labour); 2190 (average labour); 2520 (heavy labour)	1550 (light labour); 1820 (average labour); 2090 (heavy labour)
Pregnancy										
1st trimester	-	+180	-	+80	-	-	-	+50-100	-	+50
2nd trimester	-	+300	-	+280	-	+300	-	+250-300	-	+250
3rd trimester	-	+300	-	+470	-	+300	-	+450-500	-	+450
Lactation										
1st 6 months	-	+330	-	+500	-	+500	-	+500	-	+500
2nd 6 months	-	+400	-		-		-	+300	-	+675

yo: years old

†Energy for physical activity is calculated using physical activity factors for each age group, namely 1.1 for children up to the age of 1 year, 1.14 for children 1-3 years, and 1.26 for children and adults 4-64 years, and 1.12 for the elderly.

‡The recommended energy requirement value based on PAL 1.4 is recommended for children aged 1-3 and 4-6 years old, PAL 1.6 is recommended for children above 7 years, adolescents and adults

§Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding the female young adult group of 19-29 years. All countries have recommended lower requirements for the elderly (>60 years) than for adults.

All countries, except the Philippines, recommended additional energy requirements during the three trimesters of pregnancy, with increasing amounts for each trimester. The Philippines recommended the same additional energy requirement only the 2nd and 3rd trimesters. Additional energy requirements have been recommended during the lactation period for all countries. The additional amounts recommended range from 300kcal to 675kcal. Malaysia and Philippines do not recommend additional energy requirements for the latter half of the lactation period.

Recommendations for macronutrients

Protein

Table 6 summarises the RDAs/RNIs for protein by the five countries in the review. For infants 0-5 months, Vietnam has used AI for this recommendation. In addition to the international references used, most countries considered the protein quality of the population in setting the recommendations. Recommendations for daily protein intakes are rather similar for infants aged 0-5 months in all the country recommendations. For all other age groups, there are considerable variations among the recommendations. Generally, lower amounts are recommended by Malaysia and Thailand. The highest recommendations are, in most cases, for the adolescents 16-18 years group. The exception is Malaysia recommendations, where the adult group had the highest recommended intakes. Different from other countries, Philippine DRI recommends the same daily protein intake for the adults and elderly groups (71g male, 62g for female, respectively). It can also be noted that these provisions are also slightly higher compared to that recommended for the same age groups by the other four countries. All countries have also made recommendations for additional daily protein intake during pregnancy and lactation. The recommendation for additional amounts over the daily intake is higher in Philippine DRI, which is +27g throughout pregnancy and lactation period.

Fat

The RDAs/RNIs for daily fat intake by the five countries are shown in Table 7. Except for Indonesia which has provided the recommendations in g/day, the other countries have listed theirs as percentage of total energy intake (% TEI). It can be noted that for all countries, the highest fat % of TEI is for infants aged 0-5 months (ranging from 40-60%). This percentage decreases with the increase of age, from older infants, children, adolescents and adults. The fat intake recommendations for adults aged 18 and above in most countries are restricted to a conservative range of 20-35% TEI. The Philippines and Vietnam have recommended a lower range of fat intake of 18-25% TEI. Generally, no extra fat intake has been recommended for pregnancy and lactation. Some countries (e.g. Indonesia, Malaysia, Philippines and Vietnam) also discussed in general terms the requirements for specific fatty acids including saturated fatty acid, trans-fat, and essential fatty acids.

Carbohydrate

Similar to that for fat intake, the recommended carbohydrate intakes have been calculated based on the % TEI and taking into consideration the proportion of energy contributed by protein and fat. Except for Indonesia, which has presented the recommended intake as g/day, the other countries have presented the RDAs/RNIs as % TEI (Table 8).

Table 6. RDAs/RNIs for protein (g/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants										
0-5 months	9[†]		8		9	8	Breast milk	Breast milk	11[‡]	11[‡]
6-11 months	15		10		17	15	14	12	18 (6-8mths) 20 (9-11mths)	18 (6-8mths) 20 (9-11mths)
Children										
1-3 years old	20		12		18 (1-2yo)	17 (1-2yo)	16	15	20 (1-2yo)	19 (1-2yo)
4-6 years old	25		16		22 (3-5yo)	21 (3-5yo)	19 (4-5yo)	19 (4-5yo)	25 (3-5yo)	25 (3-5yo)
7-9 years old	40		23		30 (6-9yo)	29 (6-9yo)	24 (6-8yo)	24 (6-8yo)	33 (6-7yo) 40 (8-9yo)	32 (6-7yo) 40 (8-9yo)
Adolescent										
10-12 years old	50	55	30	31	43	46	39 (9-12yo)	40 (9-12yo)	50 (10-11yo)	48 (10-11yo)
13-15 years old	70	65	45	42	62	57	55	51	65 (12-14yo)	60 (12-14yo)
16-18 years old	75	65	51 (16-<18yo)	42 (16-<18yo)	72	61	61	51	74 (15-19yo)	63 (15-19yo)
Adult										
19-29 years old	65	60	62 (≥18-29yo)	53 (≥18-29yo)	71	62	61 (19-30yo)	53 (19-30yo)	69 (20-29yo)	60 (20-29yo)
30-59 years old	65 (30-64yo)	60 (30-64yo)	61	52	71	62	60 (31-60yo)	52 (31-60yo)	68 (30-49yo)	60 (30-49yo)
Elderly										
60–69 years old	64 (65-80yo)	58 (65-80yo)	58 (≥60yo)	50	71	62	59 (61-70yo)	50 (61-70yo)	70 (50-69yo)	62 (50-69yo)
≥70 years old	64 (80+yo)	58 (80+yo)			71	62	56 (≥71yo)	49 (≥71yo)	68	59
Pregnancy										
1st trimester	-	+1	-	+0.5	-	-	-	+1	-	+1
2nd trimester	-	+10	-	+8	-	+27	-	+10	-	+10
3rd trimester	-	+30	-	+25	-	+27	-	+31	-	+31
Lactation										
1st 6 months	-	+20	-	+19	-	+27	-	+19	-	+19
2nd 6 months	-	+15	-	+13	-	+27	-	+13	-	+13

mths: months; yo: years old
[†]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
[‡]Adequate intake

Table 7. RDAs/RNIs for total fat (g/day or % TEI) in SEA countries

Age group	Indonesia[†] (g/day)		Malaysia (% TEI)		Philippines (% TEI)		Thailand (% TEI)		Vietnam[‡] (% TEI)	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants										
0-5 months	31[§]		40-60%		40-60%		40-60%		45-50%	
6-11 months	35		30-40%		30-40%		35-40%		40%	
Children										
1-3 years old	45		25-35%		25-35% (1-2yo)		35-40% (1-2yo) 25-35% (2-3yo)		35-40%	
4-6 years old	50		25-35%		15-18% (3-18yo)		25–35% (4-5yo)			
7-9 years old	55		25-35%				25–35% (6-8yo)			
Adolescent										
10-12 years old	65		25-35% (10-18yo)				25–35% (9-12yo)			
13-15 years old	80	70					25–35%			
16-18 years old	85	70					25–35%			
Adult										
19-29 years old	75	65	25-30%		15-30% (>=19 years)		20-35% (19-30yo)		18-25% (adults)	
30-59 years old	70 (30-49yo)	60 (30-49yo)	25-35%				20-35% (31-50yo)			
	60 (50-64yo)	50 (50-64yo)					20-30% (51-70yo)			
Elderly										
60–69 years old	50 (65-80yo)	45 (65-80yo)	25-30% (≥60yo)							
≥70 years old	45 (80+yo)	40 (80+yo)					20-35% (≥71yo)			
Pregnancy	-	+2.3	-	25-30%			-	20-35%	-	20-25%, up to 30%
Lactation	-	+2.2	-	25-30%			-	20-35%	-	20-25%, up to 30%

yo: years old
[†]The recommended fat intake in Indonesia RDA is presented in g/day
[‡]The recommended fat requirements in % TEI for children aged 4-9 years old, adolescent and elderly are not described in Vietnam RDA
[§] Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

For each age group, the recommended carbohydrate intakes vary considerably among the countries. Malaysia, Thailand and Vietnam have provided the same recommended carbohydrate intake for all age groups, from infants to the elderly, at 50-65%, 45-65% and 60-65% of TEI, respectively. The Malaysian RNI provides carbohydrate recommendations of 50-65% TEI for all age groups. The Philippines has recommended different levels of % TEI for infants, children and adults and has the highest carbohydrate intake in the range from 55 to 75% of TEI for adults.

Dietary fibre

Dietary fibre is not traditionally recognised as an essential nutrient. Nevertheless, all countries have included recommendations on this in their recommended nutrient intakes, indicating the importance attributed to this food component for human health.

For dietary fibre intake, the recommendations for the adult population are rather similar in most countries reviewed, with most recommending a minimum intake of 20 g per day (Malaysia 20-30 g/day, Philippines 20-25 g/day, Vietnam 20-22 g/day) for adults while Thai DRI recommends 25 g/day for adults and elderly. Malaysia's recommendation of 20-30 g/day is applicable for all age groups, whereas, for the Philippines and Thailand, the amount of dietary fibre recommended for children is equivalent to age in years plus 5 g.

Dietary fibre intake recommendations for Indonesia are different from other countries, where specific recommendations have been provided for different age groups. For infants and children, males and females share the same recommendations, with the recommended amount higher with increasing age. For adolescents, adults and elderly, the recommendations for males are higher than those for females. The highest recommendations are for the adults 19-29 years group (37 g/day for males and 32 g/day for females). Lower intakes are recommended for elderly aged 65 years and above (20-25 g/day).

Sugar

In terms of recommendations for sugar intake, the majority of the countries (Malaysia, Philippines, Vietnam) adopted the WHO (2015) recommendation that intake of free sugar should be less than 10% of TEI. While, the Thai RDI provides recommendations that sugar intake should not be more than 5% of total energy or be less than six teaspoons (24 g/day). The document on nutritional adequacy values by Indonesia does not include recommendations for sugar intake.

Recommendations for vitamins and minerals

Much has been highlighted regarding the scaling up of efforts to combat double-burden of malnutrition in SEA countries. A great deal of emphasis has been given to reducing the burden of overweight, obesity and diet-related NCDs. It is important for countries to continue to pay intention to undernutrition problems, including wasting, stunting and micronutrient deficiency and insufficiency (WHO, 2022; ASEAN, 2022). This review has therefore included the vitamins and minerals that are of common concern in the five SEA countries and compare the recommendations for these micronutrients. There is a total of 14 vitamins and 15 minerals contained in the nutrient recommendation documents of the five countries (Table 3).

Recommended vitamin intakes

For the first 11 of the 14 vitamins in Table 3, all five countries have provided recommended intakes. For the remaining

Table 8. RDAs/RNIs for carbohydrate (g/day or % TEI) in SEA countries

Age group	*Indonesia*† *(g/day)*		*Malaysia (% TEI)*		*Philippines (% TEI)*		*Thailand (% TEI)*		*Vietnam (% TEI)*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	59‡		50-65% of total energy intake for all age groups		35-55%		45 - 65% of total energy intake for all age groups		60-65% of total energy intake for all age groups	
6-11 months	105				45-62%					
Children										
1-3 years old	215				50-69% (1-2yo)					
4-6 years old	220				55-79% (3-18yo)					
7-9 years old	250									
Adolescent										
10-12 years old	300	280								
13-15 years old	350	300								
16-18 years old	400	300								
Adult										
19-29 years old	430	360			55-75% (>=19 years)					
30-49 years old	415	340								
50-64 years old	340	280								
Elderly										
65–80 years old	275	230								
>80 years old	235	200								
Pregnancy										
1st trimester	-	+25								
2nd trimester	-	+40								
3rd trimester	-	+40								
Lactation										
1st 6 months	-	+45								
2nd 6 months	-	+55								

yo: years old
†The recommended fat requirement in terms of % TEI is not described in Indonesia RDA
‡Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

three vitamins, only four countries have made provisions for pantothenic acid intake and three countries for biotin and choline. Recommended intakes for these 14 vitamins by the five countries, given as RDAs/RNIs, unless otherwise mentioned, are tabulated in Tables 9-22. A summary discussion comparing the recommended intakes for each of these vitamins among the countries are given in the following paragraphs.

Vitamin A

Table 9 presents the recommendations for Vitamin A (expressed as retinol equivalents, RE) by country. All countries provide RDA/RNI values for the vitamin A recommendations for all age groups except infants where the provisions by the Philippines and Vietnam are in AI. There are no great variations in vitamin A recommendations in Indonesia, Malaysia, Philippines and Thailand for all age groups. There are also no differences between recommendations according to sex for infants, children and adolescents aged 10-12 years old except in Vietnam. The highest recommendations are, in most cases, for the adolescents, 16-18 years group. For groups aged more than 13 years old, Vietnam's vitamin A recommendations are generally higher as compared to other countries.

All country recommendations provide for additional amounts of vitamin A during pregnancy and lactation, with considerable differences in recommendations. With the exception of Vietnam and Thailand, the intakes recommended range from +100 µg/day to +300 µg/day for pregnancy (except Vietnam) and range from +250 µg/day to +450 µg/day for lactation (except Thailand). Vietnam has the lowest recommendation for additional vitamin A during pregnancy (+80 µg/day and only during the third trimester) whereas Thai DRIs recommend the highest additional vitamin A amount for lactating women at +700 µg/day.

Vitamin B1 (Thiamin)

Vitamin B1 recommendations by the five countries are rather similar for the different age groups, as indicated in Table 10. The recommendations are RDA/RNI values for all age groups in all countries except infants where the provisions are in AI for infants aged 0-5 months in Philippines, infants aged 6-11 months in Thailand and infants aged 0-11 months in Vietnam. In general, there are no differences in recommendations according to sex for infants (0.1-0.3 mg/day) and children (0.4-0.9 mg/day). For adolescents, adults and elderly, the recommendations for males (0.9-1.4 mg/day) are slightly higher than for females (0.9-1.3 mg/day). The highest daily amount of thiamin recommended are for the males, 13-15 years group (1.2 mg) and remained the same for males in the adolescents 16-18 years, adults and elderly groups. An additional 0.2-0.4 mg/day is recommended by all countries for pregnant and lactating women.

Vitamin B2 (Riboflavin)

Table 11 indicates that all countries generally provide relatively similar RDAs/RNIs for vitamin B2 for most age groups. AI is used for vitamin B2 recommendations for infants aged 0-5 months in the Philippines, infants aged 6-11 months in Thailand and infants aged 0-11 months in Vietnam. The infants and children, male and female groups share the same recommendations. For adolescent, adult and elderly groups, the recommendations for males are marginally higher than those for females. Vietnam has higher vitamin B2 intake recommendations for adolescents (1.3-1.7 mg/day) as compared to the similar age groups of other countries (0.9-1.5 mg/day). All countries provide additional

Table 9. RDAs/RNIs for vitamin A (μg Retinol Equivalent – RE/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*‡		*Vietnam*§	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	375†		375		380¶		Breast milk		300¶ (0-5mths)	
6-11 months	400		400		400		250		400¶ (6-12mths)	
Children										
1-3 years old	400		400		400 (1-2yo)		300		400 (1-2yo)	350 (1-2yo)
4-6 years old	450		450		400 (3-5yo)		350 (4-5yo)		500 (3-5yo)	400 (3-5yo)
7-9 years old	500		500		400 (6-9yo) 500 (8-9yo)		350 (6-8yo)		450 (6-7yo)	400 (6-7yo)
Adolescent										
10-12 years old	600		600		500		550 (9-12yo)		600 (10-11yo)	
13-15 years old	600		600		700	500	750	700	800 (12-14yo)	700 (12-14yo)
16-18 years old	700	600	600		800	600	750	600	900 (15-17yo) 850 (18-19y)	650 (15-17yo) 650 (18-19y)
Adult										
19-29 years old	650	600	600		700	600	700 (19-30yo)	600 (19-30yo)	850 (20-29yo)	650 (20-29yo)
30-49 years old	650	600	600 (30-50yo)		700	600	700 (31-50yo)	600 (31-50yo)	900	700
50-59 years old	650 (50-64yo)	600 (50-64yo)	600 (51-59yo)		700	600	700 (51-60yo)	600 (51-60yo)	850 (50-69yo)	700 (50-69yo)
Elderly										
60–69 years old	650 (65-80yo)	600 (65-80yo)	600 (60-65y)		700	600	700 (61-70yo)	600 (61-70yo)		
≥70 years old	650 (80+yo)	600 (80+yo)	600 (>65y)		700	600	700 (≥71yo)	600 (≥71yo)	800	650
Pregnancy										
1st trimester	-	+300	-	+200	-	+300	-	+100	-	+0
2nd trimester	-	+300	-	+200	-	+300	-	+100	-	+0
3rd trimester	-	+300	-	+200	-	+300	-	+100	-	+80
Lactation										
1st 6 months	-	+350	-	+250	-	+400	-	+700	-	+450
2nd 6 months	-	+350	-	+250	-	+400	-	+700	-	+450

mths: months; yo: years old
†Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
‡Retinol activity equivalent (RAE), 1 RAE = 1 μg retinol, 12 mg ß-carotene, 24 mg α-carotene, or 24 mg ß-cryptoxanthin
§Retinol activity equivalents (μg RAE) = Retinol (μg) + β-carotene (μg) × 1/12 + α- carotene (μg) × 1/24 + B-cryptoxanthin (μg) × 1/24 + other provitamin A carotenoid (μg) × 1/24
¶Adequate intake

Table 10. RDAs/RNIs for thiamin (vitamin B1) (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	0.2[†]		0.2		0.2[‡]		Breast milk		0.1[‡]	
6-11 months	0.3		0.3		0.4	0.3	0.3[‡]		0.2 (6-8mths)[‡] 0.2 (9-11mths)[‡]	
Children										
1-3 years old	0.5		0.5		0.5 (1-2yo)	0.4 (1-2yo)	0.5 (1-3yo)		0.5 (1-2yo)	
4-6 years old	0.6		0.6		0.5 (3-5yo)		0.6 (4-5yo)		0.7 (3-5yo)	
7-9 years old	0.9		0.9		0.7 (6-9yo)		0.6 (6-8yo)		0.8 (6-7yo)	
									1.0 (8-9yo)	0.9 (8-9yo)
Adolescent										
10-12 years old	1.1	1.0	1.2	1.1	0.9		0.9 (9-12yo)		1.2 (10-11yo)	1.1 (10-11yo)
13-15 years old	1.2	1.1	1.2	1.1	1.2	1.0	1.2	1.0	1.4 (12-14yo)	1.3 (12-14yo)
16-18 years old	1.2	1.1	1.2	1.1	1.4	1.1	1.2	1.0	1.4 (15-19yo)	1.2 (15-19yo)
Adult										
19-29 years old	1.2	1.1	1.2	1.1	1.2	1.1	1.2 (19-30yo)	1.1 (19-30yo)	1.3 (20-29yo)	1.1 (20-29yo)
30-49 years old	1.2	1.1	1.2 (30-50yo)	1.1 (30-50yo)	1.2	1.1	1.2 (31-50yo)	1.1 (31-50yo)	1.2	1.0
50-59 years old	1.2 (50-64yo)	1.1 (50-64yo)	1.2 (51-59yo)	1.1 (51-59yo)	1.2	1.1	1.2 (51-60yo)	1.1 (51-60yo)	1.2 (50-69yo)	1.0 (50-69yo)
Elderly										
60–69 years old	1.2 (65-80yo)	1.1 (65-80yo)	1.2 (60-65y)	1.1 (60-65y)	1.2	1.1	1.2 (61-70yo)	1.1 (61-70yo)		
≥70 years old	1.2 (80+yo)	1.1 (80+yo)	1.2 (>65y)	1.1 (>65y)	1.2	1.1	1.2 (≥71yo)	1.1 (≥71yo)	1.1	1.0
Pregnancy										
1st trimester	-	+0.3	-	+0.3	-	+0.3 +0.3 +0.3	-	+0.3	-	+0.2 +0.2 +0.2
2nd trimester	-	+0.3	-	+0.3	-		-	+0.3	-	
3rd trimester	-	+0.3	-	+0.3	-		-	+0.3	-	
Lactation										
1st 6 months	-	+0.4	-	+0.4	-	+0.2	-	+0.3	-	+0.2
2nd 6 months	-	+0.4	-	+0.4	-	+0.2	-	+0.3	-	+0.2

mths: months; yo: years old
[†]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
[‡]Adequate intake

Table 11. RDAs/RNIs for riboflavin (vitamin B2) (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	0.3[†]		0.3		0.3[‡]		Breast milk		0.3[‡]	
6-11 months	0.4		0.4		0.4	0.3	0.4[‡]		0.4 (6-8mths)[‡]	
									0.4 (9-11mths)[‡]	
Children										
1-3 years old	0.5		0.5		0.5 (1-2yo)	0.4 (1-2yo)	0.5 (1-3yo)		0.6 (1-2yo)	0.5 (1-2yo)
4-6 years old	0.6		0.6		0.6 (3-5yo)	0.5 (3-5yo)	0.6 (4-5yo)		0.8 (3-5yo)	
7-9 years old	0.9		0.9		0.7 (6-9yo)		0.6 (6-8yo)		0.9 (6-7yo)	
									1.1 (8-9yo)	1.0 (8-9yo)
Adolescent										
10-12 years old	1.3	1.0	1.3	1.0	1.0	0.9	0.9 (9-12yo)		1.4 (10-11yo)	1.3 (10-11yo)
13-15 years old	1.3	1.0	1.3	1.0	1.3	1.0	1.3	1.0	1.6 (12-14yo)	1.4 (12-14yo)
16-18 years old	1.3	1.0	1.3	1.0	1.5	1.1	1.3	1.0	1.7 (15-19yo)	1.4 (15-19yo)
Adult										
19-29 years old	1.3	1.1	1.3	1.1	1.3	1.1	1.3 (19-30yo)	1.1 (19-30yo)	1.5 (20-29yo)	1.2 (20-29yo)
30-49 years old	1.3	1.1	1.3 (30-50yo)	1.1 (30-50yo)	1.3	1.1	1.3 (31-50yo)	1.1 (31-50yo)	1.4	1.2
50-59 years old	1.3 (50-64yo)	1.1 (50-64yo)	1.3 (51-59yo)	1.1 (51-59yo)	1.3	1.1	1.3 (51-60yo)	1.1 (51-60yo)	1.4 (50-69yo)	1.2 (50-69yo)
Elderly										
60–69 years old	1.3 (65-80yo)	1.1 (65-80yo)	1.3 (60-65y)	1.1	1.3	1.1	1.3 (61-70yo)	1.1 (61-70yo)		
≥70 years old	1.3 (80+yo)	1.1 (80+yo)	1.3 >65y	1.1	1.3	1.1	1.3 (≥71yo)	1.1 (≥71yo)	1.3	1.1
Pregnancy										
1st trimester	-	+0.3	-	+0.3	-	+0.7	-	+0.3	-	+0.3
2nd trimester	-	+0.3	-	+0.3	-	+0.7	-	+0.3	-	+0.3
3rd trimester	-	+0.3	-	+0.3	-	+0.7	-	+0.3	-	+0.3
Lactation										
1st 6 months	-	+0.5	-	+0.5	-	+0.6	-	+0.5	-	+0.6
2nd 6 months	-	+0.5	-	+0.5	-	+0.6	-	+0.5	-	+0.6

mths: months; yo: years old
[†]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
[‡]Adequate intake

amounts of vitamin B2 during pregnancy and lactation. In most cases +0.3mg/day for pregnancy and +0.5-0.6mg/day for the lactation period. Philippines has recommended a higher amount of +0.7 mg/day for pregnancy.

Vitamin B3 (Niacin)
Generally, the RDAs/RNIs for infants and children are rather similar among the five countries (Table 12). There are also no differences in recommendations according to sex for these two groups. For infants aged 0-5 months in Philippines and infants aged 6-11 months in Thailand, the provisions are AI values. Considerable differences in recommendations for vitamin B3 among adolescents are observed among the countries. Recommendations for adolescent aged 10-12 years old in Malaysia is higher (16 mg NE/day) as compared to the similar age groups of other countries (11-12 mg NE/day). For older adolescents, the recommendations for females are all higher than those for the males.

Countries show similar vitamin B3 recommendations for adult and elderly groups, with the provision for males (16mg NE/day) slightly higher than those for females (14mg NE/day). The additional amounts recommended during pregnancy and lactation in all countries are also similar, which are +4mg NE/day and +3mg/day, respectively.

Vitamin B6 (Pyridoxine)
The RDAs/RNIs for vitamin B6 are presented in Table 13. Philippines, Thailand and Vietnam use AI values for vitamin B6 recommendations for infants. The recommended intakes for infants, and children 1-3 and 4-6 years groups are rather similar for all the countries. For children aged 7-9 years old, the recommendations by Indonesia and Malaysia (1.0 mg/day) are slightly higher than those provided by Philippines and Thailand (0.6-0.8 mg/day). For adolescents, while Indonesia and Malaysia recommend the same vitamin B6 intakes throughout the adolescent period 10-18 years old (1.3 mg/day for males & 1.2 mg/day for females), Philippines, Thailand and Vietnam have different recommendations for each of the adolescent sub-groups, increasing for the older adolescents. For the entire adolescent group, the intakes recommended for males are marginally higher than those for females. All countries recommend the same amount of 1.3 mg/day for adult males and females 19-49 years. Countries generally recommend higher vitamin B6 intake for adults aged 50-59 years and the elderly group (1.7 mg/day for males; 1.5-1.6 mg/day for females). The additional amounts recommended during pregnancy and lactation are the same for all countries, the recommended intakes per day being 1.9 mg to 2.0 mg per day respectively.

Vitamin B9 (Folate)
Table 14 summarises the RDAs/RNIs for folate in the five countries; the recommended intake values for infants (65-80 μg/day) in the Philippines are AI values. Infants in Indonesia and Malaysia have higher recommended intakes (80 μg/day) compared with the other countries which recommend 65-80 μg/day. For children, all countries recommend higher intakes than for infants, and are higher with increasing age. Indonesia, Malaysia and Philippines have higher recommendations for this group (160-300 μg/day) than Thailand (120-180 μg/day) and Vietnam (100-200 μg/day). Most countries recommend 300-400 μg/day for adolescents and 400 μg/day for adults and elderly. Thailand, however, has lower folate recommendations for adolescents (240-300 μg/day) as well as adults and

Table 12. RDAs/RNIs for niacin (vitamin B3) intake (mg NE/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	2†		2		1‡		Breast milk§		2	
6-11 months	4		4		5		4‡		4 (6-8mths) 4 (9-11mths)	
Children										
1-3 years old	6		6		6 (1-2yo)		6 (1-3yo)		6 (1-2yo)	
4-6 years old	8		8		7 (3-5yo)		8 (4-5yo)		8 (3-5yo)	
7-9 years old	10		12		9 (6-9yo)		8 (6-8yo)		8 (6-7yo) 12 (8-9yo)	
Adolescent										
10-12 years old	12		16		11	12	12 (9-12yo)		12 (10-11yo)	
13-15 years old	16	14	16		15	13	16	14	12 (12-14yo)	
16-18 years old	16	14	16		18	14	16	14	16 (15-19yo)	14 (15-19yo)
Adult										
19-29 years old	16	14	16	14	16	14	16 (19-30yo)	14 (19-30yo)	16 (20-29yo)	14 (20-29yo)
30-49 years old	16	14	16 (30-50yo)	14 (30-50yo)	16	14	16 (31-50yo)	14 (31-50yo)	16	14
50-59 years old	16 (50-64yo)	14 (50-64yo)	16 (51-59yo)	14 (51-59yo)	16	14	16 (51-60yo)	14 (51-60yo)	16 (50-69yo)	14 (50-69yo)
Elderly										
60–69 years old	16 (65-80yo)	14 (65-80yo)	16 (60-65y)	14	16	14	16 (61-70yo)	14 (61-70yo)		
≥70 years old	16 (80+yo)	14 (80+yo)	16 (>65y)	14	16	14	16 (≥71yo)	14 (≥71yo)	16	14
Pregnancy										
1st trimester	-	+4	-	+4	-	+4	-	+4	-	+4
2nd trimester	-	+4	-	+4	-	+4	-	+4	-	+4
3rd trimester	-	+4	-	+4	-	+4	-	+4	-	+4
Lactation										
1st 6 months	-	+3	-	+3	-	+3	-	+3	-	+3
2nd 6 months	-	+3	-	+3	-	+3	-	+3	-	+3

mths: months; yo: years old
†Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
‡Adequate intake
§niacin equivalent (NE), 1 mg niacin = 60 mg tryptophan; 0-6 mo = preformed niacin (not NE)

Table 13. RDAs/RNIs for pyridoxine (vitamin B6) (mg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	0.1[†]		0.1		0.1[‡]		Breast milk		0.1[‡]	
6-11 months	0.3		0.3		0.2[‡]	0.3[‡]	0.3[‡]		0.3[‡] (6-8mths) 0.3[‡] (9-11mths)	
Children										
1-3 years old	0.5		0.5		0.5 (1-2yo)		0.5 (1-3yo)		0.5 (1-2yo)	
4-6 years old	0.6		0.6		0.6 (3-5yo)	0.7 (3-5yo)	0.6 (4-5yo)		0.5 (3-5yo)	
7-9 years old	1.0		1.0		0.7 (6-9yo)	0.8 (6-9yo)	0.6 (6-8yo)		0.8 (6-7yo) 1.0 (8-9yo)	
Adolescent										
10-12 years old	1.3	1.2	1.3	1.2	1.0	1.1	1.0 (9-12yo)		1.0 (10-11yo)	
13-15 years old	1.3	1.2	1.3	1.2	1.3	1.2	1.3	1.2	1.2 (12-14yo)	1.1 (12-14yo)
16-18 years old	1.3	1.2	1.3	1.2	1.5	1.3	1.3	1.2	1.3 (15-19yo)	1.2 (15-19yo)
Adult										
19-29 years old	1.3		1.3		1.3		1.3 (19-30yo)		1.3 (20-29yo)	
30-49 years old	1.3		1.3 (30-50yo)		1.3		1.3 (31-50yo)		1.3	
50-59 years old	1.7 (50-64yo)	1.5 (50-64yo)	1.7 (51-59yo)	1.5 (51-59yo)	1.7	1.6	1.7 (51-60yo)	1.5 (51-60yo)	1.7 (50-69yo)	1.5 (50-69yo)
Elderly										
60–69 years old	1.7 (65-80yo)	1.5 (65-80yo)	1.7 (60-65y)	1.5	1.7	1.6	1.7 (61-70yo)	1.5 (61-70yo)		
≥70 years old	1.7 (80+yo)	1.5 (80+yo)	1.7(>65yo)	1.5	1.7	1.6	1.7 (≥71yo)	1.5 (≥71yo)	1.7	1.5
Pregnancy										
1st trimester	-	+0.6	-	+0.6	-	+0.6	-	+0.6	-	+0.6
2nd trimester	-	+0.6	-	+0.6	-	+0.6	-	+0.6	-	+0.6
3rd trimester	-	+0.6	-	+0.6	-	+0.6	-	+0.6	-	+0.6
Lactation										
1st 6 months	-	+0.6	-	+0.7	-	+0.7	-	+0.7	-	+0.7
2nd 6 months	-	+0.6	-	+0.7	-	+0.7	-	+0.7	-	+0.7

mths: months; yo: years old
[†]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
[‡]Adequate intake
Pregnancy and lactation recommendations are in addition to the amount recommended for women 19-49 years

Table 14. RDAs/RNIs for folate (vitamin B9) (μg dietary folate equivalents/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants										
0-5 months	80†		80		65‡		Breast milk		65	
6-11 months	80		80		80‡	70‡	85		80 (6-8mths) 80 (9-11mths)	
Children										
1-3 years old	160		160		150 (1-2yo)		120 (1-3yo)		100 (1-2yo)	
4-6 years old	200		200		200 (3-5yo)		140 (4-5yo)		150 (3-5yo)	
7-9 years old	300		300		300 (6-9yo)		180 (6-8yo)		200 (6-7yo) 200 (8-9yo)	
Adolescent										
10-12 years old	400		400		300		240 (9-12yo)		300 (10-11yo)	
13-15 years old	400		400		400		300		300 (12-14yo)	400 (12-14yo)
16-18 years old	400		400		400		300		300 (15-19yo)	400 (15-19yo)
Adult										
19-29 years old	400		400		400		300 (19-30yo)		400 (20-29yo)	
30-49 years old	400		400 (30-50yo)		400		300 (31-50yo)		400	
50-59 years old	400 (50-64yo)		400 (51-59yo)		400		300 (51-60yo)		400 (50-69yo)	
Elderly										
60–69 years old	400 (65-80yo)		400 (60-65y)		400		300 (61-70yo)			
≥70 years old	400 (80+yo)		400 (>65yo)		400		300 (≥71yo)		400	
Pregnancy										
1st trimester	-	+200	-	+200	-	+200	-	+250	-	+200
2nd trimester	-	+200	-	+200	-	+200	-	+250	-	+200
3rd trimester	-	+200	-	+200	-	+200	-	+250	-	+200
Lactation										
1st 6 months	-	+100	-	+100	-	+150	-	+150	-	+100
2nd 6 months	-	+100	-	+100	-	+150	-	+150	-	+100

mths: months; yo: years old
†Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
‡Adequate intake

elderly (300 μg/day). Overall, there is no difference in recommendations by sex for all age groups, in all countries.

The recommendations for additional folate intake during pregnancy are the same for all countries (+200 μg/day), except for Thailand which recommends an additional amount of +250 μg/day. The same trend can be seen for lactation, wherein all countries have the same recommendation of an addition of +100 μg/day, whereas Thailand has a slightly higher additional amount of +150 μg/day.

Vitamin B12 (Cobalamin)

Indonesia and Malaysia have higher RDAs/RNIs for vitamin B12 than other countries (Table 15) for all age groups. The AI values are used by Philippines and Vietnam for provisions for infants aged 0-11 months and 6-11 months for Thailand. For infants age 6-11 months, the amounts recommended by Indonesia and Malaysia are triple the recommendations of Philippines, Thailand and Vietnam. For adolescents and adults, Indonesia and Malaysia recommend intakes of 3.5-4.0 μg/day while others recommend 1.8-2.4 μg/day. All countries have also recommended higher daily vitamin B12 intakes for pregnancy and lactation, with the recommendations by Indonesia and Malaysia double that of other countries.

Vitamin C

In Philippines and Vietnam, the recommendations for vitamin C intakes for infants use AI while other countries use RNI/RDA for all age groups. There are considerable variations in these vitamin C intake recommendations for all age groups (Table 16). There are generally no difference in recommendations for males and females for the younger age groups (e.g. infants, children and adolescents). For adults and elderly groups in Indonesia, Philippines and Thailand, males have higher recommended intakes than females. Malaysia has lower recommendations for infants and children (25-30 mg/day) compared with the other countries (30-50 mg/day). For adolescents, intake recommendations range from 45-70 mg/day for Philippines to 75-100 mg/day for Vietnam. Intake recommendations for adults and elderly range from 60 mg/day for Philippines females to 100 mg/day for Vietnamese males and females.

All countries recommend additional amounts of vitamin C during pregnancy and lactation. The additional amount recommended during pregnancy is the same for all countries, at +10 mg/day. The additional amount recommended for lactation varies considerably, ranging from +25 to +60 mg/day for Malaysia and Thailand, respectively.

Vitamin D

Philippines provides AI recommendations for vitamin D for all age groups while Thailand provide an AI recommendation for infants. The RNI/RDA values are used by Indonesia, Malaysia, Vietnam for all age groups. Recommendations for vitamin D intake (Table 17) for infants are the same (at 10 μg/day) for four of the countries reviewed, namely Indonesia, Malaysia, Thailand and Vietnam. The recommended intake trend is the same for children, adolescents and adults (up to 50 years old), where the same intake of 15 μg/day is recommended for these four countries. There are no different intake recommendations for males and females. Notable differences are observed for the recommendations by Philippines, in which the recommended amounts are three times lower for all age groups compared to the other four countries. There is also no recommendation provided for Filipino infants. All countries have recommended higher

Table 15. RDAs/RNIs for cobalamin (vitamin B12) (µg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	0.4†		1.2		0.3‡		Breast milk		0.4‡	
6-11 months	1.5		1.5		0.4‡		0.5‡		0.5‡ (6-8mths) 0.5‡ (9-11mths)	
Children										
1-3 years old	1.5		1.5		0.9 (1-2yo)	1.0 (1-2yo)	0.9 (1-3yo)		0.9 (1-2yo)	
4-6 years old	1.5		1.5		1.1 (3-5yo)	1.2 (3-5yo)	1.2 (4-5yo)		1.0 (3-5yo)	
7-9 years old	2.0		2.5		1.3 (6-9yo)	1.5 (6-9yo)	1.2 (6-8yo)		1.2 (6-7yo) 1.5 (8-9yo)	
Adolescent										
10-12 years old	3.5		3.5		1.8	2.1	1.8 (9-12yo)		1.8 (10-11yo)	
13-15 years old	4.0		4.0		2.3	2.2	2.4		2.4 (12-14yo)	
16-18 years old	4.0		4.0		2.7	2.4	2.4		2.4 (15-19yo)	
Adult										
19-29 years old	4.0		4.0		2.4		2.4 (19-30yo)		2.4 (20-29yo)	
30-49 years old	4.0		4.0 (30-50yo)		2.4		2.4 (31-50yo)		2.4	
50-59 years old	4.0 (50-64yo)		4.0 (51-59yo)		2.4		2.4 (51-60yo)		2.4 (50-69yo)	
Elderly										
60–69 years old	4.0 (65-80yo)		4.0 (60-65yo)		2.4		2.4 (61-70yo)			
≥70 years old	4.0 (80+yo)		4.0 (>65yo)		2.4		2.4 (≥71yo)		2.4	
Pregnancy										
1st trimester	-	+0.5	-	+0.5	-	+0.2	-	+0.2	-	+0.2
2nd trimester	-	+0.5	-	+0.5	-	+0.2	-	+0.2	-	+0.2
3rd trimester	-	+0.5	-	+0.5	-	+0.2	-	+0.2	-	+0.2
Lactation										
1st 6 months	-	+1.0	-	+1.0	-	+0.5	-	+0.4	-	+0.4
2nd 6 months	-	+1.0	-	+1.0	-	+0.5	-	+0.4	-	+0.4

mths: months; yo: years old
†Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
‡Adequate intake

Table 16. RDAs/RNIs for vitamin C (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*		*Vietnam*[†]	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	40[‡]		25		30[§]		Breast milk		40[§]	
6-11 months	50		30		40[§]		50		40[§] (6-8mths) 40[§] (9-11mths)	
Children										
1-3 years old	40		30		45 (1-2yo)		25 (1-3yo)		35 (1-2yo)	
4-6 years old	45		30		45 (3-5y0)		30 (4-5yo)		40 (3-5yo)	
7-9 years old	45		35		45 (6-9yo)		40 (6-8yo)		55 (6-7yo) 60 (8-9yo)	
Adolescent										
10-12 years old	50		65		45		60 (9-12yo)		75 (10-11yo)	
13-15 years old	75	65	65		60	55	85	80	95 (12-14yo)	
16-18 years old	90	75	65		70	60	100	80	100 (15-19yo)	
Adult										
19-29 years old	90	75	70		70	60	100 (19-30yo)	85 (19-30yo)	100 (20-29yo)	
30-49 years old	90	75	70 (30-50yo)		70	60	100 (31-50yo)	85 (31-50yo)	100	
50-59 years old	90 (50-64yo)	75 (50-64yo)	70 (51-59yo)		70	60	100 (51-60yo)	85 (51-60yo)	100 (50-69yo)	
Elderly										
60–69 years old	90 (65-80yo)	75 (65-80yo)	70 (60-65yo)		70	60	100 (61-70yo)	85 (61-70yo)		
≥70 years old	90 (80+yo)	75 (80+yo)	70 (>65yo)		70	60	100 (≥71yo)	85 (≥71yo)	100	
Pregnancy										
1st trimester	-	+10	-	+10	-	+10	-	+10	-	+10
2nd trimester	-	+10	-	+10	-	+10	-	+10	-	+10
3rd trimester	-	+10	-	+10	-	+10	-	+10	-	+10
Lactation										
1st 6 months	-	+45	-	+25	-	+35	-	+60	-	+45
2nd 6 months	-	+45	-	+25	-	+35	-	+60	-	+45

mths: months; yo: years old

[†]The loss due to processing and cooking is not included because vitamin C is easily destroyed by oxidation, light, alkali and temperature

[‡]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

[§]Adequate intake

Pregnancy and lactation recommendations are in addition to the amount recommended for women 19-49 years

Table 17. RDAs/RNIs for vitamin D (μg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines†		Thailand‡		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants										
0-5 months	10§		10		5		10†		10	
6-11 months	10		10		5		10†		10 (6-8mths) 10 (9-11mths	
Children										
1-3 years old	15		15		5 (1-2yo)		15 (1-3yo)		15 (1-2yo)	
4-6 years old	15		15		5 (3-5yo)		15 (4-5yo)		15 (3-5yo)	
7-9 years old	15		15		5 (6-9yo)		15 (6-8yo)		15 (6-7yo) 15 (8-9yo)	
Adolescent										
10-12 years old	15		15		5		15 (9-12yo)		15 (10-11yo)	
13-15 years old	15		15		5		15		15 (12-14yo)	
16-18 years old	15		15		5		15		15 (15-19yo)	
Adult										
19-29 years old	15		15		5		15 (19-30yo)		15 (20-29yo)	
30-49 years old	15		15 (30-50yo)		5		15 (31-50yo)		15 (30-49yo)	
50-59 years old	15 (50-64yo)		15 (51-59yo)		10		15 (51-60yo)		20 (50-69yo)	
Elderly										
60–69 years old	20 (65-80yo)		15 (60-65y)		15		15 (61-70yo)			
≥70 years old	20 (80+yo)		20 (>65yo)		15		20 (≥71yo)		20	
Pregnancy										
1st trimester	-	+0	-	+0	-	+0	-	+0	-	+5
2nd trimester	-	+0	-	+0	-	+0	-	+0	-	+5
3rd trimester	-	+0	-	+0	-	+0	-	+0	-	+5
Lactation										
1st 6 months	-	+0	-	+0	-	+0	-	+0	-	+5
2nd 6 months	-	+0	-	+0	-	+0	-	+0	-	+5

mths: months; yo: years old

·†Adequate intake

‡Recommendations are given in IU/day in Thais DRI, the values are converted to μg/day for comparison (cholecalciferol, 1μg cholecalciferol = 40 IU vitamin D)

§Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

Pregnancy and lactation recommendations for Vietnam are in addition to the amount recommended for women 20-29 years

Table 18. RDAs/RNIs for vitamin E (mg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines†		Thailand		Vietnam†	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	4‡		3		3		Breast milk		3	
6-11 months	5		3		4		5		4 (6-12mths)	
Children										
1-3 years old	6		5		4 (1-2yo)		6 (1-3yo)		3.5 (1-2yo)	
4-6 years old	7		5		5 (3-5yo)		9 (4-5yo)		4.5 (3-5yo)	
7-9 years old	8		7		6 (6-9yo)		9 (6-8yo)		5.0 (6-7yo) 5.5 (8-9yo)	
Adolescent										
10-12 years old	11	15	10	7.5	7	9	13 (9-12yo)	11 (9-12yo)	5.5 (10-11yo)	
13-15 years old	15		10	7.5	10	9	13	11	7.5 (12-14yo)	6.0 (12-14yo)
16-18 years old	15		10	7.5	11	10	13	11	7.5 (15-17yo) 6.5 (18-19yo)	6.0 (15-17yo) 6.0 (18-19yo)
Adult										
19-29 years old	15		10	7.5	10		13 (19-30yo)	11 (19-30yo)	6.5 (20-29yo)	6.0 (20-29yo)
30-49 years old	15		10 (30-50yo)	7.5 (30-50yo)	10		13 (31-50yo)	11 (31-50yo)	6.5	6.0
50-59 years old	15 (50-64yo)		10 (51-59yo)	7.5 (51-59yo)	10		13 (51-60yo)	11 (51-60yo)	6.5 (50-69yo)	6.0 (50-69yo)
Elderly										
60–69 years old	15 (65-80yo)	20 (65-80yo)	10 (60-65y)	7.5 60-65y)	10		13 (61-70yo)	11 (61-70yo)		
≥70 years old	15 (80+yo)	20 (80+yo)	10 (>65yo)	7.5 (>65yo)	10		13 (≥71yo)	11 (≥71yo)	6.5	6.0
Pregnancy										
1st trimester	-	+0	-	+0	-	+0	-	+0	-	+0.5
2nd trimester	-	+0	-	+0	-	+0	-	+0	-	+0.5
3rd trimester	-	+0	-	+0	-	+0	-	+0	-	+0.5
Lactation										
1st 6 months	-	+4	-	+0	-	+4	-	+0	-	+1
2nd 6 months	-	+4	-	+0	-	+4	-	+0	-	+1

mths: months; yo: years old
†Adequate intake
‡Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

daily vitamin D intakes for older adults, especially for the age group of 70 and above (aged 65 and above for Malaysia).

For all countries except Vietnam, no additional intakes are recommended for pregnant and lactating women. In Vietnam, the vitamin D requirements for these population groups are set at 20 μg/day, or an additional 5 μg/day over the recommendation for adults (20-49 years).

Vitamin E

Table 18 lists the recommended intakes for vitamin E. Philippines and Vietnam use AI for vitamin E recommendations for all age groups while other three countries provide RDA/RNI values for the recommendations. There are considerable variations in the vitamin E intake recommendations for all age groups. For infants aged 6-11 months, the amounts recommended by Indonesia and Thailand (5 mg/day) are slightly higher than those recommended by other three countries (3-4 mg/day). For children aged 1-9 years old, Thailand has higher vitamin E intake recommendations (6-9 mg/day) as compared to the similar age groups of other countries (ranged from 3.5-8.0 mg/day). For adolescents, adults and elderly, the amounts recommended by Indonesia are highest (11-15 mg/day for adolescent, 15 mg/day for adults and 15-20 mg/day for elderly) as compared to other countries. Vietnam, on the other hand, has the lowest vitamin E intake recommendations for most age groups, from children to elderly, with the recommended amounts about half of that recommended by Indonesia. For the other three countries, the vitamin E intake recommendations ranged from 7-13 mg/day for adolescents, and 7.5-13 mg/day for both adults and elderly. Interestingly, for elderly groups in Indonesia, females have higher recommended intake whereas the other four countries respectively have higher recommended intake for male elderly groups.

Only Vietnam recommended additional vitamin E intake (+0.5 mg/day) for pregnant women. For lactating women, Indonesia and Philippines recommends additional intake of +4 mg/day over the recommendation for adults whereas Vietnam recommends +1 mg/day of vitamin E intake for lactation.

Vitamin K

The recommendations for daily vitamin K intake by the five countries are presented in Table 19. Thailand and Vietnam use AI for vitamin K recommendations while other three countries provide RNI/RDA values for this vitamin. For infant groups, Thailand has the lowest recommended intake for infant aged 6-11 months (2.5 μg/day) as compared to the other four countries (ranging from 7-10 μg/day) whereas for infant 0-5 months, no recommended intake value is provided in Thailand as the fulfilment of the needs are to be from exclusive breastfeeding. The recommendations for all other age groups vary among countries, with the recommendations by Thailand (ranging from 30-120 μg/day) double that of Indonesia, Malaysia and Philippines (ranging from 15-65 μg/day) whereas Vietnam's recommendations (60-150 μg/day), the highest among the five countries, are four times higher that of Indonesia, Malaysia and Philippines. For all countries, the recommendations increase with age and there is generally no difference in recommendations for males and females for the younger age groups (e.g. infants, children and adolescents) in all countries except Philippines. For adults and elderly, the amounts recommended for male are slightly higher than those recommended for female in all countries, with the exception of Vietnam, which show no difference in recommendations for males and females for all age groups. No

Table 19. RDAs/RNIs for vitamin K (μg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand†		Vietnam†	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	5‡		5		7	6	Breast milk		4	
6-11 months	10		10		9	8	2.5		7 (6-12mths)	
Children										
1-3 years old	15		15		12 (1-2yo)		30 (1-3yo)		60 (1-2yo)	
4-6 years old	20		20		18 (3-5yo)	17 (3-5yo)	55 (4-5yo)		70 (3-5yo)	
7-9 years old	25		25		23 (6-9yo)		55 (6-8yo)		85 (6-7yo)	
									100 (8-9yo)	
Adolescent										
10-12 years old	35		35-55		33	36	60 (9-12yo)		120 (10-11yo)	
13-15 years old	55		35-55		49	46	75		150 (12-14yo)	
16-18 years old	55		35-55		59	52	75		160 (15-17yo)	
Adult									150 (18-19yo)	
19-29 years old	65	55	65	55	61	53	120 (19-30yo)	90 (19-30yo)	150 (20-29yo)	
30-49 years old	65	55	65 (30-50yo)	55 (30-50yo)	61	53	120 (31-50yo)	90 (31-50yo)	150	
50-59 years old	65 (50-64yo)	55 (50-64yo)	65 (51-59yo)	55 (51-59yo)	61	53	120 (51-60yo)	90 (51-60yo)	150 (50-69yo)	
Elderly										
60–69 years old	65 (65-80yo)	55 (65-80yo)	65 (60-65yo)	55	61	53	120 (61-70yo)	90 (61-70yo)		
≥70 years old	65 (80+yo)	55 (80+yo)	65 (>65yo)	55	61	53	120 (≥71yo)	90 (≥71yo)	150	
Pregnancy										
1st trimester	-	+0	-	+0	-	+0	-	+0	-	+0
2nd trimester	-	+0	-	+0	-	+0	-	+0	-	+0
3rd trimester	-	+0	-	+0	-	+0	-	+0	-	+0
Lactation										
1st 6 months	-	+0	-	+0	-	+0	-	+0	-	+0
2nd 6 months	-	+0	-	+0	-	+0	-	+0	-	+0

mths: months; yo: years old
†Adequate intake
‡Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 20. RDAs/RNIs for pantothenic acid (Vitamin B5) (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*[‡]		*Philippines*[†]		*Thailand*[‡]		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants					-	-				
0-5 months	1.7[§]		1.7				Breast milk		1.7	
6-11 months	1.8		1.8				1.8		1.7 (6-8mths) 1.8 (9-11mths)	
Children					-	-				
1-3 years old	2.0		2.0				2.0 (1-3yo)		2.0 (1-2yo)	
4-6 years old	3.0		3.0				3.0 (4-5yo)		3.0 (3-5yo)	
7-9 years old	4.0		4.0				3.0 (6-8yo)		3.0 (6-7yo) 4.0 (8-9yo)	
Adolescent					-	-				
10-12 years old	5.0		5.0				4.0 (9-12yo)		4.0 (10-11yo)	
13-15 years old	5.0		5.0				5.0		4.0 (12-14yo)	
16-18 years old	5.0		5.0				5.0		5.0 (15-19yo)	
Adult					-	-				
19-29 years old	5.0		5.0				5.0 (19-30yo)		5.0 (20-29yo)	
30-49 years old	5.0		5.0 (30-50yo)				5.0 (31-50yo)		5.0	
50-59 years old	5.0 (50-64yo)		5.0 (51-59yo)				5.0 (51-60yo)		5.0 (50-69yo)	
Elderly					-	-				
60–69 years old	5.0 (65-80yo)		5.0 (60-65yo)				5.0 (61-70yo)			
≥70 years old	5.0 (80+yo)		5.0 (>65yo)				5.0 (≥71yo)		5.0	
Pregnancy					-	-				
1st trimester	-	+1.0	-	+1.0		-	-	+1.0	-	+1.0
2nd trimester	-	+1.0	-	+1.0		-	-	+1.0	-	+1.0
3rd trimester	-	+1.0	-	+1.0			-	+1.0	-	+1.0
Lactation					-	-				
1st 6 months	-	+2.0	-	+2.0			-	+2.0	-	+2.0
2nd 6 months	-	+2.0	-	+2.0			-	+2.0	-	+2.0

mths: months; yo: years old
[†]No recommendations for vitamin B5
[‡]Adequate intake
[§]Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

country has provided additional vitamin K intake recommendations for pregnancy and lactation.

Vitamin B5 (Pantothenic acid)
There are no recommendations for vitamin B5 intake in the Philippine DRI (Table 20). Although Malaysia and Thailand use AI for the recommendations while Indonesia and Vietnam provide RDA/RNI values, no major differences are observed in vitamin B5 recommendations in these four countries for all age groups. There are also no differences in recommendations according to sex. The recommendations for children range from 2-4 mg/day while the recommendations for adolescents range from 4-5 mg/day. For adults and elderly, 5 mg/day has been recommended. For all countries, the same provisions have been made for additional vitamin B5 intake during pregnancy (+1 mg/day) and lactation (+2 mg/day).

Biotin
Only three countries in this review has provided recommendations for biotin, namely Indonesia, Thailand and Vietnam (AI is used by Thailand and Vietnam). In general, all three countries provide similar recommendations for biotin for most age groups (Table 21). Male and female share the same recommendation values, and the recommendations increase with age, from 5-6 μg/day for infants, to 30 μg/day for adults and elderly. While there is no additional recommendation for pregnancy by these 3 countries, an additional of +5 μg/day is recommended for lactating women.

Choline
Similar to biotin, only Indonesia, Thailand and Vietnam have made recommendations for choline. Thailand and Vietnam use AI for choline recommendations for all age groups. The recommended intakes for all age groups are rather similar for all the three countries, with the values increasing with age (Table 22). There is generally no difference in recommendations by sex for the younger age groups (i.e. infants, children and adolescent up to 12 years old). In this regard, Indonesia provides higher choline recommendations for children aged 7-9 years old (375 mg/day) than Thailand (250-375 mg/day) and Vietnam (250 mg/day). For adolescent aged 13 years and above, adults and elderly groups, all three countries provide the same recommendations, with higher recommended intakes for males (500 mg/day) than females (from 400-425 mg/day). The additional amounts recommended during pregnancy and lactation in these countries are also similar, which are +25 mg/day for pregnancy and +125 mg/day for lactation respectively.

Recommended mineral intakes
For the first nine of the 15 minerals in Table 3, all five countries have provided recommended intakes. For the next five minerals, only four countries have made provisions for recommended daily intake, while only two countries have made recommendations for molybdenum intake. Recommended intakes for these 15 minerals by the five countries, given as RDAs/RNIs, unless otherwise mentioned, are tabulated in Tables 23-37. A summary discussion comparing the recommended intakes for each of these minerals among the countries are given in the following paragraphs.

Calcium
Notable differences in recommendations for calcium intake are observed (Table 23). Indonesia, Malaysia, Philippines and Vietnam provide RDA/RNI recommendations whereas Thailand provides AI amounts. For infants aged

Table 21. RDAs/RNIs for biotin (µg/day) in SEA countries

Age group	Indonesia		Malaysia†		Philippines†		Thailand‡		Vietnam‡	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants			-	-	-	-				
0-5 months	5§						Breast milk		5	
6-11 months	6						6		5 (6-8mths) 6 (9-11mths)	
Children			-	-	-	-				
1-3 years old	8						8 (1-3yo)		8 (1-2yo)	
4-6 years old	12						12 (4-5yo)		12 (3-5yo)	
7-9 years old	12						12 (6-8yo)		12 (6-7yo) 20 (8-9yo)	
Adolescent										
10-12 years old	20						20 (9-12yo)		20 (10-11yo)	
13-15 years old	25						25		25 (12-14yo)	
16-18 years old	30						25		25 (15-19yo)	
Adult			-	-	-	-				
19-29 years old	30						30 (19-30yo)		30 (20-29yo)	
30-49 years old	30						30 (31-50yo)		30	
50-59 years old	30 (50-64yo)						30 (51-60yo)		30 (50-69yo)	
Elderly			-	-	-	-				
60–69 years old	30 (65-80yo)						30 (61-70yo)			
≥70 years old	30 (80+yo)						30 (≥71yo)		30	
Pregnancy			-	-	-	-				
1st trimester	-	+0					-	+0	-	+0
2nd trimester	-	+0					-	+0	-	+0
3rd trimester	-	+0					-	+0	-	+0
Lactation			-	-	-	-				
1st 6 months	-	+5					-	+5	-	+5
2nd 6 months	-	+5					-	+5	-	+5

mths: months; yo: years old
†No recommendations for biotin
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 22. RDAs/RNIs for choline (mg/day) in SEA countries

Age group	Indonesia		Malaysia†		Philippines†		Thailand‡		Vietnam‡	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants			-	-	-	-				
0-5 months	125§						Breast milk		125	
6-11 months	150						150		150 (6-8mths)	
									150 (9-11mths)	
Children			-	-	-	-				
1-3 years old	200						200 (1-3yo)		200 (1-2yo)	
4-6 years old	250						250 (4-5yo)		250 (3-5yo)	
7-9 years old	375						250 (6-8yo)		250 (6-7yo)	
									250 (8-9yo)	
Adolescent			-	-	-	-				
10-12 years old	375						375 (9-12yo)		375 (10-11yo)	
13-15 years old	550	400					550	400	550 (12-14yo)	400 (12-14yo)
16-18 years old	550	425					550	400	550 (15-19yo)	425 (15-19yo)
Adult			-	-	-	-				
19-29 years old	550	425					550 (19-30yo)	425 (19-30yo)	550 (20-29yo)	425 (20-29yo)
30-49 years old	550	425					550 (31-50yo)	425 (31-50yo)	550	425
50-59 years old	550 (50-64yo)	425 (50-64yo)					550 (51-60yo)	425 (51-60yo)	550 (50-69yo)	425 (50-69yo)
Elderly			-	-	-	-				
60–69 years old	550 (65-80yo)	425 (65-80yo)					550 (61-70yo)	425 (61-70yo)		
≥70 years old	550 (80+yo)	425 (80+yo)					550 (≥71yo)	425 (≥71yo)	550	425
Pregnancy			-	-	-	-				
1st trimester	-	+25					-	+25	-	+25
2nd trimester	-	+25					-	+25	-	+25
3rd trimester	-	+25					-	+25	-	+25
Lactation			-	-	-	-				
1st 6 months	-	+125					-	+125	-	+125
2nd 6 months	-	+125					-	+125	-	+125

mths: months; yo: years old
†No recommendations for choline
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 23. RDAs/RNIs for calcium (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*†		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	200‡		200 (bf)†; 250 (ff)†		200†		Breast milk		300	
6-11 months	270		260†		400		260		400 (6-8mths) 400 (9-11mths)	
Children										
1-3 years old	650		700		500 (1-2yo)		500 (1-3yo)		500 (1-2yo)	
4-6 years old	1000		1000		550 (3-5yo)		800 (4-5yo)		600 (3-5yo)	
7-9 years old	1000		1000		700 (6-9yo)		800 (6-8yo)		650 (6-7yo) 700 (8-9yo)	
Adolescent										
10-12 years old	1200		1300		1000		1000 (9-12yo)		1000 (10-11yo)	
13-15 years old	1200		1300		1000		1000		1000 (12-14yo)	
16-18 years old	1200		1300		1000		1000		1000 (15-19yo)	
Adult										
19-29 years old	1000		1000		750		800 (19-30yo)		800 (20-29yo)	
30-49 years old	1000		1000 (30-50yo)		750		800 (31-50yo)		800 (30-49yo)	
50-59 years old	1200 (50-64yo)		1000 (51-59yo)	1200 (51-59yo)	750	800	1000 (51-60yo)		800 (50-69yo)	900 (50-69yo)
Elderly										
60–69 years old	1200 (65-80yo)		1000 (60-65yo)	1200	800		1000 (61-70yo)			
≥70 years old	1200 (80+yo)		1000 (>65yo)	1200	800		1000 (≥71yo)		1000	
Pregnancy										
13-19 years old	-	-	-	+300	-	-	-	-	-	-
1st trimester	-	+200	-	+0	-	+0	-	+0	-	+400
2nd trimester	-	+200	-	+0	-	+0	-	+0	-	+400
3rd trimester	-	+200	-	+0	-	+0	-	+50	-	+400
Lactation										
13-19 years old	-	-	-	+300	-	-	-	-	-	-
1st 6 months	-	+200	-	+0	-	+0	-	+0	-	+500
2nd 6 months	-	+200	-	+0	-	+0	-	+0	-	+500

mths: months; yo: years old; bb: breast fed; ff: formula fed
†Adequate intake
‡ Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
Pregnancy and lactation recommendations are in addition to the amount recommended for women 19-49 years

6-11 months, Philippines and Vietnam recommend higher calcium intake (400 mg/day) whereas the recommendations by the other countries range from 260-270 mg/day. For children aged 1-9 years, the recommendations by Indonesia (650-1000 mg/day) and Malaysia (700-1000 mg/day) are higher than those recommended by Philippines, Thailand and Vietnam (ranging from 500-800 mg/day). Indonesia (1200 mg/day) and Malaysia (1300 mg/day) recommendations for adolescent are also higher as compared to the other three countries (1000 mg/day). The same trend is observed for recommendations for adults (19-59 years), with the highest intakes for Indonesia and Malaysia, ranging from 1000-1200 mg/day. For the other three countries, recommendations for adults range from 750-1000 mg/day. Philippines has the lowest calcium intake recommendations for adults (750 mg - 800 mg for aged 19-59 years old) and elderly (800 mg/day for elderly aged 60 and above). Calcium intake recommendations for elderly in most countries range from 1000-1200 mg/day, with the exception of Philippines with a provision of 800 mg/day. In all countries, for all age groups, the same calcium intake is recommended for males and females.

Only Indonesia and Vietnam provide for additional calcium intake starting from 1st trimester of pregnancy and lactation. Philippines recommends additional intake at 3rd trimester and no additional intake for lactation. Malaysia specifically indicated a recommended intake of 1300 mg/day (an additional amount of 300 mg/day) for teenage pregnancy and lactation at aged 13-19 years.

Iron

All countries provide RDA/RNI values for iron intake of all groups, except infants aged 0-5 months in Philippines where AI amount is provided. For iron intake recommendations, Malaysia and Vietnam recommendations are based on two different levels of dietary iron bioavailability (i.e. intermediate (10%) and high (15%) bioavailability) (Table 24). Indonesia RDAs assumed that 75% of the iron is from a haem iron source whereas Philippines DRI adopted 8.5% iron bioavailability based on food consumption pattern observed in national nutrition surveys.

In general, the recommendations for iron are approximately 1.5 times higher for adolescent females 16-18 years than their male counterparts in all the countries. The highest iron intake recommendations are for adult women (aged 19-49 years) in all countries, about twice the amount for men in the same age group. Philippines has the same iron recommendations for the adolescent girls from 10 years onwards till women 49 years of 28 mg/day. This amount is the highest among all country recommendations, being 2.3 times that of the males and has indicated that the requirement cannot be met by diet alone.

All countries recommend additional iron intake for pregnant women, wherein Malaysia, Thailand and Vietnam recommend iron supplements for all pregnant women. All countries recommend additional iron intake during lactation, except Indonesia. Malaysia and Vietnam provide the recommendations based on the menstruation status during lactation period with assumption that menstruation may resume after exclusive breastfeeding, and that much higher iron requirement is recommended for lactating women with menstruation. Philippines adopts a recommended intake of 30 mg/day for lactating women (additional 2 mg/day to that of non-pregnant adult women aged 19-49 years), regardless of menstruation in order to allow for build-up of iron stores for future increased needs. On

Table 24. RDAs/RNIs for iron (mg/day) in SEA countries

Age group	Indonesia[†]		Malaysia				Philippines		Thailand		Vietnam			
	Male	Female	Male		Female		Male	Female	Male	Female	Male		Female	
			10%	15%	10%	15%					10%	15%	10%	15%
Infants														
0-5 months	0.3[‡]		a	a	a	a	0.4[§]		Breast milk		0.93	-	0.93	-
6-11 months	11		9	6	9	6	10	9	9.0		8.5 (6-8mths) 9.4 (9-11mths)	5.6 (6-8mths) 6.3 (9-11mths)	7.9 (6-8mths) 8.7 (9-11mths)	5.2 (6-8mths) 5.8 (9-11mths)
Children														
1-3 years old	7		6	4	6	4	8 (1-2yo)		5.0 (1-3yo)		5.4 (1-2yo)	3.6 (1-2yo)	5.1 (1-2yo)	3.5 (1-2yo)
4-6 years old	10		6	4	6	4	9 (3-5yo)		6.0 (4-5yo)		5.5 (3-5yo)	3.6 (3-5yo)	5.4 (3-5yo)	3.6 (3-5yo)
7-9 years old	10		9	6	9	6	10 (6-9yo)	9 (6-9yo)	6.6 (6-8yo)		7.2 (6-7yo) 8.9 (8-9yo)	4.8 (6-7yo) 5.9 (8-9yo)	7.1 (6-7yo) 8.9 (8-9yo)	4.7 (6-7yo) 5.9 (8-9yo)
Adolescent														
10-12 years old	8		15	10	14 (nm) 33 (m)	9 (nm) 22 (m)	12	20	11.5 (9-12yo)	12.5 (nm) [puberty]) 15.6 (m) (9-12yo)	11.3 (10-11yo)	7.5 (10-11yo)	10.5 (nm) 24.5 (m) (10-11yo)	7 (nm) 16.4 (m) (10-11yo)
13-15 years old	11	15	15 (13-14yo) 19 (15yo)	10 (13-14yo) 12 (15yo)	14 (nm) 33 (m) (13-14yo) 31 (15yo)	9 (nm) 22 (m) (13-14yo) 21 (15yo)	19	28[¶]	15.0 (13-15yo)	16.0 (13-15yo)	15.3 (12-14yo)	10.2 (12-14yo)	14.0 (nm) 32.6 (m) (12-14yo)	9.3 (nm) 21.8 (m) (12-14yo)
16-18 years old	11	15	19	12	31	21	14	28[¶]	11.0 (16-18yo)	16.0 (16-18yo)	17.5 (15-19yo)	11.6 (15-19yo)	29.7 (15-19yo)	19.8 (15-19yo)
Adult														
19-29 years old	9	18	14	9	29	20	12	28[¶]	11.5 (19-30yo)	20.0 (19-30yo)	11.9 (20-29yo)	7.9 (20-29yo)	26.1 (20-29yo)	17.4 (20-29yo)
30-49 years old	9	18	14 (30-50yo)	9 (30-50yo)	29 (30-50yo)	20 (30-50yo)	12	28[¶]	11.5 (31-50yo)	20.0 (31-50yo)	11.9	7.9	26.1	17.4
50-59 years old	9 (50-64yo)	8 (50-64yo)	14 (51-59yo)	9 (51-59yo)	11 (51-59yo)	8 (51-59yo)	12	10	11.5 (51-60yo)	10.0 (51-60yo)	11.9 (50-69yo)	7.9 (50-69yo)	10.0 (nm) 26.1 (m) (50-69yo)	6.7 (nm) 17.4 (m) (50-69yo)

Table 24. RDAs/RNIs for iron (mg/day) in SEA countries *(continued)*

Age group	*Indonesia*†		*Malaysia*				*Philippines*		*Thailand*		*Vietnam*			
	Male	*Female*	*Male*		*Female*		*Male*	*Female*	*Male*	*Female*	*Male*		*Female*	
			10%	*15%*	*10%*	*15%*					*10%*	*15%*	*10%*	*15%*
Elderly														
60–69 years old	9 (65-80yo)	8 (65-80yo)	14 (60-65yo)	9 (60-65yo)	11 (60-65y)	8 (60-65y)	12	10	11.0 (61-70yo)	10.0 (61-70yo)				
≥70 years old	9 (80+yo)	8 (80+yo)	14 (>65yo)	9 (>65yo)	11 (>65yo)	8 (>65yo)	12	10	11.0 (≥71yo)	10.0 (≥71yo)	11.0	7.3	9.4	6.3
Pregnancy														
1st trimester	-	+0	-	-	b	b	-	+10¶	-	c	-	-	+15 (d)	+10 (d)
2nd trimester	-	+9	-	-	b	b	-	+10¶	-	c	-	-	+15 (d)	+10 (d)
3rd trimester	-	+9	-	-	b	b	-	+10¶	-	c	-	-	+15 (d)	+10 (d)
Lactation														
1st 6 months	-	+0	-	-	+4	+2	-	+2	-	+3	-	-	Menopause 13.3	Menopause 8.9
2nd 6 months	-	+0	-	-	+4 (nm) +21 (m)	+2 (nm) +13 (m)	-	+2	-	+10	-	-	Return of menstruation 26.1	Return of menstruation 17.4

nm: non-menstruating; m: menstruating; mths: months; yo: years old
†It is assumed that 75% of the iron is from a haem iron source
‡Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
§Adequate intake
¶Requirement cannot be met by diet alone. Intake of iron-rich and iron-fortified foods and the use of supplements are recommended, if necessary.
% indicates iron bioavailability levels
a - No recommendations. Neonatal iron stores are sufficient to meet iron requirement for first 6 months in full-term infants. Premature infants and low birth weight infants require additional iron
b - Iron supplements in table form recommended for all pregnant women. In the non-anaemic pregnant women, daily supplements of 100mg iron given during second half of pregnancy are adequate. In the anaemic women, higher doses are usually required
c - pregnant women should receive 60 mg of iron supplement/day
d - Iron supplement is recommended for all pregnant women during pregnancy. Women with anaemia need a higher supplemental dose
Lactation recommendations for Malaysia are in addition to the amount recommended for women 51-59 years
Pregnancy and lactation recommendations for Philippines are in addition to the amount recommended for non-pregnant women 19-49 years
Pregnancy and lactation recommendations for Thailand are in addition to the amount recommended for women 51-60 years

the other hand, Thailand recommends that lactating/nursing mothers should receive 13 and 20 mg of dietary iron/day during 0-5 months and 6-11 months of lactation, respectively.

Iodine

Indonesia, Malaysia and Philippines provide an RDA/RNI for iodine intake for all age groups, whereas Thailand uses AIs for iodine intake recommendation. In Vietnam, AI amounts are provided for infants aged 0-11 months while RDA values are used for other age groups. The recommended iodine intake for Indonesia, Philippines, Thailand and Vietnam are rather similar for all age groups (Table 25). The amounts recommended increase with age, from 90-100 for infants, to 150 μg/day for adults and elderly. There are also no sex differences in the recommendations of these countries. The iodine recommendations by Malaysia are lower than those recommended by the other four countries for most age groups, and the intakes for males are generally higher than for females. All countries recommend additional iodine intake during pregnancy (200-250 μg/day) and lactation (200-290 μg/day).

Zinc

The RDAs/RNIs for zinc are presented in Table 26. For infants aged 0-5 months in Philippines, AI is used for the recommended values. Malaysia and Philippines recommend the zinc intakes based on zinc absorption of 30%. Thailand adjusted the value to Thai dietary pattern (mixed diet) with an average of 900 mg of phytate intake per day. Different from other countries, Vietnam provides recommendations for three levels of zinc bioavailability i.e. good absorption (50%), moderate absorption (30%) and poor absorption (15%). There are no major differences in the recommendations for infants, children and adolescents among the five countries, using the level for moderate absorption for Vietnam. There are greater variations in recommendations for adult and elderly groups, the amounts by Indonesia, Thailand and Vietnam (moderate absorption) are generally higher than those provided by Malaysia and Philippines. Females are recommended lower zinc intakes for all age groups, in all countries. All countries have recommended additional zinc intake for pregnant and lactating women, with varying amounts.

Sodium

Notable differences are observed for the sodium recommendation in these countries as well as the way the recommendations are presented (Table 27). Malaysia, Philippines and Thailand use AI amounts for recommendations for all age groups. Different from other countries, Thailand provide a sodium intake range for each age group, whereas the values recommended by Philippines are as electrolyte Na^+. Vietnam introduces dietary goal for sodium recommendations and listed both recommended needs and diet goals for each age group. It is observed that for the prevention and control of NCDs, countries generally keep the sodium recommendations to <2000 mg/day for adults and lower provisions are made for children and elderly.

Selenium

There are considerable variations in the selenium intake recommendations for all age groups by the five countries (Table 28). Thailand has made higher recommendations for selenium than other countries for all age groups. All countries provide RDA/RNI values for the recommendations for all age groups except the provision for infant aged 6-11 months by Thailand where AI amount is used. For infants, the

Table 25. RDAs/RNIs for iodine (µg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand[†]		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	90[‡]		67.5 (0-2mths) 105.0 (3-5mths)	63.0 (0-2mths) 96.0 (3-5mths)	90		Breast milk		100[†]	
6-11 months	120		124.5 (6-8mths) 138.0 (9-11mths)	114.0 (6-8mths) 127.5 (9-11mths)	90		70		130[†] (6-8mths) 130[†] (9-11mths)	
Children										
1-3 years old	90		73.2	69.0	90 (1-2yo)		90 (1-3yo)		90 (1-2yo)	
4-6 years old	120		109.8	109.2	90 (3-5yo)		90 (4-5yo)		90 (3-5yo)	
7-9 years old	120		101.6	100.0	120 (6-9yo)		90 (6-8yo)		90 (6-7 yo)	
Adolescent									120 (8-9yo)	
10-12 years old	120		133.6	141.6	120		120 (9-12yo)		120 (10-11yo)	
13-15 years old	150		99.2	93.0	150		130		120 (12-14yo)	
16-18 years old	150		118.4	100.6	150		130		150 (15-19yo)	
Adult										
19-29 years old	150		122.8	105.8	150		150 (19-30yo)		150 (20-29yo)	
30-49 years old	150		121.2 (30-50yo)	104.4 (30-50yo)	150		150 (31-50yo)		150	
50-59 years old	150 (50-64yo)		121.2 (50-59yo)	104.4 (50-59yo)	150		150 (51-60yo)		150 (50-69yo)	
Elderly										
60–69 years old	150 (65-80yo)		116.2 (60-65y)	99.0 (60-65y)	150		150 (61-70yo)			
≥70 years old	150 (80+yo)		116.2 (>65y)	99.0 (>65y)	150		150 (≥71yo)		150	
Pregnancy										
1st trimester	-	+70	-	+100	-	+100	-	+50	-	+70
2nd trimester	-	+70	-	+100	-	+100	-	+50	-	+70
3rd trimester	-	+70	-	+100	-	+100	-	+50	-	+70
Lactation										
13-19 years old	-	-	-	+100	-	-	-	-	-	-
1st 6 months	-	+140	-	+100	-	+100	-	+50	-	+100
2nd 6 months	-	+140	-	+100	-	+100	-	+50	-	+100

mths: months; yo: years old
[†] Adequate intake
[‡] Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
Pregnancy and lactation recommendations are in addition to the amount recommended for women 19-49 years

Table 26. RDAs/RNIs for zinc (mg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	1.1[†]		1.1 (bf); 2.8 (ff)		2.0[‡‡]		Breast milk		6.6[‡] (pa); 2.8[§] (ma); 1.1[¶] (ga)	
6-11 months	3		4.1	3.7	4.2	3.7	2.7		8.3[†] (pa); 4.1[††] (ma); 0.8[¶]-2.5[††] (ga) (6-8mths)	
									8.3[†] (pa); 4.1[††] (ma); 0.8[¶]-2.5[††] (ga) (9-11mths)	
Children										
1-3 years old	3		4.2	4.0	4.1 (1-2yo)	4.0 (1-2yo)	4.4 (1-3yo)		8.3 (pa); 4.1 (ma); 2.4 (ga) (1-2yo)	
4-6 years old	5		5.2		5.0 (3-5yo)	4.8 (3-5yo)	5.3 (4-5yo)		9.6 (pa); 4.8 (ma); 2.9 (ga) (3-5yo)	
7-9 years old	5		5.7	5.6	5.1 (6-9yo)	5.0 (6-9yo)	6.3 (6-8yo)		11.2; (pa)5.6 (ma); 3.3 (ga) (6-7yo)	
									12 (pa) 6.0 (ma) 3.3 (ga) (8-9yo)	11.2 (pa) 5.6 (ma) 3.3 (ga) (8-9yo)
Adolescent										
10-12 years old	8		7.0	6.3	6.6	6.1	9.5 (9-12yo)	9.0 (9-12yo)	17.2 (pa) 8.6 (ma) 5.1 (ga) (10-11yo)	14.4 (pa) 7.2 (ma) 4.3 (ga) (10-11yo)
13-15 years old	11	9	9.3	7.7	9.2	7.4	12.5	9.8	18.0 (pa) 9.0 (ma) 6.4 (ga) (12-14yo)	16.0 (pa) 8.0 (ma) 4.8 (ga) (12-14yo)
16-18 years old	11	9	9.9	7.7	9.0	7.2	12.9	9.8	20.0 (pa) 10.0 (ma) 6.0 (ga) (15-19yo)	16.0 (pa) 8.0 (ma) 4.8 (ga) (15-19yo)
Adult										
19-29 years old	11	8	6.6	4.7	6.5	4.6	11.6 (19-30yo)	9.7 (19-30yo)	20.0 (pa) 10.0 (ma) 6.0 (ga) (20-29yo)	16.0 (pa) 8.0 (ma) 4.8 (ga) (20-29yo)
30-49 years old	11	8	6.5 (30-50yo)	4.6 (30-50yo)	6.5	4.6	10.9 (31-50yo)	9.2 (31-50yo)	20.0 (pa) 10.0 (ma) 6.0 (ga)	16.0 (pa) 8.0 (ma) 4.8 (ga)
50-59 years old	11 (50-64yo)	8 (50-64yo)	6.5 (50-59yo)	4.6 (50-59yo)	6.5 (50-59yo)	4.6 (50-59yo)	10.9 (51-60yo)	9.2 (51-60yo)	20.0 (pa) 10.0 (ma) 6.0 (ga) (50-69yo)	16.0 (pa) 8.0 (ma) 4.8 (ga) (50-69yo)

Table 26. RDAs/RNIs for zinc (mg/day) in SEA countries *(continued)*

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Elderly										
60–69 years old	11 (65-80yo)	8 (65-80yo)	6.3 (60-65yo)	4.4	6.5	4.6	10.9 (61-70yo)	8.6 (61-70yo)		
≥70 years old	11 (80+yo)	8 (80+yo)	6.2 (>65yo)	4.3	6.5	4.6	10.3 (≥71yo)	8.6 (≥71yo)	18.0 (pa) 9.0 (ma) 5.4 (ga)	14.0 (pa) 7.0 (ma) 4.2 (ga)
Pregnancy										
1st trimester	-	+2	-	+0.9	-	+5.1	-	+1.6	-	+4.0 (pa) +2.0 (ma) +1.2 (ga)
2nd trimester	-	+4	-	+2.4	-	+5.1	-	+1.6	-	+4.0 (pa) +2.0 (ma) +1.2 (ga)
3rd trimester	-	+4	-	+5.4	-	+5.1	-	+1.6	-	+4.0 (pa) +2.0 (ma) +1.2 (ga)
Lactation										
1st 6 months	-	+5	-	+4.9 (1-3 months) +4.2 (4-6 months)	-	+7.0	-	+2.9	-	+6.0 (pa) +3.0 (ma) +1.8 (ga) (0-3 months) +6.0 (pa) +3.0 (ma) +1.8 (ga) (4-6 months)
2nd 6 months	-	+5	-	+2.6 (7-12 months)	-	+7.0	-	+2.9	-	+6.0 (pa) +3.0 (ma) +1.8 (ga) (7-12 months)

bf: breast fed; ff: formula fed; mths: months; yo: years old; ga; good absorption; ma: moderate absorption; pa: poor absorption
Good absorption: good biological value of zinc = 50% (diets high in animal or fish products); moderate absorption: average biological value of zinc = 30% (diet with moderate animal or fish products: molecular phytate-zinc ratio is 5: 15); poor absorption: low biological value of zinc = 15% (diet with little or no animal or fish products
Pregnancy and lactation recommendations for Malaysia are in addition to the amount recommended for women 30-50 years
†Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding
‡Children on formula milk, complementary foods high in phytates and plant source proteins
§Babies who consume formula and are partially breastfed or supplemented with low phytate and other milk solutions
¶Exclusive breastfed babies
††Not applicable to exclusively breastfed babies
‡‡Adequate intake

Table 27. RDAs/RNIs for sodium (mg/day) in SEA countries

Age group	Indonesia		Malaysia†		Philippines†‡		Thailand†		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	120§		120 (0-6mths)		120		Breast milk		100† (RN); 100 (DG)	
6-11 months	370		370 (7-12mths)		200		175-550		600† (RN); 600 (DG)	
Children										
1-3 years old	800		1000		225 (1-2yo)		225-675 (1-3yo)		<900 (DG) (1-2yo)	
4-6 years old	900		1200 (4-8yo)		300 (3-5yo)		300-900 (4-5yo)		<1100 (DG) (3-5yo)	
7-9 years old	1000				400 (6-9yo)		325-950 (6-8yo)		<1300 (DG) (6-7yo)	
									<1600 (DG) (8-9yo)	
Adolescent										
10-12 years old	1300	1400	1500 (9-13yo)		500		400-1175 (9-12yo)	350-1100 (9-12yo)	<1900 (DG) (10-11yo)	
13-15 years old	1500				500		500-1500	400-1250	<2000 (DG) (12-14yo)	
16-18 years old	1700	1600	1500 (14-18yo)		500		525-1600	425-1275	< 2000 (DG) (15-17yo)	
Adult										
19-29 years old	1500		1500		500		500-1475 (19-30yo)	400-1200 (19-30yo)	600 (RN); <2000 (DG) (18-29yo)	
30-49 years old	1500		1500 (30-50yo)		500		475-1450 (31-50yo)	400-1200 (31-50yo)	600 (RN); <2000 (DG)	
50-59 years old	1300 (50-64yo)	1400 (50-64yo)	1500 (51-59yo)		500		475-1450 (51-60yo)	400-1200 (51-60yo)	600 (RN); <2000 (DG) (50-69yo)	
Elderly										
60–69 years old	1100 (65-80yo)	1200 (65-80yo)	1500		500		475-1450 (61-70yo)	400-1200 (61-70yo)		
≥70 years old	1000 (80+yo)		1200		500		400-1200 (≥71yo)	350-1050 (≥71yo)	600 (RN); <2000 (DG)	
Pregnancy					-	-				
1st trimester	-	+0	-	+0 (14-50yo)			-	+50-200	-	< 2000 (DG) for pregnancy
2nd trimester	-	+0	-	+0 (14-50yo)			-	+50-200	-	
3rd trimester	-	+0	-	+0 (14-50yo)			-	+50-200	-	
Lactation					-	-				
1st 6 months	-	+0	-	+0 (14-50 yo)			-	+125-350	-	< 2000 (DG) for lactation
2nd 6 months	-	+0	-	+0 (14-50 yo)			-	+125-350	-	

RN: recommended needs; DG: dietary goals; mths: months; yo: years old
† Adequate intake
‡ As electrolyte Na+
§ Nutritional needs of infants 0-5 months are to be met by exclusive breastfeeding

Table 28. RDAs/RNIs for selenium (μg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	7[†]		6		7	6	Breast milk		6	
6-11 months	10		10	9	10	9	20[‡]		10 (6-8mths) 10 (9-11mths)	
Children										
1-3 years old	18		17	16	17 (1-2yo)	16 (1-2yo)	20 (1-3yo)		17 (1-2yo)	
4-6 years old	21		21		20 (3-5yo)		30 (4-5yo)		20 (3-5yo)	
7-9 years old	22		22	21	20 (6-9yo)	19 (6-9yo)	30 (6-8yo)		22 (6-7yo) 22 (8-9yo)	
Adolescent										
10-12 years old	22	19	21	19	21	23	40 (9-12yo)		32 (10-11yo)	26 (10-11yo)
13-15 years old	30	24	31	24	30	29	55 (13-15yo)		32 (12-14yo)	26 (12-14yo)
16-18 years old	36	26	27	26	37	32	55 (16-18yo)		32 (15-19yo)	26 (15-19yo)
Adult										
19-29 years old	30	24	32	25	38	33	55 (19-30yo)		34 (20-29yo)	26 (20-29yo)
30-49 years old	30	25	32 (30-50yo)	24 (30-50yo)	38	33	55 (31-50yo)		34	26
50-59 years old	30 (50-64yo)	25 (50-64yo)	32 (51-59yo)	24 (51-59yo)	38	33	55 (51-60yo)		34 (50-69yo)	26 (50-69yo)
Elderly										
60–69 years old	29 (65-80yo)	24 (65-80yo)	31 (60-65yo)	23	38	33	55 (61-70yo)			
≥70 years old	29 (80+yo)	24 (80+yo)	30 (>65yo)	23	38	33	55 (≥71yo)		33	25
Pregnancy										
1st trimester	-	+5	-	+0	-	+4	-	+5	-	+0
2nd trimester	-	+5	-	+2	-	+4	-	+5	-	+2
3rd trimester	-	+5	-	+4	-	+4	-	+5	-	+4
Lactation										
1st 6 months	-	+10	-	+9	-	+9	-	+15	-	+9
2nd 6 months	-	+10	-	+16	-	+9	-	+15	-	+16

mths: months; yo: years old
[†]Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding
[‡]Adequate intake
Malaysia's recommendation for pregnancy & lactation – in addition to those recommended for age 19-29

amount recommended by Thailand for infants aged 6-11 months (20 µg/day) is double the recommendations by other countries (9-10 µg/day). For children, the recommended amounts increase with age, with most countries (Indonesia, Thailand, and Vietnam) provide no differences for males and females (from 16-30 µg/day), whereas those recommended for Malaysian and Filipino male children aged 1-3 years and 7-9 years are marginally higher than those recommended for their female counterparts of the same age. For adolescents, adults and elderly, the recommendations vary considerably between countries, with amounts recommended generally higher for males, increase with age and lower recommendations for elderly. Different from other countries, Thailand recommends the same amount of selenium intake for individuals aged 13 years up to elderly (55 µg/day for both males and females). The additional amount recommended for pregnancy and lactation also vary considerably among the countries, ranging from +2 to +5 µg/day for pregnancy and +9 to +16 µg/day for lactation, respectively.

Phosphorus

Table 29 shows the recommendations for phosphorus by country. Malaysia, Philippines and Thailand use AI for phosphorus recommendations for infants. There are no large variations in phosphorus recommendations by all five countries for most age groups. In all countries, males and females shared the same recommendations. For infants aged 6-11 months, Vietnam used different age groupings with separate recommendations for infants aged 6-8 months (275 mg/day) and 9-11 months (330 mg/day) respectively, while other four countries have the same recommendations for infants aged 6-11 months (275 mg/day). In all countries, the highest recommendations are provided for adolescents' groups. Vietnam's phosphorus recommendations for adolescents are generally lower (1000 mg/day) as compared to the other four countries (1250 mg/day). Similar intakes are recommended for adults and elderly (700 mg/day). No additional intakes are recommended for pregnant and lactating women in all five countries.

Potassium

There are notable differences observed in the recommendations for potassium intakes (Table 30). While Indonesia and Malaysia provide RDA/RNI recommendations, AI is used for potassium recommendations in Philippines, Thailand and Vietnam. Different from other countries, Thailand provides a potassium intake range for all age groups. In Indonesia, Thailand and Vietnam, the highest recommended potassium requirements are for the males and females in the 16-18 years group. For almost all age groups except infants, the amounts recommended by Indonesia and Malaysia (ranging from 2600 – 5300 mg/day) are double the AI values provided by Philippines, Thailand and Vietnam (ranging from 900 – 4500 mg/day). In addition to recommended AIs, Vietnam also provides dietary goals for potassium intakes for population aged 4 years and above, with the recommended amounts ranging from >1870 to >2720 mg/day for children, >3230 to 3510 mg/day for adolescents, and >3510 mg/day for adults and elderly. These dietary goal values are 5-80% higher than the AI recommendations. Most countries have no additional recommendation for pregnancy with the exception of Thailand, which suggested additional intake of 350-575 mg/day for second and third trimesters. For teenage pregnancy, Malaysia recommended

Table 29. RDAs/RNIs for phosphorus (mg/day) in SEA countries

Age group	*Indonesia*		*Malaysia*		*Philippines*		*Thailand*		*Vietnam*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	100‡		100† (0-6mths)		90†		Breast milk		100	
6-11 months	275		275† (7-12mths)		275†		275†		275 (6-8mths) 330 (9-11mths)	
Children										
1-3 years old	460		460 (1-3yo)		460 (1-2yo)		460 (1-3yo)		460 (1-2yo)	
4-6 years old	500		500 (4-8yo)		500 (3-5yo)		500 (4-5yo)		500 (3-5yo)	
7-9 years old	500				500 (6-9yo)		500 (6-8yo)		500 (6-7yo) 500 (8-9yo)	
Adolescent										
10-12 years old	1250		1250 (9-13yo)		1250		1000 (9-12yo)		1250 (10-11yo)	
13-15 years old	1250		1250 (14-18yo)		1250		1000		1250 (12-14yo)	
16-18 years old	1250				1250		1000		1250 (15-19yo)	
Adult										
19-29 years old	700		700		700		700 (19-30yo)		700 (20-29yo)	
30-49 years old	700		700 (30-50yo)		700		700 (31-50yo)		700	
50-59 years old	700 (50-64yo)		700 (51-59yo)		700		700 (51-60yo)		700 (50-69yo)	
Elderly										
60–69 years old	700 (65-80yo)		700		700		700 (61-70yo)			
≥70 years old	700 (80+yo)		700		700		700 (≥71yo)		700	
Pregnancy										
1st trimester	-	+0	-	+0 (14-50yo)	-	+0	-	+0	-	+0
2nd trimester	-	+0	-	+0 (14-50yo)	-	+0	-	+0	-	+0
3rd trimester	-	+0	-	+0 (14-50yo)	-	+0	-	+0	-	+0
Lactation										
1st 6 months	-	+0	-	+0 (14-50yo)	-	+0	-	+0	-	+0
2nd 6 months	-	+0	-	+0 (14-50yo)	-	+0	-	+0	-	+0

mths: months; yo: years old
†Adequate intake
‡Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 30. RDAs/RNIs for potassium (mg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines†		Thailand†		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants										
0-5 months	400‡		400 (0-6mths)		500		Breastmilk		400†	
6-11 months	700		700 (7-12mths)		700		925-1550		700† (6-8mths) 700† (9-11mths)	
Children										
1-3 years old	2600		3000		1000 (1-2yo)		1175-1950 (1-3yo)		900† (1-2yo)	
4-6 years old	2700		3800 (4-8y)		1400 (3-5yo)		1525-2550 (4-5yo)		1100† ; >1870§ (3-5yo)	
7-9 years old	3200				1600 (6-9yo)		1625-2725 (6-8yo)		1300†; >2210§ (6-7yo) 1600†; >2720§ (8-9yo)	1200†; >2210§ (6-7yo) 1500† ; >2720§ (8-9yo)
Adolescent										
10-12 years old	3900	4400	4500 (9-13yo)		2000		1975-3325 (9-12yo)	1875-3125 (9-12yo)	1900†; >3230§ (10-11yo)	1800†; >3230§ (10-11yo)
13-15 years old	4800				2000		2450-4100 (13-15yo)	2100-3500 (13-15yo)	2400†; >3400§ (12-14yo)	2200†; >3400§ (12-14yo)
16-18 years old	5300	5000	4700 (14-18yo)		2000		2700-4500 (16-18yo)	2150-3600 (16-18yo)	2800†; >3510§ (15-19yo)	2100†; >3510§ (15-19yo)
Adult										
19-29 years old	4700		4700		2000		2524-4200 (19-30yo)	2050-3400 (19-30yo)	2500†; >3510§ (20-29yo)	2000†; >3510§ (20-29yo)
30-49 years old	4700		4700 (30-50yo)		2000 (30-49yo)		2450-4100 (31-50yo)	2050-3400 (31-50yo)	2500†; >3510§ (30-49yo)	2000†; >3510§ (30-49yo)
50-59 years old	4700 (50-64yo)		4700 (51-59yo)		2000		2450-4100 (51-60yo)	2050-3400 (51-60yo)	2500†; >3510§ (50-69yo)	2000†; >3510§ (50-69yo)
Elderly										
60–69 years old	4700 (65-80yo)		4700		2000		2450-4100 (61-70yo)	2050-3400 (61-70yo)		
≥70 years old	4700 (80+yo)		4700		2000		2050-3400 (≥71yo)	1825-3025 (≥71yo)	2500†; >3510§ (≥70)	2000†; >3510§ (≥70)
Pregnancy					-	-				
1st trimester	-	+0	-	+0 (14-50yo)			-	+0	-	2000†; >3510§ for pregnancy
2nd trimester	-	+0	-	+0 (14-50yo)			-	+350-575	-	
3rd trimester	-	+0	-	+0 (14-50yo)			-	+350-575	-	
Lactation					-	-				
1st 6 months	-	+400	-	+400 (14-50yo)			-	+575-975	-	2000†; >3510§ for lactation
2nd 6 months	-	+400	-	+400 (14-50yo)			-	+575-975	-	

mths: months; yo: years old1
† Adequate intake
‡ Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding
§ Dietary goals
Malaysia: Recommendations given in g/day; the values are converted to mg/day for comparison

+400 mg/day. For lactation, both Indonesia and Malaysia suggested additional intake of +400 mg/day while Thailand recommends +575-975 mg/day. Vietnam recommends an AI of 2000mg/day and dietary goal of >3510 mg/day for both pregnant and lactating women, which are no different from non-pregnant/non-lactating adult women.

Magnesium

The RDAs/RNIs for magnesium for the countries are presented in Table 31. Malaysia, Philippines and Thailand use AI for magnesium recommendations for infants. Philippines has made lower magnesium recommendations for magnesium than other countries for all age groups. Generally, in all countries, there are no differences between recommendations for males and females for younger age groups (infants and children). From 10 years onwards, for all countries, the recommendations for males are generally marginally higher than those for females. For infants aged 6-11 months, the amounts recommended by Malaysia (75 mg/day) is higher than other countries (which range from 50-60 mg/day). For children aged 1-9 years, Philippines recommends intakes of 60-90 mg/day while others recommend higher intakes ranging from 60-240 mg/day. For adolescents, adults and elderly, the amounts recommended by Malaysia (240-420 mg/day) are almost double than those provided by Philippines (150-240 mg/day), while recommendations by other three countries range from 160-360 mg/day). Indonesia, Thailand and Vietnam have recommended lower daily magnesium intake for age group of 70 and above compared to the adults. The recommendations for additional magnesium intake during pregnancy range from +30-40 mg/day in Malaysia, Thailand and Vietnam, while no additional intake is recommended by Indonesia and Philippines. Malaysia provides a recommendation of +40 mg/day for teenage pregnancy (14-18 years old), an additional amount that is similar to adult pregnancy. Only Philippines provide for additional magnesium for lactating women (+50 mg/day).

Chromium

All countries except Philippines provide recommendations for chromium intake (Table 32). Malaysia, Thailand and Vietnam use AI for the recommendations. While there are differences in the way countries categorise age groups for each physiological stage, the chromium recommendations by Malaysia, Thailand and Vietnam are similar for all stages, from infants to elderly groups. The amounts recommended increase with age, from 0.2-5.5 μg/day for infants, to 25-35 μg/day for adults. Chromium intake recommendations by Indonesia for all age groups are slightly higher than those provided by other three countries, with the highest recommendation for male adolescents aged 16-18 years old (41 μg/day). For all countries, lower amounts are recommended for adults aged 50 years and above (19-30 μg/day). There are no differences in recommendations according to sex for infants and children groups. For adolescents, adults and elderly groups, the recommendations for male are considerably higher than for female for the four countries. In terms of additional provision for pregnancy, all four countries respectively recommend +5 μg/day, except for Vietnam, which recommends marginally lower additional intake of +4 μg/day. The additional intake recommendation for teenage pregnancy by Malaysia is similar to those recommended for adults, i.e. +5 μg/day. For lactating women, all four countries recommend a same additional

Table 31. RDAs/RNIs for magnesium (mg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand		Vietnam	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants										
0-5 months	30†		30‡ (0-6mths)		26‡		Breast milk		40	
6-11 months	55		75‡ (7-12mths)		50‡		60‡		50 (6-8mths)	
									60 (9-11mths)	
Children										
1-3 years old	65		80		60 (1-2yo)		60 (1-3yo)		70 (1-2yo)	
4-6 years old	95		130 (4-8)		70 (3-5yo)		80 (4-5yo)		100 (3-5yo)	
7-9 years old	135				90 (6-9yo)		120 (6-8yo)		130 (6-7yo)	
									170 (8-9yo)	160 (8-9yo)
Adolescent										
10-12 years old	160	170	240 (9-13)		150	160	170 (9-12yo)		210 (10-11yo)	
13-15 years old	225	220	410 (14-18)		220	210	240	220	290 (12-14yo)	280 (12-14yo)
16-18 years old	270	230			265	230	290	250	350 (15-19yo)	300 (15-19yo)
Adult										
19-29 years old	360	330	400	310	240	210	310 (19-30yo)	250 (19-30yo)	340 (20-29yo)	270 (20-29yo)
30-49 years old	360	340	420 (30-50yo)	320 (30-50yo)	240	210	320 (31-50yo)	260 (31-50yo)	370	290
50-59 years old	360 (50-64yo)	340 (50-64yo)	420 (51-59yo)		240	210	300 (51-60yo)	260 (51-60yo)	350 (50-69yo)	290 (50-69yo)
Elderly										
60–69 years old	350 (65-80yo)	320 (65-80yo)	420		240	210	300 (61-70yo)	260 (61-70yo)		
≥70 years old	350 (80+yo)	320 (80+yo)	420	320	240	210	280 (≥71yo)	240 (≥71yo)	320	260
Pregnancy										
1st trimester	-	+0	-	+40 (14-50yo)	-	+0	-	+30	-	+40
2nd trimester	-	+0	-	+40 (14-50yo)	-	+0	-	+30	-	+40
3rd trimester	-	+0	-	+40 (14-50yo)	-	+0	-	+30	-	+40
Lactation		+0								
1st 6 months	-	+0	-	+0 (14-50yo)	-	+50	-	+0	-	+0
2nd 6 months	-	+0	-	+0 (14-50yo)	-	+50	-	+0	-	+0

mths: months; yo: years old
†Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding
‡Adequate intake
Malaysia pregnancy – in addition to the value of the same age group

Table 32. RDAs/RNIs for chromium (μg/day) in SEA countries

Age group	Indonesia		Malaysia‡		Philippines†		Thailand‡		Vietnam‡	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants					-	-				
0-5 months	0.2§		0.2 (0-6mths)				Breast milk		0.2	
6-11 months	6		5.5 (7-12mths)				5.5		5.5	
Children					-	-				
1-3 years old	14		11				11 (1-3yo)		11 (1-2yo)	
4-6 years old	16						15 (4-5yo)		15 (3-5yo)	
7-9 years old	21		15 (4-8)				15 (6-8yo)		15 (6-7yo)	
									25 (8-9yo)	21 (8-9yo)
Adolescent					-	-				
10-12 years old	28	26	25 (9-13)	21 (9-13)			25 (9-12yo)	21(9-12yo)	25 (10-11yo)	21 (10-11yo)
13-15 years old	36	27	35 (14-18)	24 (14-18)			35 (13-15yo)	24 (13-15yo)	25 (12-14yo)	21 (12-14yo)
16-18 years old	41	29					35 (16-18yo)	24 (16-18yo)	35 (15-17yo)	24 (15-17yo)
Adult					-	-				
19-29 years old	36	30	35	25			35 (19-30yo)	25 (19-30yo)	35 (18-29yo)	25 (18-29yo)
30-49 years old	34	29	35 (30-50yo)	25 (30-50yo)			35 (31-50yo)	25 (31-50yo)	35	25
50-59 years old	29 (50-64yo)	24 (50-64yo)	30 (51-59yo)	20 (51-59yo)			30 (51-60yo)	20 (51-60yo)	30 (50-69yo)	20 (50-69yo)
Elderly					-	-				
60–69 years old	24 (65-80yo)	21 (65-80yo)	30	20			30 (61-70yo)	20 (61-70yo)		
≥70 years old	31 (80+yo)	19 (80+yo)	30	20			30 (≥71yo)	20 (≥71yo)	30	20
Pregnancy					-	-				
1st trimester	-	+5	-	+5 (14-50yo)			-	+5	-	+4
2nd trimester	-	+5	-	+5 (14-50yo)			-	+5	-	+4
3rd trimester	-	+5		+5 (14-50yo)			-	+5	-	+4
Lactation			-		-	-				
1st 6 months	-	+20	-	+20 (14-50yo)			-	+20	-	+20
2nd 6 months	-	+20	-	+20 (14-50yo)			-	+20	-	+20

mths: months; yo: years old
†No recommendations for chromium
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

amount of +20 µg/day, which is four times higher than the additional amount recommended during pregnancy.

Copper

Table 33 lists the recommended copper intake values by Indonesia, Malaysia, Thailand and Vietnam. No recommended intake values for copper are provided by Philippines. Thailand uses AI values for copper intake recommendations for all age groups, while Malaysia and Vietnam use AI values only for the recommendations for infant groups. Of the four countries, the majority (Indonesia, Malaysia and Vietnam) shared similar recommendations across all age groups, with the amounts recommended increasing with age (200-220 µg/day for infants, 340-700 µg/day for children, 700-890 µg/day for adolescent, 900 µg/day for adult and elderly). There are also no sex differences in the recommendations of these countries. Compared to the recommendations by the other three countries, the provisions by Thailand are higher for all age groups as, ranging from 400 µg/day for infant, 700-1000 µg/day for children, 1000-1300 for adolescent, and 1300-1600 µg/day for adults and elderly. There are also notable differences in Thailand's recommendations for groups aged 11 years and above in which the recommended intake values provided for males are considerably higher than those provided for females. All four countries recommend additional copper intake for pregnant and lactating women, with Vietnam providing an additional amount of +200 µg/day. Recommendations by Indonesia, Malaysia and Vietnam are rather different. The amount recommended for these three countries for pregnancy is 100-110 µg/day, whereas during lactation, the amount recommended is four times higher, at +400 µg/day.

Manganese

There are no recommendations for manganese intake in the Philippines. Malaysia, Thailand and Vietnam use AI values for manganese intake recommendations for all age groups. Table 34 shows that Indonesia, Malaysia and Vietnam generally provide similar manganese recommendations for most age groups. For infants and children, male and female groups share the same recommendations except for children aged 8-9 years old in Vietnam where higher daily amount of manganese is recommended for males (1.8 mg/day) than females (1.6 mg/day). On the other hand, Thailand has lower manganese intake recommendations for infants aged ≥6 months and children (0.4-1.1 mg/day) as compared to the similar age groups of the other three countries (0.6-1.9 mg/day). For adolescents, adults and elderly, the recommendations for males (1.9-2.3 mg/day) are slightly higher than for females (1.6-1.8 mg/day) in Indonesia, Malaysia and Vietnam. Thailand has the highest manganese recommendation for the 16-18 years group (2.5 mg/day) and remained the same for adults and elderly groups. There are also no differences in Thailand's recommendations according to sex. While there are no additional manganese recommendations for pregnancy and lactation by Thailand, the other three countries respectively recommend +0.2 mg/day for pregnancy and +0.8 mg/day for lactation. The same recommendations are provided for teenage pregnancy in Malaysia (14-18 years group).

Fluoride

Table 35 presents the recommendations for fluoride by country. No recommendations for fluoride intake is provided by Thailand. AI is used for fluoride intake recommendations in Malaysia, Philippines and Vietnam. In

Table 33. RDAs/RNIs for copper (μg/day) in SEA countries

Age group	Indonesia		Malaysia		Philippines		Thailand†,‡		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants					-	-				
0-5 months	200§		200‡ (0-6mths)				Breast milk		200‡ (0-5mths)	
6-11 months	220		220‡ (7-12mths)				400		220‡ (6-8mths) 220‡ (9-11mths)	
Children					-	-				
1-3 years old	340		340				700 (1-3yo)		340 (1-2yo)	
4-6 years old	440		440 (4-8yo)				1000 (4-5yo)		440 (3-5yo)	
7-9 years old	570						1000 (6-8yo)		440 (6-7yo) 700 (8-9yo)	
Adolescent					-	-				
10-12 years old	700		700 (9-13yo)				1000 (9-10yo) 1300 (11-12yo)	1000 (9-10yo) 1100 (11-12yo)	700 (10-11yo)	
13-15 years old	795		890 (14-18yo)				1300	1100	700 (12-14yo)	
16-18 years old	890						1300	1100	890 (15-19yo)	
Adult					-	-				
19-29 years old	900		900				1600 (19-30yo)	1300 (19-30yo)	900 (20-29yo)	
30-49 years old	900		900 (30-50yo)				1600 (31-50yo)	1300 (31-50yo)	900	
50-59 years old	900 (50-64yo)		900 (51-59yo)				1600 (51-60yo)	1300 (51-60yo)	900 (50-69yo)	
Elderly					-	-				
60–69 years old	900 (65-80yo)		900				1600 (61-70yo)	1300 (61-70yo)		
≥70 years old	900 (80+yo)		900				1600 (≥71yo)	1300 (≥71yo)	900	
Pregnancy					-	-				
1st trimester	-	+100	-	+110 (14-18yo) +100 (19-50yo)			-	+200	-	+100
2nd trimester	-	+100	-	+110 (14-18yo) +100 (19-50yo)			-	+200	-	+100
3rd trimester	-	+100	-	+110 (14-18yo) +100 (19-50yo)			-	+200	-	+100
Lactation					-	-				
1st 6 months	-	+400	-	+410 (14-18yo) +400 (19-50yo)			-	+200	-	+400
2nd 6 months	-	+400	-	+410 (14-18yo) +400 (19-50yo)			-	+200	-	+400

mths: months; yo: years old
† mg/day Thailand: Recommendations given in mg/day; the values are converted to μg/day for comparison
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 34. RDAs/RNIs for manganese (mg/day) in SEA countries

Age group	Indonesia		Malaysia[†]		Philippines		Thailand[†]		Vietnam[†]	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants					-	-				
0-5 months	0.003[‡]		0.003 (0-6mths)				Breast milk		0.003	
6-11 months	0.7		0.6 (7-12mths)				0.4		0.6 (6-8mths) 0.6 (9-11mths)	
Children					-	-				
1-3 years old	1.2		1.2				0.6 (1-3yo)		1.2 (1-2yo)	
4-6 years old	1.5		1.5 (4-8yo)				0.8 (4-5yo)		1.5 (3-5yo)	
7-9 years old	1.7						1.1 (6-8yo)		1.5 (6-7yo)	
									1.9 (8-9yo)	1.6 (8-9yo)
Adolescent					-	-				
10-12 years old	1.9	1.6	1.9 (9-13yo)	1.6 (9-13yo)			1.6 (9-12yo)		1.9 (10-11yo)	1.6 (10-11yo)
13-15 years old	2.2	1.6	2.2 (14-18yo)	1.6 (14-18yo)			2.2 (13-15yo)		1.9 (12-14yo)	1.6 (12-14yo)
16-18 years old	2.3	1.8					2.5 (16-18yo)		2.2 (15-19yo)	1.6 (15-19yo)
Adult					-	-				
19-29 years old	2.3	1.8	2.3	1.8			2.5 (19-30yo)		2.3 (20-29yo)	1.8 (20-29yo)
30-49 years old	2.3	1.8	2.3 (30-50yo)	1.8 (30-50yo)			2.5 (31-50yo)		2.3	1.8
50-59 years old	2.3 (50-64yo)	1.8 (50-64yo)	2.3 (51-59yo)	1.8 (51-59yo)			2.5 (51-60yo)		2.3 (50-69yo)	1.8 (50-69yo)
Elderly					-	-				
60–69 years old	2.3 (65-80yo)	1.8 (65-80yo)	2.3	1.8			2.5 (61-70yo)			
≥70 years old	2.3 (80+yo)	1.8 (80+yo)	2.3	1.8			2.5 (≥71yo)		2.3	1.8
Pregnancy					-	-				
1st trimester	-	+0.2	-	+0.4 (14-18yo) +0.2 (19-50yo)			-	+0	-	+0.2
2nd trimester	-	+0.2	-	+0.4 (14-18yo) +0.2 (19-50yo)			-	+0	-	+0.2
3rd trimester	-	+0.2	-	+0.4 (14-18yo) +0.2 (19-50yo)			-	+0	-	+0.2
Lactation					-	-				
1st 6 months	-	+0.8	-	+1.0 (14-18yo) +0.8 (19-50yo)			-	+0	-	+0.8
2nd 6 months	-	+0.8	-	+1.0 (14-18yo) +0.8 (19-50yo)			-	+0	-	+0.8

mths: months; yo: years old
[†] Adequate intake
[‡] Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

Table 35. RDAs/RNIs for fluoride (mg/day) in SEA countries

Age group	Indonesia		Malaysia‡		Philippines‡		Thailand†		Vietnam‡	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants							-	-		
0-5 months	0.01§		0.01 (0-6mths)		0.01				0.01	
6-11 months	0.5		0.5 (7-12mths)		0.5	0.4			0.5 (6-8mths) 0.5 (6-8mths)	
Children							-	-		
1-3 years old	0.7		0.7 (1-3yo)		0.6 (1-2yo)				0.7 (1-2yo)	
4-6 years old	1.0		1.0 (4-8yo)		0.9 (3-5yo)				1 (3-5yo)	
7-9 years old	1.4				1.2 (6-9yo)	1.1 (6-9yo)			1 (6-7yo) 2 (8-9yo)	
Adolescent							-	-		
10-12 years old	1.8	1.9	2.0 (9-13yo)		1.7	1.8			2 (10-11yo)	
13-15 years old	2.5	2.4	3.0 (14-18yo)		2.4	2.3			2 (12-14yo)	
16-18 years old	4.0	3.0			3.0	2.6			3 (15-19yo)	
Adult							-	-		
19-29 years old	4.0	3.0	4.0	3.0	3.0	2.6			4 (20-29yo)	3 (20-29yo)
30-49 years old	4.0	3.0	4.0 (30-50yo)	3.0 (30-50yo)	3.0	2.6			4	3
50-59 years old	4.0 (50-64yo)	3.0 (50-64yo)	4.0 (51-59yo)	3.0 (51-59yo)	3.0	2.6			4 (50-69yo)	3 (50-69yo)
Elderly							-	-		
60–69 years old	4.0 (65-80yo)	3.0 (65-80yo)	4.0	3.0	3.0	2.6				
≥70 years old	4.0 (80+yo)	3.0 (80+yo)	4.0	3.0	3.0	2.6			4	3
Pregnancy							-	-		
1st trimester	-	+0	-	+0 (14-50yo)	-	+0			-	+0
2nd trimester	-	+0	-	+0 (14-50yo)	-	+0			-	+0
3rd trimester	-	+0	-	+0 (14-50yo)	-	+0			-	+0
Lactation			-				-	-		
1st 6 months	-	+0	-	+0 (14-50yo)	-	+0			-	+0
2nd 6 months	-	+0	-	+0 (14-50yo)	-	+0			-	+0

mths: months; yo: years old
†No recommendations for fluoride
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding

general, there are no great variations in fluoride recommendation of Indonesia, Malaysia and Vietnam for infants (0.01-0.5 mg/day), children (0.7-2.0 mg/day), adults and elderly (3-4 mg/day) groups. Philippines fluoride's recommendations for children (0.6-1.2 mg/day), adults and elderly (2.6-3.0 mg/day) groups are generally lower as compared to the other countries. Considerable differences in recommendations for adolescents are observed among the countries. Recommendations for male are slightly higher than those for female adolescents for Indonesia and Philippines while male and female adolescents in Malaysia and Vietnam share the same recommendations. None of the four countries recommend additional fluoride intake during pregnancy and lactation.

Chloride

Of the five countries studied, only Malaysia has no provision for chloride intake recommendations. Notable differences are observed for the chloride recommendations in the other four countries and the way the recommendations are presented (Table 36). While Thailand provides a chloride-adequate intake range for each age group, Vietnam uses AI and/or dietary goals for chloride intake recommendations for different age groups. For infants aged 6-11 months, Vietnam has the highest chloride recommendations with the recommended adequate intake values triple that of Philippines and double that of Indonesia and Thailand. For children, adolescents, adults and elderly, Indonesia has recommendations that are 2-3 times higher than those provided by Philippines and Thailand. On the other hand, Vietnam sets dietary goals of <1300-<2300 mg/day for children and <2800-<2900 mg/day for adolescents. Both adequate intake amount of 900 mg/day and a dietary goal of <2900 mg/day are provided for adults and elderly in Vietnam. Only Thailand has provided additional chloride intake recommendations for pregnancy and lactation, the intakes recommended range from +100 to +200 mg/day for pregnancy and +175 to +350 mg/day for lactation.

Molybdenum

Only Malaysia and Thailand provide RDA/RNI values for molybdenum; whereas AI is used for the recommendations for infants in Malaysia (Table 37). In both countries, there are no differences in recommendations according to sex for all age groups. The recommended intake values by Thailand are higher than those provided by Malaysia for infants, adolescents, adult and elderly groups. For infants age 6-11 months, the recommended intake value by Thailand (10 μg/day) is triple that of Malaysia (3 μg/day). Thailand has slightly lower molybdenum intake recommendations for children aged 1-5 years old (15-20 μg/day) as compared to the similar age groups of Malaysia (17-22 μg/day). The recommendations by both countries increase with age, with the highest recommendations for adolescents aged 16-18 and remained the same for adults and elderly groups. This highest recommended values are higher in Thailand (55 μg/day) than in Malaysia (45 μg/day). Only Malaysia listed additional molybdenum intake for pregnancy and lactation, i.e. +5 μg/day throughout pregnancy and lactating period for adults and +7 μg/day throughout pregnancy and lactating period for teenagers aged 14-18 years old.

DISCUSSION

Establishment of recommended nutrient intakes in SEA countries

The nutrition scene in the SEA has indeed changed dramatically over the

Table 36. RDAs/RNIs for chloride (mg/day) in SEA countries

Age group	Indonesia		Malaysia[†]		Philippines[‡]		Thailand[‡]		Vietnam	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Infants			-	-						
0-5 months	180[§]				180		Breast milk		150[‡]	
6-11 months	570				300		275-550		900[‡] (6-8mths), 900[‡] (9-11mths)	
Children			-	-						
1-3 years old	1200				350 (1-2yo)		350-700 (1-3yo)		<1300[¶] (1-2yo)	
4-6 years old	1300				500 (3-5yo)		450-900 (4-5yo)		<1600[¶] (3-5yo)	
7-9 years old	1500				600 (6-9yo)		500-975 (6-8yo)		<1900[¶] (6-7yo) <2300[¶] (8-9yo)	
Adolescent			-	-						
10-12 years old	1900	2100			750		600-1200 (9-12yo)	550-1125 (9-12yo)	<2800[¶] (10-11yo)	
13-15 years old	2300	2300			750		750-1500 (13-15yo)	625-1250 (13-15yo)	<2900[¶] (12-14yo)	
16-18 years old	1500	2400			750		825-1650 (16-18yo)	650-1300 (16-18yo)	<2900[¶] (15-19yo)	
Adult			-	-						
19-29 years old	2250				750		750-1500 (19-30yo)	600-1225 (19-30yo)	900[‡]; <2900[¶] (20-29yo)	
30-49 years old	2250				750		725-1475 (31-50yo)	600-1225 (31-50yo)	900[‡]; <2900[¶]	
50-59 years old	2100 (50-64yo)				750 (50-59yo)		725-1475 (51-60yo)	600-1225 (51-60yo)	900[‡]; <2900[¶] (50-69yo)	
Elderly			-	-						
60–69 years old	1900 (65-80yo)				750		725-1475 (61-70yo)	600-1225 (61-70yo)		
≥70 years old	1600 (80+yo)				750		600-1225 (≥71yo)	600-1075 (≥71yo)	900[‡]; <2900[¶]	
Pregnancy			-	-	-	-			-	-
1st trimester	-	+0					-	+0		
2nd trimester	-	+0					-	+100-200		
3rd trimester	-	+0					-	+100-200		
Lactation			-	-	-	-			-	-
1st 6 months	-	+0					-	+175-350		
2nd 6 months	-	+0					-	+175-350		

mths: months; yo: years old
†No recommendations for chloride
‡Adequate intake
§Fulfilment of the nutritional needs of infants 0-5 months comes from exclusive breastfeeding
¶Dietary goals

Table 37. RDAs/RNIs for molybdenum (μg/day) in SEA countries

Age group	*Indonesia*†		*Malaysia*‡		*Philippines*†		*Thailand*‡		*Vietnam*†	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*	*Male*	*Female*
Infants	-	-			-	-			-	-
0-5 months			2 (0-6mths)				Breast milk			
6-11 months			3 (7-12mths)				10			
Children	-	-			-	-			-	-
1-3 years old			17 (1-3yo)				15 (1-3yo)			
4-6 years old			22 (4-8yo)				20 (4-5yo)			
7-9 years old							25 (6-8yo)			
Adolescent	-	-			-	-			-	-
10-12 years old			34 (9-13yo)				35 (9-12yo)			
13-15 years old			43 (14-18yo)				50 (13-15yo)			
16-18 years old							55 (16-18yo)			
Adult	-	-			-	-			-	-
19-29 years old			45				55 (19-30yo)			
30-49 years old			45 (30-50yo)				55 (31-50yo)			
50-59 years old			45 (51-59yo)				55 (51-60yo)			
Elderly	-	-			-	-			-	-
60–69 years old			45				55 (61-70yo)			
≥70 years old			45				55 (≥71yo)			
Pregnancy	-	-			-	-			-	-
1st trimester			-	+7 (14-18yo) +5 (19-50yo)			-	+0		
2nd trimester			-	+7 (14-18yo) +5 (19-50yo)			-	+0		
3rd trimester			-	+7 (14-18yo) +5 (19-50yo)			-	+0		
Lactation	-	-			-	-			-	-
1st 6 months			-	+7 (14-18yo) +5 (19-50yo)			-	+0		
2nd 6 months			-	+7 (14-18yo) +5 (19-50yo)			-	+0		

mths: months; yo: years old
†No recommendations for molybdenum
‡Adequate intake

decades. Countries in the region have made substantial economic growth and seen improvements in food and nutrition security over the past decades. However, this progress has not brought equitable or uniform outcomes among different groups within the countries. Individuals and families in these countries are still facing economic, physical, social and cultural barriers to consuming nutritious diets and accessing adequate health and nutrition services (ASEAN/UNICEF/WHO, 2016; ASEAN, 2022). While the prevalence of undernutrition, vitamin and mineral deficiencies are declining gradually, there is a significant rise in overweight and obesity across many age groups, as well as the associated increase in NCDs (WHO, 2022). This double burden of malnutrition that is increasingly existing side by side across countries in the region has highlighted to the countries the importance of developing appropriate recommendations for energy and nutrient intake to the population. These have become vital tools for various food and nutrition activities of countries in the region, including assessing adequacy or potentially excessive intakes of energy and nutrients.

The availability of the recommended intake documents in the five SEA countries studied demonstrate that these countries recognise the need for such recommendations. The development of such documents in these countries have started decades ago, with the earliest dating from 1941 (Philippines) with close to eight decades of history. The recommended intake documents of these countries have all undergone revision periodically (every 5 to 10 years) as the countries recognise the continuous changes in scientific knowledge and the need to keep them updated in the light of the most up-to-date scientific evidence. Thus, the five current documents used in this review are all relatively recent, with most published in or after 2016.

Comparing recommended energy and nutrient intakes

Examining the recommended intake documents of the five countries it can be observed that there are several similarities in their essential attributes. Firstly, these documents have been published by nutrition and health authorities in the respective country through an extensive review process. Four out of five countries share a similar format of publication i.e. as a multi-chapter monograph with similar chapters providing detailed information for each nutrient). The exception is Indonesia’s document, which was published as a government gazette with less background information. It is also noted that these official recommended intake documents serve similar uses by multi-stakeholders in the respective country. These documents also show similarities in concepts and definitions used to establish recommendations on nutrient intakes (e.g. RNI, RDA, AI, EAR, UL).

While all five countries’ recommended energy and nutrient intakes values covered all ages in the entire life cycle, the age groups adopted differ among countries, especially for the children, adolescents and elderly groups. This is due to differences in defining population groups among these countries. However, the derivation of the age groupings is not clearly described in the publication of most of these countries; only Philippines describes the rationale for each of the age groups defined. In the meantime, the reference weight and height for adults adopted by these countries are largely different as countries make use of the average height data obtained from the national nutrition surveys in deriving the reference weight used. On the other hand, in terms of the reference weight used for children and adolescents, most countries referred to the WHO child growth standard and WHO growth reference.

The nutrients covered in the documents of the five countries are strikingly similar. All countries provide recommendations for macronutrient energy, protein, carbohydrate and fats. Out of the 14 vitamins included in this review, 11 of them (vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin B9, vitamin B12, vitamin C, vitamin A, vitamin D, vitamin E and vitamin K) are in all countries' recommendations. For minerals, nine (calcium, iron, iodine, zinc, selenium, phosphorus, sodium, potassium, magnesium) out of the 15 included in this review are covered by all five countries. Nutrients that are included in the recommendation by four out of five countries include vitamin B5, chromium, copper, manganese, fluoride and chloride. Only two vitamins (biotin and choline) are covered by three countries whereas the mineral molybdenum is covered by two countries. Among the five countries in this review, only Indonesia and Philippines provide recommended intake values for water.

Approaches and references for recommended nutrients

The approaches and references used as the basis for the development of the recommended intake levels also show remarkable similarities where most countries referred to/adopted recommendations from similar international research organisations e.g. WHO/FAO, IOM and EFSA. However, it is observed that the final recommendations of the intake levels for the nutrients are different among the five countries, some with notable differences i.e. energy, protein, vitamin C, vitamin E, calcium, selenium, potassium. These could be due to adjustment to suit local situations, physiological requirements, the differences in the final references adopted, reference weight and height used as well as the protein quality in the diet of the respective population. The differences between the final recommendations could also be due to the varying age groups defined after the infancy period, especially the different sub-age groups used for children and adolescents, where the available data on requirements were extrapolated for different ages.

In addition, it is noted that different parameters (i.e. RNI, RDA, AI) have been used by the countries for nutrient recommendations. For majority of the nutrients, countries use mostly RNI/ RDA, i.e. intakes that meet the nutrient requirement of almost all apparently healthy individuals. However, for some nutrients or certain age groups, AI is used. For example, Indonesia's document Regulation of the Minister of Health Concerning the Nutritional Adequacy Values for Indonesian Population provides RDA values for all the nutrients covered in the decree and indicates that the nutritional needs of infants 0-5 months for all nutrients are to be met by exclusive breastfeeding. In Malaysia RNI 2017, RNI is used for all nutrients except vitamin B5, sodium, chromium, manganese and fluoride where AI is used. AI is also used for calcium, magnesium, copper and molybdenum intake recommended for infants (0-12 months).

In Philippines' DRIs 2015, while RNI is used for most of the nutrients, AI is used for vitamin D, vitamin E, sodium, potassium, fluoride and chloride, as well as for recommended intake of certain nutrients for infants aged 0-5 months (vitamin A, vitamin B1, vitamin B2, vitamin B3, calcium, iron, zinc) and infants aged 0-11 months (vitamin B6, vitamin B9, vitamin B12, vitamin C, phosphorus and magnesium).

In the DRIs for Thai 2020, AI is used for recommended intake of vitamin K, vitamin B5, biotin, choline, calcium, iodine, sodium, potassium, chromium, copper, manganese, chloride and molybdenum, and for all nutrients recommended for infants except vitamin A, vitamin B9, vitamin C, vitamin E, iron and zinc where RDA is used for the recommended amounts for infants. Thai DRI indicates that in all aged groups, AI for nutrients is expected to be higher than RDA (MOPH Thailand, 2020).

Vietnam's 2015 nutritional requirements recommendation uses RDA for most of the nutrients. AI is used for vitamin E, vitamin K, biotin, choline, potassium, chromium, manganese, fluoride and chloride. The recommended intake levels of certain nutrients for infants (0-12 months) are also provided in AI, i.e. vitamin A, vitamin B1, vitamin B2, vitamin B6, vitamin B12, vitamin C, iodine, sodium and copper. AI is also used for protein recommended for infants aged 0-5 months.

Data for establishing national nutrient intake recommendations

As observed in this review, most of the nutrient recommendations in the countries in the review are based on RNI or RDA. The definition of RNI/RDA by most countries, as indicated in Table 1, is that, these are set at EAR plus 2 standard deviations (SD), which meets the nutrient requirement of almost all apparently healthy individuals (97-98%) in an age- and sex-specific population group. Allen, Carriquiry & Murphy (2020) and Yaktine, King & Allen (2020) have pointed out that since these covers almost all individuals, these are not appropriate indicators to assess the prevalence of inadequate nutrient intakes of population groups as they tend to give rise to overestimates of inadequacy. It was further suggested that in order to accurately evaluate the adequacy and safety of population level nutrient intakes, average requirement (AR) and UL for the population are to be used. It was also pointed out that many countries, regions, and organisations cannot afford the cost or time to revise their current recommendations or develop new values for ARs and ULs. We have also pointed out that countries in this review do not have the resources to establish such reference intake levels.

The review has indicated that the five countries had intended that the recommended energy and nutrient intakes to be developed using evidence-based approaches. However, these countries have been faced with the same concern of limited local research data available on nutrient requirements and the relations between diet and health in SEA population. Thus, for the five countries in this review, the general principle for developing national recommendations for energy and nutrients and the recommended intakes were mainly based on recommendations of several internationally renowned research organisations.

The earlier review by Tee (1998) has also reported that nutrient recommendations for most countries were not based on sufficient experimental data. There were no resources and expertise to carry out extensive experimental studies to establish nutrient requirements for various population groups. It was therefore necessary for these countries to make use of data from other countries as well as from international recommendations and adapt them to local situations.

This situation has also been pointed out in the FAO/WHO review of the recommended vitamin and minerals intake values of 55 countries (FAO/WHO, 2011). The report was made available for discussions at the 33rd Session of the Codex Committee on Nutrition and Foods for Special Dietary Uses in 2011 for the agenda on establishing Nutrient Reference Values for nutrition labelling purposes. In reviewing the information obtained for 28 vitamins and minerals from these countries, it was reported that only a few national sets of recommended nutrient intake values were based on a country's primary analysis of scientific data. It was pointed out that many intake values for the same nutrient had the same basis and same value. The report pointed out that some countries wholly or partially select or adapt their national recommended nutrient intake values from other well-documented reference sources. The most commonly used reference source by countries was the FAO/WHO (2004) recommended nutrient intake as well as several publications of IOM and EFSA. A few SEA countries could have established their own requirements data for a few nutrients through local research. However, it was acknowledged that establishing own national recommended intake values is expensive and tedious undertakings and would require scientific expertise.

Harmonisation of recommended nutrient intakes

Having a set of harmonised recommended nutrient intake has been deemed to be beneficial to SEA countries as it provides a common framework that can help countries in reviewing respective recommendations, and better extrapolate or modify existing recommendations to meet their populations' specific requirements. Harmonised recommended nutrient intakes will also form a common basis for countries in SEA to facilitate public health improvement, public understanding of health and diet issues, consumer education as well as facilitating trade in the region (Tee & Florentino, 2005; Pavlovic *et al*., 2007; Barba & Cabrera, 2008). In this regard, some initiatives have been made.

The ILSI SEA Region organised a series of six workshops and a working group meeting between 1997 and 2003 among nutrition scientists working in the area of recommended nutrient intakes. The meetings aimed to facilitate countries and government agencies to update national nutrient recommendations based on the latest science and the utilisation of national data. Participants to these meetings included country representatives from Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam, as well as other international and regional nutrition experts and regulators. The series of meetings culminated in the publication of a harmonised set of RDAs which can be used as references by the Southeast Asian countries (Tee & Florentino 2005). The monograph, covering 14 selected core nutrients jointly prepared by several SEA countries representatives, was to serve as a reference for countries in formulating and revising respective national RDAs. Nevertheless, it can be noted that the monograph by ILSI on harmonised RDAs for SEA countries was also based heavily on the FAO/WHO Expert Consultation on RNIs for vitamins and minerals (WHO/FAO, 2004) and several IOM reports.

There have been other efforts on harmonisation of recommended nutrient intake values. King & Garza (2007) co-chairs of the Working Group on International Harmonization of Approaches for Developing Nutrient-Based Dietary Standards explained that the working group was organized to convened to harmonise concepts and approaches (rather than deriving specific recommendations) for developing recommended nutrient intake values. This Working Group was organised by the United Nations University's Food and

Nutrition Programme, in collaboration with the FAO, WHO, and UNICEF. The reasons given for this proposed harmonization include providing a common basis for the use of nutrient intake values across countries, regions, and across the globe which will enable the establishment of public health objectives, food and nutrition policies including for addressing regulatory and trade issues. The Working Group also felt that the harmonisation will enable developing countries which often have limited resources to develop nutrient intake values for their populations and other activities. This is an issue we highlighted above. The Group recommended the development of nutrient intake values (NIVs) framework which is conceptually similar to DRI and dietary reference value (DRV).

A follow-up workshop to explore achieving global harmonization of methodological approaches to establishing recommended nutrient intake values was organised in 2017 by the FNB of the National Academies of Sciences, Engineering, and Medicine (NASEM), in partnership with the Department of Nutrition for Health and Development of the WHO and the Nutrition Division of the FAO (Pray & Yatkine, 2018). The goal of the workshop is to deliberate on ways to provide a uniform and consistent basis for setting nutrient intake recommendations across countries while accommodating culturally and context-specific food choices and dietary patterns.

Yaktine *et al.* (2020) reiterated the importance of defining, on a global scale, the methodological derivation of the core Nutrient Reference Values (NRVs), which can benefit countries globally regardless of their economic status. The report provided details of the NASEM workshop in 2017 and discussed approaches and made recommendations for the derivation of NRVs. The authors opined that awareness of the advantages of harmonization of the NRV process along with improvements in access for all countries to data needed to derive NRVs could transform the way many countries approach the challenge of developing NRVs.

Recognising the need for reference values that can be applied globally to assess intakes across populations, Allen *et al.* (2020) demonstrated an approach to harmonise published NRVs values, and a set of proposed harmonised ARs and ULs values (termed H-ARs and H-ULs) and the justification for the proposed values were documented in detail. The proposed H-ARs for 25 nutrients, and H-ULs for 19 nutrients may be used to assess intakes of populations for many applications in global and regional contexts. The H-ARs and H-ULs can be readily modified to meet regional or local needs, if the user prefers. It was pointed out that in the past, many countries have not had the resources or expertise to develop or publish the ARs and ULs that are needed. The authors proposed that the process presented may be able to assist countries such as these or other organisations to decide whether to accept, adapt, or revise these proposed recommendations rather than start a new, expensive, time-consuming process to derive new requirement and toxicity values. The authors suggested for an international group such as WHO/FAO to review the values proposed and modify as needed.

CONCLUSION

Moving forward, it is clear that relevant organisations and researchers in the region involved in this work would continue to update recommended nutrient intake values for their population. There would certainly be interest to obtain more appropriate recommended nutrient intake values for more effective applications in food and nutrition programmes. Recognising the general similarities in the dietary pattern of population in the region, there could be closer collaboration among researchers in the region. Establishing a platform for the periodic sharing of experiences and views would be most beneficial. Consideration could be given to the above-summarised work by NASEM on establishing a harmonised approach to establishing recommended nutrient intake values.

Acknowledgement

The authors acknowledge the contribution of the Secretariat of the SEA-PHN Network, Versacomm Sdn Bhd especially Ms Voon Siok Hui and Ms Muhaini Hussin for assistance rendered in compiling the information from the five countries and preparing the manuscript. The authors also thanked Bureau of Nutrition, Department of Health, Ministry of Public Health Thailand for providing related information of Thai DRI. Funding for publication of this review was provided through an unrestricted educational grant to the SEA-PHN Network by BENEO-Institute, IFF and PepsiCo Services Asia Ltd.

Authors' contributions

Tee ES, contributed to the conception of the study design, hypothesis generation, data management, data analysis, data interpretation, discussion, and initiating manuscript write-up; Florentino RF, Chongviriyaphan N, Hardinsyah R, Appukutty M and Mai TT, contributed to the data verification, data interpretation, discussion and literature review for each country respectively. All authors approved the final draft.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

Abdul Majid H, Ramli L, Ying SP, Tin TS, Jalaludin MY & Al-Sadat Abdul Mohsein N (2016). Dietary intake among adolescents in a middle-income country: An outcome from the Malaysian health and adolescents longitudinal research team study (the MyHeARTs Study). *PloS One* 11:1-14

ADA (2002). Position of the American Dietetic Association: health implications of dietary fibre. *J Am Diet Assoc* 102:993-1000.

Allen LH, Carriquiry AL & Murphy SP (2020). Perspective: Proposed harmonized nutrient reference values for populations. *Adv Nutr* 11:469-483.

Appel LJ, Sacks FM, Carey VJ, Obarzanek E, Swain JF, Miller III ER, Conlin PR, Erlinger TP, Rosner BA, Laranjo NM, Charleston J, McCarron P, Bishop LM, for the OmniHeart Collaborative Research Group (2005). Effects of protein, monounsaturated fat, and carbohydrate intake on blood pressure and serum lipids: Results of the OmniHeart Randomized Trial. *JAMA* 294:2455-2464.

ASEAN/UNICEF/WHO (2016). Regional Report on Nutrition Security in ASEAN, Volume 1. UNICEF, Bangkok.

ASEAN (2022). ASEAN Food and Nutrition Security Report 2021 Volume 1. Association of Southeast Asian Nations, ASEAN Secretariat, Jakarta

Barba CVC & Cabrera MIZ (2008). Recommended energy and nutrient intakes for Filipinos 2002. *Asia Pac J Clin Nutr* 17(S2):399-404.

DOST- FNRI (1989). Recommended Dietary Allowances for Filipinos. Department of Science and Technology, Food and Nutrition Research Institute, Manila.

DOST-FNRI (2017). PDRI 2015: Philippine Dietary Reference Intakes. Department of Science and Technology–Food and Nutrition Research Institute. Taguig City, Philippines.

Dwyer JT (1995). Dietary fiber for children: How much? *Pediatrics* 96(5):1019-1922.

EFSA (2012). Scientific Opinion on Dietary Reference Values for protein. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 10(2):2557; 66 pp.

EFSA (2013a). Scientific Opinion on Dietary Reference Values for energy. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 11(1):3005; 112 pp.

EFSA (2013b). Scientific Opinion on Dietary Reference Value for vitamin C. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 11 (11):3418; 66 pp.

EFSA (2013c). Scientific Opinion on Dietary Reference Values for manganese. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 11(11):3418; 44 pp.

EFSA (2013d). Scientific Opinion on Dietary Reference Values for molydenum. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 11(8):3333; 35 pp.

EFSA (2014a). Scientific Opinion on Dietary Reference Values for niacin. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 12(7):3759; 42 pp.

EFSA (2014b). Scientific Opinion on Dietary Reference Values for pantothenic acid. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA), European Food Safety Authority. *EFSA J* 12(2):3581; 25 pp.

EFSA (2014c). Scientific Opinion on Dietary Reference Values for folate. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 12(11):3893; 59 pp.

EFSA (2014d). Scientific opinion on Dietary Reference values for zinc. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 12(10):3844; 76 pp.

EFSA (2015a). Scientific Opinion on Dietary Reference Values for cobalamin (vitamin B12). EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 13(7):4150; 64 pp.

EFSA (2015b). Scientific Opinion on Dietary Reference Values for vitamin A. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). *EFSA J* 13(3):4028; 84 pp.

EFSA (2015c). Scientific Opinion on Dietary Reference Values for vitamin E as α-tocopherol. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). *EFSA J* 13(7):4149; 72 pp.

EFSA (2015d). Scientific Opinion on Dietary Reference Values for phosphorus. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 13(7):4185; 54 pp.

EFSA (2015e). Scientific Opinion on Dietary Reference Values for magnesium. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). European Food Safety Authority. *EFSA J* 13(7):4186; 63 pp.

EFSA (2015f). Scientific Opinion on Dietary Reference Values for copper. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). *EFSA J* 13(10):4253; 51 pp.

EFSA (2016). Scientific opinion on Dietary Reference Values for Vitamin B6. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). *EFSA J* 14(6):4485; 79 pp.

FAO (2010). Fats and Fatty Acids in Human Nutrition: Report of An Expert Consultation. FAO Food and Nutrition Paper No. 91, Food and Agriculture Organization, Rome.

FAO (2018). Asia and the Pacific Regional Overview of Food Security and Nutrition 2018 - Accelerating progress towards the SDGs. Bangkok.

FAO/WHO/UNO (2004). Human Energy Requirements, Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Technical Report Series, Food and Agriculture Organization, Rome.

FAO/WHO/UNO (2007). Protein and amino acid requirements in human nutrition. Report of a joint FAO/WHO/UNU expert consultation. World Health Organization, Geneva.

FAO/WHO (1988). Requirements of vitamin A, iron, folate and vitamin B12. Report of a Joint FAO/WHO Expert Consultation. FAO Food and Nutrition Series 23. Food and Agriculture Organization, Rome.

FAO/WHO (2002). Human Vitamin and Mineral Requirement, Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Division, Food and Agriculture Organization of the United Nations, Rome.

FAO/WHO (2007). Scientific Update on carbohydrates in human nutrition: Conclusions *Eur J Clin Nutr* 61(Suppl 1): S132-S137.

FAO/WHO (2011). Review of Existing Daily Vitamin and Mineral Intake Reference Values. Prepared for the 33rd Session of the Codex Committee on Nutrition and Foods for Special Dietary Uses, Bad Soden am Taunus, Germany. Food and Agriculture Organization and World Health Organization.

FNRI-DOST (2015). Philippine Nutrition Facts and Figures 2013. 8th National Nutrition Survey: Overview. Department of Science and Technology Compound, Food and Nutrition Research Institute Bldg. Bicutan, Taguig City, Philippines.

Holliday MA & Segar WE (1957). The maintenance need for water in parental fluid therapy. *Pediatrics* 19(5):823–832.

IOM (1997). Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (1998). Dietary Reference Intake for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic acid, Biotin and Choline. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2000). Dietary Reference Intakes for Ascorbic acid, Vitamin E, Selenium, and Carotenoids. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2001). Dietary References Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2002). Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein and Amino Acids (Macronutrients). Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2005a). Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2005b). Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC.

IOM (2006). Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. JJ Otten, JP Hellwig & LD Meyers (eds). National Academy of Sciences, Washington.

IOM (2011). Committee to Review Dietary Reference Intakes for Vitamin D & Calcium. The National Academies Collection: Reports funded by National Institutes of Health. In Ross AC, Taylor CL, Yaktine AL & Del Valle HB(eds). Dietary Reference Intakes for Calcium and Vitamin D. National Academies Press (US) National Academy of Sciences, Washington DC.

IOM (2018). Harmonization of Approaches to Nutrient Reference Values: Applications to Young Children and Women of Reproductive Age. Food and Nutrition Board, Institute of Medicine. National Academies Press, Washington DC

IPH (2014). National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey (MANS) Vol. II: Survey Findings. Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, Kuala Lumpur.

IPH (2015). National Health and Morbidity Survey 2015 (NHMS 2015). Vol. II: Non-Communicable Diseases, Risk Factors & Other Health Problems. Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, Kuala Lumpur.

Ismail MN, Ng KK, Chee SS, Roslee R & Zawiah H (1998). Predictive equations for the estimation of basal metabolic rate in Malaysian adults. *Mal J Nutr* 4:81-90.

IZiNCG (2004). Assessment of the risk of zinc deficiency in populations and options for its control. International Zinc Nutrition Consultative Group Technical Document #1. *Food Nutr Bull* 25(1):94S-203S.

King JC & Garza C (2007). Harmonization of nutrient intake values – Executive summary. *Food Nutr Bull* 28(1):S3-S12.

Kranz S, Brauchla M, Slavin JL & Miller KB (2012). What do we know about dietary fiber intake in children and health? The effects of fiber intake on constipation, obesity, and diabetes in children. *Adv Nutr* 3(1):47–53.

Ministry of Health, Labour & Welfare Japan (2015). Dietary Reference Intakes for Japanese 2015. Health Service Bureau, Ministry of Health, Labour and Welfare, Japan, Tokyo.

MOH Indonesia (2019). Regulation of the Minister of Health of the Republic of Indonesia Number 28 of 2019 About Nutritional Adequacy Values for Indonesian Population (Peraturan Menteri Kesehatan Republik Indonesia Nomor 28 Tahun 2019 Tentang Angka Kecukupan Gizi yang Dianjurkan untuk Masyarakat Indonesia).

MOPH Thailand (2020). Dietary Reference Intake for Thais 2020. Bureau of Nutrition, Department of Health, Ministry of Public Health Thailand, Bangkok.

Monsen ER, Hallberg L, Layrisse M, Hegsted DM, Cook JD. Mertz W & Finch CA (1978). Estimation of available dietary iron. *Am J Clin Nutr* 31(1):134–141.

National Research Council (1989). Recommended dietary allowances, 10th ed. Report of the Subcommitte on the Tenth Edition of the RDA. Food and Nutrition Board, Commission on Life Sciences. National Aoademy Press, Washington, DC.

NIHN Japan (2010). Dietary Reference Intake for Japanese 2010. Department of Nutritional Epidemiology, National Institute of Health and Nutrition Japan, Tokyo.

NIN Vietnam (2016). Nutritional Requirements Recommendations for Vietnamese People. Medical Publishing House, Hanoi.

NCCFN (2005). Recommended Nutrient Intakes for Malaysia. A Report of the Technical Working Group on Nutritional Guidelines. Mohd Ismail N, Khor GL & Tee ES (2005) (Eds). National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Putrajaya.

NCCFN (2017). Recommended Nutrient Intakes for Malaysia. A Report of The Technical Working Group on Nutritional Guidelines. Mohd Ismail N, Poh BK, Tee ES, Khor GL & Gui SL (Eds). National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Putrajaya.

NHMRC (2006). Nutrient reference values for Australia and New Zealand: including recommended dietary intakes. National Health and Medical Research Council (Australia & New Zealand). Ministry of Health Australia. Department of Health and Ageing, Canberra.

Olson JA (1987). Recommended dietary intakes (RDI) of vitamin A in humans. *Am J Clin Nutr* 45(4):704–716.

Pavlovic M, Prentice A, Thorsdottir I, Wolfram G & Branca F (2007). Challenges in harmonizing energy and nutrient recommendations in Europe. *Ann Nutr Metab* 51(2):108–114.

PHC (2016). Healthy Eating Guidelines & Weight Loss Advice for the United Kingdom. Informing & Implementing Healthy Decisions. Public Health Collaboration.

PHE (2016). The Eatwell Guide. Gateway Number: 2015588. NHS Choices. Public Health England.

Poh BK, Ismail MN, Ong HF, Norimah AK & Safiah MY (2004). BMR predictive equations for Malaysian adolescents aged 12 - 18 years. Final Report for IRPA 06-02-02-0096 Research Project. Department of Nutrition and Dietetics, Faculty of Allied Health Sciences, Universiti Kebangsaan Malaysia, Kuala Lumpur.

Pray L & Yaktine AL (2018). Global harmonization of methodological approaches to nutrient intake recommendations: Proceedings of a workshop. National Academies of Sciences, Engineering, and Medicine (NASEM). The National Academies Press. Washington, DC.

Siri-Tarino PW, Sun Q, Hu FB & Krauss RM (2010). Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. *Am J Clin Nutr* 91(3):535-546.

Tee ES (1998). Current Status of Recommended Dietary Allowances in Southeast Asia: A Regional Overview. *Nutr Rev* Vol 56(4):S10-S18.

Tee ES & Florentino R (2005) (Editors). Recommended Dietary Allowances (RDA). Harmonization in Southeast Asia. Monograph Series, International Life Sciences Institute Southeast Asia Region, Singapore

Teoh ST (1975). Recommended daily dietary intakes for Peninsular Malaysia. *Med J Malaysia* 30(1):38-42

Trinidad TP, Cruz EM, Madriaga JR, Ponce LM, Valdez DH & Sison CC (1986). Non-heme iron availability from regional meals in the Philippines. *Philipp J Nutr* 39:144–154.

USDA (2007). Nutrient intakes from food. Mean amounts consumed per individual, by gender and age. What we eat in America, NHANES 2007/2008. United States Department of Agriculture/ Agricultural Research Service. From: www.ars.usda.gov/ba/bhnrc/fsrg [Retrieved 30 March 2023].

USDA (2015). 2015-2020 Dietary Guidelines for Americans. 8th Edition. U.S. Department of Health and Human Services and U.S. Department of Agriculture. From http://health.gov/dietaryguidelines/2015/guidelines/ [Retrieved 20 March 2023]

WHO/FAO (2004). Vitamin and Mineral Requirements in Human Nutrition. Second Edition. Report of a Joint FAO/WHO Expert Consultation. World Health Organization.

WHO/UNICEF/ICCIDD (2001). Assessment of Iodine Deficiency Disorders and Monitoring Their Elimination. A Guide for Programme Planners, 2nd ed. World Health Organization/ United Nations Children's Fund/International Council for the Control of Iodine Deficiency Disorders. World Health Organization, Geneva.

WHO (1985). Energy and protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. WHO Technical Report Series 724. World Health Organization, Geneva.

WHO (1990). Diet, nutrition, and the prevention of chronic diseases. Report of a WHO Study group. Technical Report Series 797. World Health Organization, Geneva.

WHO (1996). Trace Elements in Human Nutrition and Health. World Health Organization, Geneva.

WHO (2003). Diet, nutrition and the prevention of chronic diseases: Report of a Joint WHO Technical Report Series, No. 916. World Health Organization, Geneva. From http://whqlibdoc.who.int/trs/WHO_TRS_916.pdf [Retrieved 20 March 2023]

WHO (2006). The WHO Child Growth Standards. World Health Organization, Geneva.

WHO (2007). Growth Reference Data for 5-19 Years. World Health Organization, Geneva.

WHO (2007). Protein and amino acid requirements in human nutrition. Report of a joint FAO/WHO/UNU expert consultation. World Health Organization, Geneva.

WHO (2012a), Guideline: Sodium Intake for adults and children. World Health Organization, Geneva.

WHO (2012b). Guideline: Potassium intake for adults and children. World Health Organization, Geneva.

WHO (2015). Guideline: Sugar intake for adults and children. World Health Organization, Geneva.

WHO (2022). Mid-term review of the Strategic Action Plan to reduce the double burden of malnutrition in the WHO South- East Asia Region 2016– 2025. World Health Organization, Geneva.

Yaktine AL, King JC & Allen LH (2020). Why the derivation of nutrient reference values should be harmonized and how it can be accomplished. Adv Nutr 11(5):1102–1107.

Mal J Nutr 29(2): 243-253, 2023

A bibliometric analysis of coconut sap research

Anis Fadhlina[1,2], Hassan I. Sheikh[3,5], Maryana Mohamad Nor[2,4*], Noor Hafizoh Saidan[4] & Nurul Amira Zainurin[4]

[1]*Department of Fundamental Dental and Medical Sciences, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia;* [2]*Institute of Food Security and Sustainable Agriculture, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan*; [3]*Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*; [4]*Faculty of Agro Based Industry, Universiti Malaysia Kelantan, Jeli, Kelantan, Malaysia;* [5]*Food Security Research Cluster, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia*

ABSTRACT

Introduction: Coconut sap is a sweet, fragrant liquid obtained from the inflorescence of coconut tree. In this study, a literature search was conducted using the Scopus database to study the trends of coconut sap research. **Methods:** Data extracted from the Scopus database were analysed and visualised using VOSviewer to determine top authors, papers, countries, collaborations, and research areas. A total of 76 publications up to year 2021 were identified and refined using keywords of "coconut sap", "coconut sugar", "coconut inflorescence", "coconut inflorescence sap", "coconut neera", and "*Cocos nucifera*". **Results:** Based on the analysis, research on coconut sap started in 1984, with a total of 53 authors, nine countries, and 12 sources that had published more than two documents. The analysis of countries and sources revealed that India and IOP Conference Series: Earth and Environmental Science (EES) were the most prolific country and sources, respectively. The most influential document was on the chemical compositions and bacteriology of coconut sap. The results also showed that research on coconut sap was in the field of food processing during the early years, followed by fermentation, agriculture, and bacteriology of coconut sap. Research on coconut sap's bacteriology started in 1986 and became a major interest, especially among high impact journals. **Conclusion:** Overall, coconut sap is a potential target for the development of nutraceutical products, especially in the food and beverage industry.

Keywords: bibliometric, coconut sap, nutraceutical

INTRODUCTION

Coconut, *Cocos nucifera* L., is native to tropical countries such as Malaysia, Indonesia, Africa, South America, Australia, and other tropical regions (Lima *et al.*, 2015). In the flowering phase, coconut sap is collected from the unblossomed coconut tree's spadix, which produces inflorescence throughout the year (Ghosh *et al.*, 2018). Locals have been harvesting coconut sap as a nourishing drink which can be consumed in two forms: non-fermented and fermented sap. The non-fermented

*Corresponding author: Dr. Maryana Mohamad Nor
Institute of Food Security and Sustainable Agriculture, Universiti Malaysia Kelantan.
17600 Jeli, Kelantan.
Tel: (6)09-9477480; E-mail: maryana.mn@umk.edu.my
doi: https://doi.org/10.31246/mjn-2022-0079

sap is called neera, while the fermented sap is called toddy, with 5-8% of alcohol content (Chinnamma *et al.*, 2019). It has high market value either as fermented or non-fermented products such as sweetener, reducing agent, natural preservative, broiler diets, vinegar, yoghurt, as well as alcoholic, sport and probiotic drinks (Asghar *et al.*, 2020; Joseph *et al.*, 2021; Rajesh *et al.*, 2020; Srikaeo & Thongta, 2015; Ravindran *et al.*, 1984).

Coconut sap is a highly nutritious drink that is rich in minerals (potassium, sodium, magnesium, phosphorus, calcium, ferum, zinc, iron), vitamins (A, B1, B2, B3, B6, B10, C), sugar (sucrose, glucose, fructose), amino acid (aspartic acid, glutamic acid, histidine, leucine, threonine, methionine, valine, alanine, cysteine, isoleucine, tyrosine, arginine), protein, carbohydrates and fats (Jose *et al.*, 2018; Chinnamma *et al.*, 2019; Asghar *et al.*, 2020; Hebbar *et al.*, 2020). Despite the rapid increase in the number of published studies and profound findings on coconut sap, no quantitative analysis has been done on its research trends to identify key research issues, active researchers, research gaps, and future prospects. Hence, this review aims to provide valuable insight into the trend of coconut sap research and its market opportunities.

MATERIALS AND METHODS

Data collection

Five main search keywords were used, namely “coconut sap”, “coconut sugar”, “coconut inflorescence”, “coconut inflorescence sap”, and “coconut neera”, together with the scientific name of coconut (*Cocos nucifera*). Titles containing these keywords were selected. The papers were retrieved up to 31st December 2021.

Data analysis and visualization

Data from Scopus were analysed and visualized using VOSviewer 1.6.17 according to Fadhlina *et al.* (2023). The analyses consisted areas on authorship, countries, keywords, and terms co-occurrence. The author’s credit for publications in this study was based on “complete count”. Each occurrence of an author was counted regardless of appearance sequence. Network and overlay visualization were used to present the data.

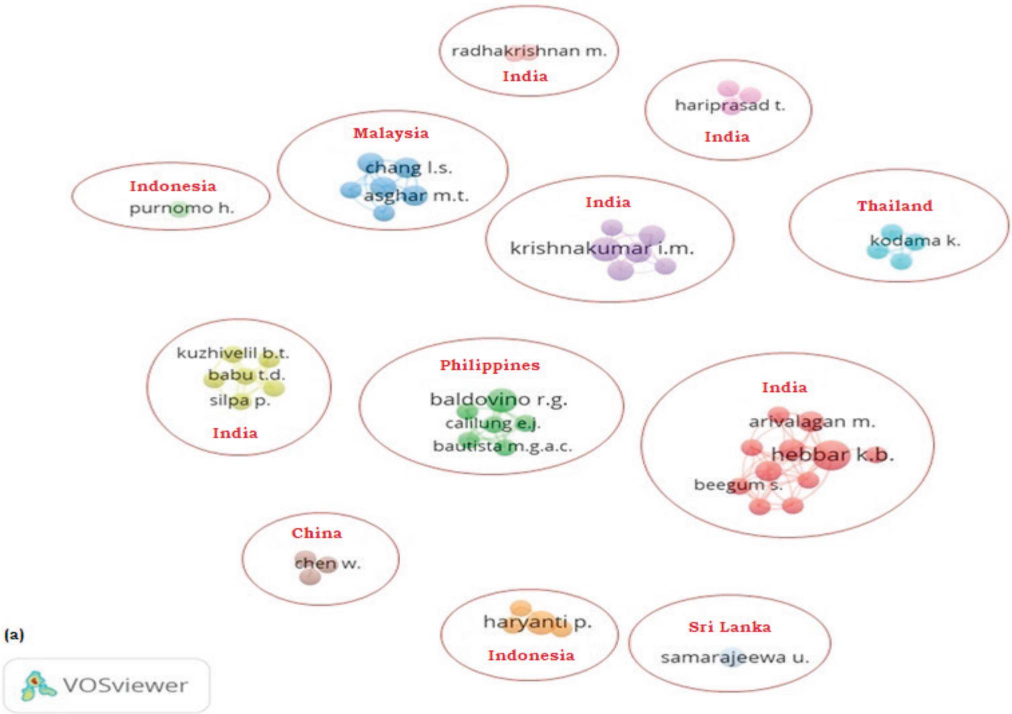
Selection criteria

The 168 articles identified from the database were subjected to inclusion and exclusion criteria according to Sheikh *et al.* (2022). Titles that contained no abstract and review papers were first removed followed by articles not related to coconut inflorescence sap. These irrelevant articles included articles on coconut husk, coconut inflorescence fibril, coconut water, coconut-associated insects and others. A total of 76 articles were selected for this bibliometric analysis.

RESULTS & DISCUSSION

Co-authorship, sources and countries analyses

A total of 53 authors (out of 265 authors) met the threshold of a minimum of two documents per author, analysed using the network and overlay visualization for co-authorship analysis. Based on the analysed authors, a total of 12 clusters were observed (Figure 1a). However, there was no connection established among the clusters and they were working independently within the same cluster throughout the years. The most prolific author was Hebbar K.B. (six documents), who conducted research on the nutritional, physicochemical, and microbial studies of coconut sap. Other



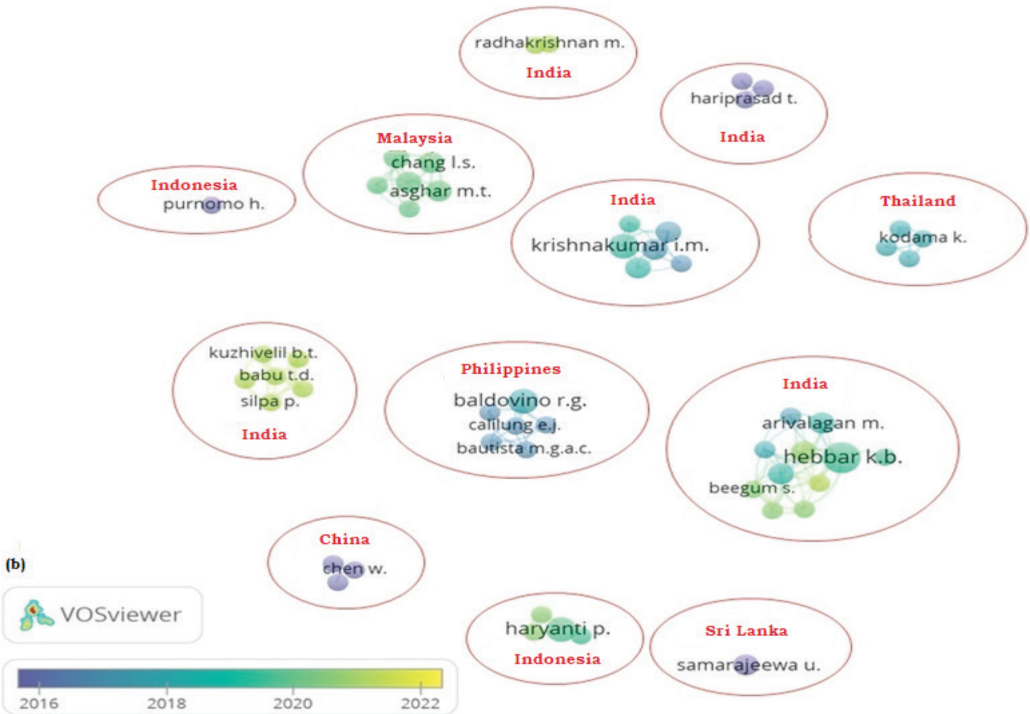


Figure 1. (a) Main authors and their networks. (b) Timewise visualization of main authors.

Table 1. List of top 10 authors, sources, countries and documents

Author	*PC*	*Sources*	*PC*	*Country*	*PC*
Hebbar KB	6	IOP Conference Series: Earth and Environmental Science	7	India	24
Baldovino RG	4	International Food Research Journal	4	Indonesia	18
Haryanti P	4	Food Microbiology	3	Thailand	13
Krishnakumar IM	4	Food Research	3	Philippines	6
Samarajeewa U	3	LWT	3	Malaysia	5
Manikantan MR	3	Frontiers in Microbiology	2	Sri Lanka	5
Asghar MT	3	Journal of Food Biochemistry	2	China	3
Chang LS	3	Journal of Food Science and Technology	2	Pakistan	3
Manaf YN	3	Journal of Food Measurement and Characterization	2	United States	2
Yusof YA	3	ACM International Conference Proceeding Series	2		

Document	*Title*	*Citations*	*Links*
Borse *et al.* (2007)	Chemical composition of volatiles from coconut sap (neera) and effect of processing	63	11
Atputharajah, Widanapathirana & Samarajeewa (1986)	Microbiology and biochemistry of natural fermentation of coconut palm sap.	59	11
Somashekaraiah *et al.* (2019)	Probiotic properties of lactic acid bacteria isolated from neera: A naturally fermenting coconut palm nectar	51	2
Hebbar *et al.* (2015)	Coconut inflorescence sap and its value addition as sugar–collection techniques, yield, properties and market perspective.	34	7
Xia *et al.* (2011)	Chemical composition changes of post-harvest coconut inflorescence sap during natural fermentation.	28	13
Srikaeo & Thongta (2015)	Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat-based foods.	28	3
Asghar *et al.* (2020)	Coconut (*Cocos nucifera* L.) sap as a potential source of sugar: Antioxidant and nutritional properties	24	5
Karseno *et al.* (2018)	Effect of pH and temperature on browning intensity of coconut sugar and its antioxidant activity.	24	2
A-Sun *et al.* (2016)	Effect of spray drying conditions on physical characteristics of coconut sugar powder.	21	1
Jirapeangtong, Siriwatanayothin S & Chiewchan (2008)	Effects of coconut sugar and stabilizing agents on stability and apparent viscosity of high-fat coconut milk.	21	0

PC: Publication count

prolific authors included Baldovino R.G., Haryanti P., and Krishnakumar I.M. with four documents (Table 1). Based on the overlay visualization (timewise), authors from India consistently contributed in coconut sap research across the years (Figure 1b), with research mainly focused on the microbial studies of neera/non-fermented coconut inflorescence sap (NFCIS).

A total of nine countries with a minimum of two documents per country were extracted from the country's co-authorship analysis. Based on the network and overlay visualization of analysed countries, Thailand was observed to have collaboration with several countries, such as India, Malaysia and Pakistan, while the rest of the countries, such as Indonesia, Sri Lanka, Philippines and China, worked independently. India and Indonesia were the most prolific countries, followed by Thailand, the Philippines and Malaysia. Indonesia had shown a high number of documents (five) published in the Institute of Physics (IOP) Conference Series: Earth and Environmental Science (EES). In recent years, Pakistan, the United States and Malaysia were observed to have conducted research related to this topic.

Based on the analysis of sources, the highest number of publications was observed for the IOP Conference Series: EES, a Scopus-indexed proceeding with a total of seven publications. All publications between the years 2020-2021 were focused on improving the quality of coconut sap by the use of laru (a natural preservative derived from the bark of certain trees), as well as other chemical agents such as arginine and sodium metabisulfite. In addition, research on the use of chengal wood and the biodiversity of bacteria in coconut sap were also published in the proceeding. Food Microbiology and LWT were among the top five prolific journals whereby research was focused on the microbial studies of coconut sap in the early years (1986-1988), a topic which gained interest again between the years 2020-2021. This may indicate that the microbial studies of coconut sap were among the main interest for publication in high impact journals. Meanwhile, for lower impact journals, the publications were focused on the antioxidant activities, bioactive compounds, and processing of coconut sap, as well as its sugar.

Keywords co-occurrence analysis

A total of 143 (after exclusion of 10 keywords: article, non-human, controlled study, unclassified drug, priority journal, male, human, adult, humans, Indonesia) keywords with a minimum of two occurrences of a keyword were analysed. A total of eight clusters were observed in the co-occurrence analysis of keywords with "coconut" as the most frequent keyword (20 occurrences). The use of keywords can be seen moving from "coconut sugar" to "coconut sap" and currently, to the keyword "coconut inflorescence sap" (Figure 2). In terms of research trends, food processing started in the early years of research, followed by the fermentation process and currently, the agriculture and bacteriology of coconut sap. Meanwhile, research on the antioxidant activities and sugar industry of coconut sap was consistently observed throughout the years of research since 2015.

Citation analysis of documents

A total of 47 documents with a minimum of two citations per document were connected and analysed for their network of citations. The most influential documents with the highest citations were authored by Borse B.B. (63 citations), followed by Atputharajah J.D. (59 citations), and Somashekaraiah R. (51 citations), which focused on

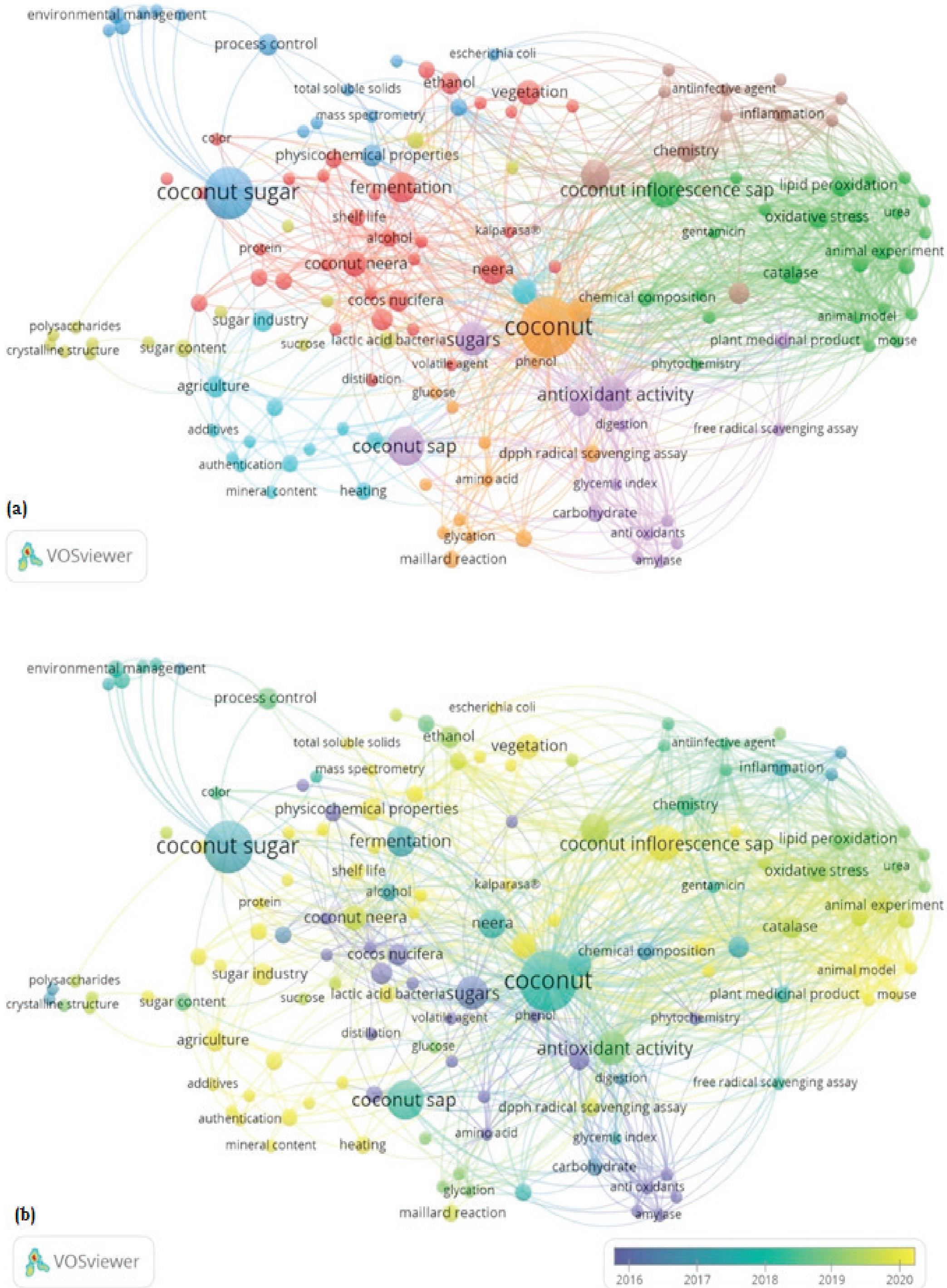


Figure 2. (a) Network visualization of main keywords. (b) Timewise visualization of main keywords.

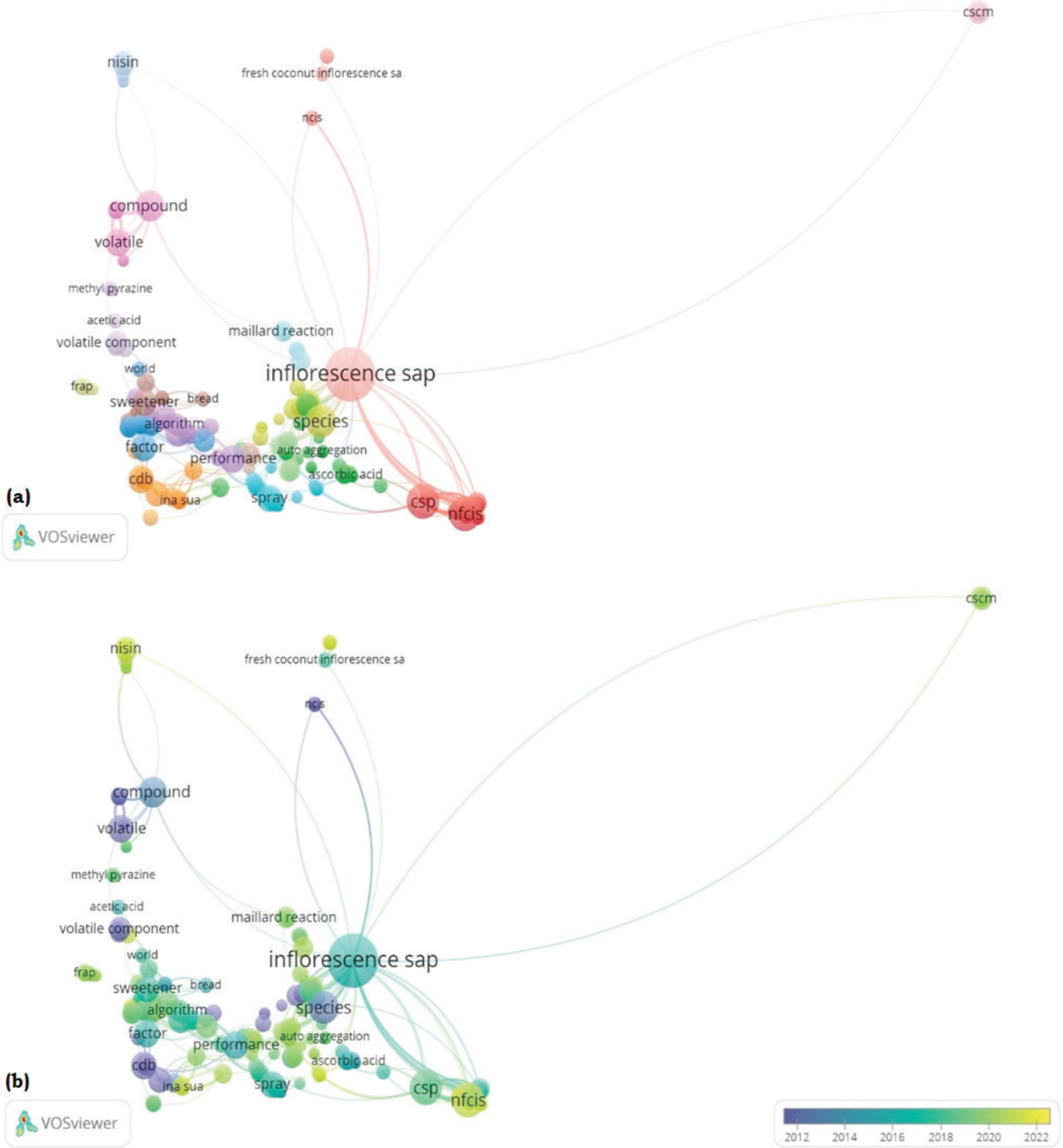


Figure 3. (a) Network visualization of terms co-occurrence. (b) Timewise visualization of terms co-occurence.

the study of chemical compositions and bacteriology of coconut sap (Table 1). Research on its bacteriology was observed to have started in the early years (1986) and continued to be of interest. The rest of the research listed in the top ten highest citations focused on food processing and nutraceutical properties of coconut sap.

Co-occurrence of terms in text data

A total of 318 (after exclusion of 36 unrelated terms: volume, higher amount, degree Celsius, percent, minute, g l, lab, type, ppm, ml 100g fish, g ml, ton, tree day, evening, noon, morning, afternoon, sec, l ml, year, g water, ml kg min, average, w kg b, hour, duration, kind, total, iii, first time, problem, w v, Thailand, Philippine, group, approach) terms with a minimum of two occurrences of a term were analysed. All terms were extracted from the title and abstract of selected documents for the analysis of terms co-occurrence and a total of 18 clusters were observed. From the clusters observation, the highest occurrence (38) term was "inflorescence sap", which was connected to most clusters (Figure 3a). This term was frequently used in research involving animal studies, bioactive compounds, and product innovation of coconut sap. Other frequently used terms were csp and nfcis, which stands for coconut inflorescence sap and non-fermented coconut inflorescence sap, respectively. Timewise, the term nfcis was frequently used in recent years involving its antioxidant studies in comparison to the fermented form, as well as bacteriology of coconut sap (Figure 3b).

Marketable products of coconut sap

Coconut sap may offer varieties of products to be commercialised owing to its nutritional and health benefits. It has been reported to show numerous bioactivities such as antioxidant (Asghar *et al.*, 2020; Devi *et al.*, 2015), anti-inflammatory (Ratheesh *et al.*, 2017), hepatoprotective, nephroprotective (Jose *et al.*, 2017), antimicrobial, and cytotoxic (Rajesh *et al.*, 2020) activities. It contains a lot of nutritional values such as vitamins, minerals, amino acids, carbohydrates, protein and sugars (Table 2). The diversity of coconut varieties, harvesting (tapping, collecting, processing) methods, geographical locations, and climatic conditions may cause variations in the total and reducing sugar contents of coconut sap (Chinnamma *et al.*, 2019; Sarma *et al.*, 2021). In addition, the concentration of volatile compounds, such as acetic acid, dodecanoic acid, 1,4-dimethyl-6-1 butyl acetate, and 2-methylcyclohexane, had previously been found to decrease from morning to evening tapping of coconut sap (Purnomo, 2007). Once harvested, coconut sap is prone to fermentation, which affects its commercial value. Thus, prevention of the fermentation process to suppress microbial growth by incorporation of limestone, potassium metabisulphite, and citric acid or natural preservatives, such as mangosteen skin, the bark of jack fruit, and chengal wood, have been reported (Chinnamma *et al.*, 2019; Purnomo, 2007; Saidan *et al.*, 2020).

Several products have been developed from coconut sap, namely Kalparasa (unfermented drink), Rasgulla (sugar-based dessert), coconut sap yoghurt, and Coconut Sap Powder (CSP). CSP was previously reported to show an ergogenic effect, which may have the potential to be commercialised as an energy drink (Joseph *et al.*, 2021). Meanwhile, coconut sugar has a low glycaemic index (GI) value, which offers promising market as a diabetic sugar and a better replacement for regular refined sugar, as well as muscovado sugar. Besides, it can be used in wheat-based products (e.g., bread with coconut sugar) and produce acceptable bread quality in comparison to conventional bread made using sugarcane (Srikaeo & Thongta, 2015). Coconut sap also had been used in improving the shelf life and sensory attributes of foods such as fermented salted fish (Wattimena, Temartenan & Lesbatta, 2021), acidophilus milk (Jirasatid & Nopharatana, 2020), and animal feeds (Ravindran, Sriskandarjah & Rajaguru, 1984). Lactic acid bacteria (LAB) isolates from neera demonstrated probiotic attributes with antimicrobial activities, therefore exhibiting the

Table 2. Marketable products and nutritional values of coconut sap

Marketable products	*Applications*	*References*
Non-alcoholic products	Unfermented coconut sap drink/ Kalparasa/ Neera, energy drink (CSP)	Hebbar *et. al.*, 2015
Fermented products	Toddy, vinegar, gluten-free soy source alternative	Mesquita *et al.*, 2020
Probiotic drinks	Lactic Acid Bacteria (LAB)	Somashekaraiah *et al.*, 2019
Preservative	Fermented-salted fish	Mahulette *et al.*, 2016
Milk emulsifier	*Acidophilus* milk, high-fat coconut milk	Jirapeangtong Siriwatanayothin S & Chiewchan 2008; Jirasatid & Nopharatana, 2020
Yoghurt	Coconut sap drink yoghurt	Karseno *et al.*, 2021
Sweetener	Syrup (Coconut Nectar, Sucrose heavy dessert e.g., Rasgulla) Coconut Sap Powder (COCOZEN™) Wheat-based foods	Kaur & Goswami, 2021 Srikaeo *et al.*, 2015
Chicken feed	Coconut sap distillery by-products	Ravindran *et. al.*, 1984.
Reducing agent	Synthesis of silver nanoparticles (AgNPs)	Joseph *et. al.*, 2021
Fermentation medium	Levan production	Mummaleti *et al.*, 2020
	Nutritional values	
Proximate composition & minerals: Carbohydrates, Protein, Fats, Sucrose, Glucose, Fructose, Potassium, Magnesium, Selenium, Phosphorous, Sodium, Zinc, Iron, Copper, Manganese, Choline, Nitrate, Calcium (Jose *et al.*, 2017; Jose *et al.*, 2018; Chinnamma *et al.*, 2019)	Amino acids: Aspartic acid, Glutamic acid, Serine, Valine, Alanine, Threonine, Methionine, Leucine, Isoleucine, Histidine, Cysteine, Arginine, Tyrosine (Chinnamma *et al.*, 2019; Hebbar *et al.*, 2020)	Vitamins: Vitamin A, Thiamine (B1), Riboflavin (B2), Niacin (B3), Pyridoxine (B6), Biotin (B7), Folic acid (B9), Adenine (B4), Para-aminobenzoic acid (B10), Vitamin C (Asghar *et al.*, 2020; Chinnamma *et al.*, 2019)

potentiality for use as probiotics in food and feed formulations (Somashekaraiah *et al.*, 2019).

CONCLUSION

Based on the data search in Scopus (1984-2021), there were a total of 76 articles published on coconut sap research. The bibliometric analysis revealed that 53 authors and 12 sources produced more than two documents. Hebbar K.B. from India was the most prolific author, while the most influential publication was authored by Borse B.B., reporting on the effect of processing in bioactive compounds identification (63 citations). Observation of the research trend revealed that the bacteriology of coconut sap was consistently reported from the earliest years to the present. This review also showed that coconut sap has a huge potential in the nutraceutical food and beverage industry and appears to be an emerging product which may penetrate the global market.

Acknowledgement

This research was made possible by the financial support from the Ministry of Higher Education through Fundamental Research Grant Scheme (FRGS)(FRGS/1/2020/WAB13/UMK/02/3) and Universiti Malaysia Kelantan, Jeli, Kelantan, which provided the facilities to perform the analysis. The authors would also like to acknowledge the International Islamic University Malaysia (IIUM)'s library for providing the necessary resources to write this review.

Authors' contributions:

Fadhlina A, led the data analysis and prepared the draft of the manuscript; Sheikh HI, advised on the data analysis and interpretation, and reviewed the manuscript; Nor MM, principal investigator, conceptualised and designed the study; Saidan NH, assisted in drafting the manuscript and reviewed the manuscript; Zainurin NA, assisted in data collection.

Conflict of interest

The authors declare no conflict of interest.

References

Asghar MT, Yusof YA, Mokhtar MN, Ya'acob ME, Mohd Ghazali H, Chang LS & Manaf YN (2020). Coconut (*Cocos nucifera* L.) sap as a potential source of sugar: Antioxidant and nutritional properties. *Food Sci Nutr* 8(4):1777-1787.

A-sun K, Thumthanaruk B, Lekhavat S & Jumnongpon R (2016). Effect of spray drying conditions on physical characteristics of coconut sugar powder. *Int Food Res J* 23(3):1315.

Atputharajah JD, Widanapathirana S & Samarajeewa U (1986). Microbiology and biochemistry of natural fermentation of coconut palm sap. *Food Microbiol* 3(4):273-280.

Borse BB, Rao LJM, Ramalakshmi K & Raghavan B (2007). Chemical composition of volatiles from coconut sap (neera) and effect of processing. *Food Chem* 101(3):877-880.

Chinnamma M, Bhasker S, Binitha Hari M, Sreekumar D & Madhav H (2019). Coconut neera – a vital health beverage from coconut palms: harvesting, processing and quality analysis. *Beverages* 5(1):22.

Devi NS, Hariprasad T, Ramesh K & Merugu R (2015). Antioxidant properties of coconut sap and its sugars. *Int J Chemtech Res* 7(6):2645-2647.

Fadhlina A, Alias NF, Sheikh HI, Zakaria NH, Majid FA, Hairani MA & Hudiyanti D (2023). Role of herbal tea (*Camellia sinensis* L. Kuntze, *Zingiber officinale* Roscoe and *Morinda citrifolia* L.) in lowering cholesterol level: A review and bibliometric analysis. *J Agric Food Res* 24:100649.

Ghosh DK, Bandyopadhyay A, Das S, Hebbar KB & Biswas B (2018). Coconut Sap(Neera)-Untapped Opportunity of Spinoff Gains in West Bengal, India. *Int J Curr Microbiol Appl Sci* 7(09):1883-1897.

Hebbar KB, Arivalagan M, Manikantan MR, Mathew AC, Thamban C, Thomas GV & Chowdappa, P (2015). Coconut inflorescence sap and its value addition as sugar–collection techniques, yield, properties and market perspective. *Curr Sci* 109(25):1411-1417.

Hebbar KB, Arivalagan M, Pavithra KC, Roy TK, Gopal M, Shivashankara KS & Chowdappa P (2020). Nutritional profiling of coconut (*Cocos nucifera* L.) inflorescence sap collected using novel coco-sap chiller method and its value added products. *J Food Meas Charact* 14(5):2703-2712.

Jirapeangtong K, Siriwatanayothin S & Chiewchan N (2008). Effects of coconut sugar and stabilizing agents on stability and apparent viscosity of high-fat coconut milk. *J Food Eng* 87(3):422-427.

Jirasatid S & Nopharatana M (2020). Impact of coconut sugar syrup on quality of acidophilus milk during cold storage. *Int J Agric Technol* 16(4):819-830.

Jose SP, Asha S, Krishnakumar IM, Ratheesh M, Santhosh S, Sandya S, Kumar G & Pramod C (2017). Nephro-protective effect of a novel formulation of unopened coconut inflorescence sap powder on gentamicin induced renal damage by modulating oxidative stress and inflammatory markers. *Biomed Pharmacother* 85:128-135.

Jose SP, Mohanan R, Sandya S, Asha S & Krishnakumar IM (2018). A novel powder formulation of coconut inflorescence sap inhibits alcoholic liver damage by modulating inflammatory markers, extracellular matrix metalloproteinase, and oxidative stress. *J Food Biochem* 42(5):e12543.

Joseph A, Jose SP, Kalyan BT, Mammen RR, Krishnakumar IM, Fleenor BS & Mohan R (2021). Coconut inflorescence sap enhances exercise performance and plasma antioxidant status in young active men. *NFS J* 23:37-43.

Karseno E, Yanto T, Setyowati R & Haryanti P (2018). Effect of pH and temperature on browning intensity of coconut sugar and its antioxidant activity. *Food Res* 2(1):32-38.

Kaur G & Goswami TK (2021). Physical and sensory characteristics of low sugar dairy dessert (rasgulla) developed at different level coconut sap syrup. *J Food Science Tech* 58(1):343-348.

Lima EBC, Sousa CNS, Meneses LN, Ximenes NC, Santos MA, Vasconcelos GS, Lima NBC, Patrocínio MCA, Macedo D & Vasconcelos SMM (2015). *Cocos nucifera* (L.)(Arecaceae): A phytochemical and pharmacological review. *Braz J Med Biol Res* 48:953-964.

Mahulette F, Mubarik NR, Suwanto A & Widanarni (2016). Isolation and characterization of lactic acid bacteria from inasua. *J Trop Biodiv Biotechnol* 1(2):71-76.

Mesquita MC, Leandro EDS, de Alencar ER & Botelho RBA (2020). Fermentation of chickpea (Cicer arietinum L.) and coconut (*Coccus nucifera* L.) beverages by *Lactobacillus paracasei* subsp paracasei LBC 81: The influence of sugar content on growth and stability during storage. *Lebensm Wiss Technol* 132(1):109834

Mummaleti G, Sarma C, Kalakandan S, Sivanandham V, Rawson A & Anandharaj A (2021). Optimization and extraction of edible microbial polysaccharide from fresh coconut inflorescence sap: An alternative substrate. *LWT* 138.

Purnomo H (2007). Volatile components of coconut fresh sap, sap syrup and coconut sugar. *ASEAN Food J* 14(1):45.

Rajesh MK, Muralikrishna KS, Nair SS, Krishna KB, Subrahmanya TM, Sonu KP, Subaharan K, Sweta H, Keshava PT, Neeli C & Karunasagar I (2020). Facile coconut inflorescence sap mediated synthesis of silver nanoparticles and its diverse antimicrobial and cytotoxic properties. *Mater Sci Eng C* 111:110834.

Ratheesh M, Svenia JP, Asha S, Sandya S, Girishkumar B & Krishnakumar IM (2017). Anti-inflammatory effect of a novel formulation of coconut inflorescence sap against ox-LDL induced inflammatory responses in human peripheral blood mononuclear cells by modulating TLR-NF-κB signaling pathway. *Toxicol Mech Methods* 27(8):615-621.

Ravindran V, Sriskandarjah N & Rajaguru ASB (1984). The utilization of coconut sap distillery by-products by broiler chicks. *Agric Wast* 11(2):115-124.

Saidan NH, Kartayasa MA, Lokman NI, Ab Llah NF, Nor MM, Mokhtar SI, Zaman KA, Sidek NM & Hamil MS (2020). Effect of Chengal Wood (*Neobalanocarpus heimii*) on Physicochemical and Antimicrobial Properties of Coconut Sap (*Cocos nucifera*). *IOP Conf Ser: Earth Environ Sci* 549:1.

Sarma C, Mummaleti G, Sivanandham V, Kalakandan S, Rawson A & Anandharaj A (2021). Anthology of palm sap: The global status, nutritional composition, health benefits & value added products. *Trends Food Sci Technol* 119: 530-54.

Sheikh H, John A, Musa N, Abdulrazzak LA, Alfatama M & Fadhlina A (2022). Vibrio spp. And Their Vibriocin as a Vibriosis Control Measure in Aquaculture. *Appl Biochem Biotechnol* 194(10):4477-91.

Somashekaraiah R, Shruthi B, Deepthi BV & Sreenivasa MY (2019). Probiotic properties of lactic acid bacteria isolated from neera: a naturally fermenting coconut palm nectar. *Front Microbiol* 10:1382.

Srikaeo K & Thongta, R (2015). Effects of sugarcane, palm sugar, coconut sugar and sorbitol on starch digestibility and physicochemical properties of wheat based foods. *Int Food Res J* 22(3):923-929.

Wattimena SC, Temartenan JS & Lesbatta KJ (2021). The effect of coconut sap amount and salt texture on the protein content and total bacterial number in ina sua. *J Phys Conf Ser* 1943(1):12064.

Xia Q, Li R, Zhao S, Chen W, Chen H, Xin B, Huang Y & Tang M (2011). Chemical composition changes of post-harvest coconut inflorescence sap during natural fermentation. *Afr J Biotechnol* 10(66):14999-15005.

Mal J Nutr 29(2): 255-266, 2023

Access to and use of health information technology among obese and non-obese Americans: Analysis of the Health Information National Trends Survey data

Jacksaint Saintila[1*], Cristian Ramos-Vera[2], Yaquelin E. Calizaya-Milla[1], Veronica Ileana Hidalgo Villarreal[3], Antonio Serpa-Barrientos[4] & Wilter C. Morales-García[5]

[1]*Research Group for Nutrition and Lifestyle, Escuela de Nutrición Humana, Universidad Peruana Unión, Lima, Perú;* [2]*Research Area, Faculty of Health Sciences, Universidad César Vallejo, Lima, Perú;* [3]*Departamento de Saúde Pública, Instituto Aggeu Magalhaes, Fiocruz, Recife, Brasil;* [4]*Escuela de Psicología, Universidad Nacional Mayor de San Marcos, Lima, Perú;* [5]*Escuela de Medicina Humana, Universidad Peruana Unión, Lima, Perú.*

ABSTRACT

Introduction: Health information technology (HIT) is essential in the prevention, management, and treatment of obesity due to the medical data and information available to health care providers and patients. However, exploration of HIT access and use among obese individuals remains limited. **Objective:** The purpose of this study was to compare access to and use of HIT among obese and non-obese Americans. **Methods:** We considered cross-sectional secondary data from 3,865 United States adults that were collected through the Health Information National Trends Survey in 2020. Contingency tables were performed stratifying between men and women to assess whether they differed according to body mass index (BMI) levels with respect to HIT categories. **Results:** Elevated BMI in women was associated with the use of a computer, smartphone, or other electronic device to e-mail or use the Internet to communicate with a doctor or a doctor's office. In addition, elevated BMI in both genders was associated with sharing information from a smartphone/electronic device with a health professional. Finally, the use of an electronic device to monitor or track health or activity was found to be more prevalent among women with elevated BMI compared to those with normal BMI. **Conclusion:** Future studies should expand research in terms of interventions linked to health information technology in adults with obesity by considering the gender factor. Moreover, the expansion of research into electronic health (eHealth) interventions is particularly important because it would favour the prevention, management, control, and treatment of obesity.

Keywords: BMI, eHealth, obesity, smartphone, telemedicine

INTRODUCTION

Obesity is among the leading causes of death in the world and is a determining factor for the development of metabolic syndrome (Booranasuksakul *et al.*, 2019; Stokes *et al.*, 2018). Globally, a remarkable increase in the prevalence of obesity was evidenced in the last

*Corresponding author: Jacksaint Saintila, MSc
Research Group for Nutrition and Lifestyle, Escuela de Nutrición Humana, Universidad Peruana Unión, Lima, Perú.
Tel: +51 991 354 542; E-mail: jacksaintsaintila@gmail.com
doi: https://doi.org/10.31246/mjn-2022-0058

decade, from 30.5% in 2000 to 40.4% in 2018 (Booranasuksakul *et al.*, 2019). In the United States (U.S.), the burden of obesity continues to grow at a dizzying rate. In fact, in 2020, according to a report published by the Centre for Disease Control and Prevention (CDC), the prevalence of obesity was over 40% (CDC, 2020). This prevalence remained significantly higher in adults living in rural areas, representing more than a third of the U.S. population classified as obese (34.2%), compared with those living in urban areas (28.7%) (CDC, 2020).

Health information technology (HIT) refers to technological tools that provide information, data, and knowledge used by healthcare providers, patients, insurance companies, and government entities for storing, retrieving, and communicating medical information, as well as making decisions (Onyeaka *et al.*, 2021). In the U.S., the adoption of policies such as the implementation of the Health Information Technology for Economic and Clinical Health Act has favoured accelerated access to and use of HIT in healthcare (DesRoches *et al.*, 2013). With the advent of new communication tools, such as smartphones/tablets, other electronic devices, and social networks, there has been a dramatic improvement in the use of HIT in recent years (Pew Research Centre, 2021). The extension of electronic health (eHealth) tools, such as health-related apps to smartphones and electronic devices like Fitbit and smartwatches (Shan *et al.*, 2019), as well as remote patient monitoring systems through text messages and video calls are becoming increasingly important strategies for a better provision of health services (Onyeaka *et al.*, 2020). In addition, patients are increasingly embracing the integration of these digital tools while being cared for by healthcare professionals (Anstey Watkins *et al.*, 2018). In fact, patients' use of eHealth tools is associated with increased access to health information, lower health care costs, better emotional support, improved self-care, and management of chronic conditions (Tarver *et al.*, 2018).

Although there has been evidence of a significant increase in the ownership of smartphones and tablets with health-related apps in the last decade (Saintila *et al.*, 2021); however, it is not clear how the use of HIT can improve the health of people with obesity. On the other hand, the use of eHealth depends mainly on Internet access. Therefore, understanding the current patterns in terms of access, use, and preferences for health information technology in individuals with obesity is important to address related issues through the implementation of health policies that positively impact on this group of people in the U.S.

The availability of smart devices, the use of HIT, and applications related to health can improve current strategies for the treatment, control, and prevention of obesity by modifying risk factors, given that 97% of U.S. adults own some type of cell phone and 85% reportedly have a smartphone in 2021 (Pew Research Centre, 2021). The aim of this study was to compare the access to and use of HIT in obese and non-obese American adults.

MATERIALS AND METHODS

Data sources and participants

In this study, we used secondary data from the Health Information National Trends Survey (HINTS), a cross-sectional and nationally representative survey conducted via mail in U.S. adults ≥ 18 years of age. The HINTS focused on the collection of relevant health information and included questions on the access to and use of health information technology. In this study, the HINTS 5 cycle 4 data collected between February and June

2020 were used, using the next birthday method for the selection of participants. There were 3,865 responses in the full dataset, which were used to perform the statistical analyses. The survey used a two-stage sampling technique: In the first stage, a stratified sample of addresses was selected from a list of residual addresses and then one adult was selected within each household. The HINTS 5 survey was approved by the Institutional Review Board of Westat. Since the data were not identified and extracted from the National Cancer Institute, therefore, informed consent was not required from the participants. All procedures followed were conducted in accordance with the U.S. Federal Policy for the Protection of Human Subjects.

HIT measures

HIT was evaluated through responses to 13 questions listed in Table 1. Measures included: *"Own smartphone", "Own tablet", "Have a health/wellness app", "Use e-mail to converse with a clinician", "Use of smartphone/tablet to track health progress", "Use of smartphone/ tablet to make health decisions", "Use smartphone/tablet to converse with health care provider", "Look for health information.", "Go online to access the Internet, or to send and receive e-mails", "Health tracking", "Look up medical test results", "Monitoring health or activity"*, and *"Use of an electronic device or smartphone to share information with a healthcare professional".*

Sociodemographic data

Sociodemographic variables in the study included gender (female and male), education level (high school or less, incomplete university, and university graduate), employment (yes or no), income range (USD 0 to 19,999, USD 20,000 to 49,999, USD 50,000 to 99,999 and ≥ USD 100,000), and race (white, African American, and others).

Body mass index (BMI)

Anthropometric data, such as weight and height, were considered. Participants were asked *"About how tall are you without shoes?"* and *"About how much do you weigh, in pounds, without shoes?"*. These data were self-reported. In addition, the data obtained were converted into kilograms and meters to estimate BMI. The Quetelet index was used to calculate BMI - dividing weight (measured in kilograms) by the square of height (measured in meters). BMI was categorised into a binary variable: normal BMI ($\geq 18.5 - \leq 24.9$ kg/m^2) and elevated BMI (>25 kg/m^2) (WHO, 1998).

Statistical analysis

Descriptive statistics of absolute frequency and proportions were used to examine the difference in HIT access and use between participants with normal and elevated BMI. Contingency tables were performed stratifying men and women to evaluate if there were differences according to normal BMI (≥ 18.5 - ≤ 24.9 kg/m^2) and elevated BMI (>25 kg/m^2) with respect to the health information technology variables. Chi-square test was used and a *p*-value of less than 0.05 was considered as a parameter of statistical significance. All analyses were performed using JASP (version 0.15.1), an open-source statistical software programme (Department of Psychological Methods University of Amsterdam, Amsterdam, The Netherlands).

RESULTS

Table 2 shows the socio-demographic profile of respondents based on BMI classification. Data from a total of 3,865 respondents were analysed. The

Table 1. Health Information National Trends Survey (HINTS) (cycle 4 de HINTS 5) - Survey questions assessing health information technology

Outcome measure	*Survey question(s)*
Own smartphone	"Please indicate if you have a - Smartphone (for example, an iPhone, Android, Blackberry, or Windows Phone)"
Own tablet	"Please indicate if you have a - Tablet computer (for example, an iPad, Samsung Galaxy, Motorola Xoom, or Kindle Fire)"
Have a health/wellness app	"On your tablet or smartphone, do you have any apps related to health and wellness?"
Electronic conversation with doctor	Used e-mail or the Internet to communicate with a doctor or a doctor's office the past 12 months?
Used smartphone/tablet to track health progress	"Has your tablet or smartphone helped you track progress on a health-related goal, such as quitting smoking, losing weight, or increasing physical activity?"
Used smartphone/tablet to make health decision	"Has your tablet or smartphone helped you make a decision about how to treat an illness or condition?"
When interacting with a clinician, smartphone or tablet helped discussion	"Has your tablet or smartphone helped you in discussions with your health care provider?
Look for health information	Looked for health or medical information for yourself the past 12 months?
Go online to access the Internet, or to send and receive e-mails	Do you ever go online to access the Internet or World Wide Web, or to send and receive e-mail?
Health tracking	In the last month have you used at least once a week any portable device to monitor your health?
Test results	Looked up medical test results the past 12 months?
Shared health device information	Have you shared health information from either an electronic monitoring device or smartphone with a health professional within the last 12 months?
Wearable device to track health	In the last 12 months, have you used an electronic wearable device to monitor or track your health or activity? For example, a Fitbit, Apple Watch, or Garmin Vivofit.

Table 2. Description of the sociodemographic profile of the respondents according to BMI classification

Characteristics	*BMI*			χ^2	*p-value*
	Total n=3,865	*Normal n=1,474*	*Elevated n=2,391*		
	%	**%**	**%**		
Age (years) (Mean±*SD*)	55.4±18.3	54.5±19.7	56.4±16.9		<0.001***
Gender				7.69	0.006**
Female	43.0	40.2	44.7		
Male	57.0	59.8	55.3		
Education level				51.15	<0.001***
High school or less	8.4	12.0	6.2		
University incomplete	48.6	38.8	54.5		
University graduate	43.0	49.3	39.3		
Employment				0.03	0.958
Yes	51.1	51.2	51.1		
No	48.9	48.8	48.9		
Income range				29.52	<0.001***
USD 0 to 19,999	26.9	32	24.1		
USD 20,000 to 49,999	23.6	24.8	22.9		
USD 50,000 to 99,999	25.7	24.1	26.7		
≥ USD 100,000	23.8	19.1	26.4		
Race					
White	70.0	70.7	69.6	36.84	<0.001***
African American	16.8	12.1	19.7		
Others	13.2	17.2	10.7		

SD: Standard deviation, BMI: Body mass index, USD: United States dollar
****p*<0.001 ***p*<0.01, **p*<0.05

participants were aged 55.4±18.3 years, predominantly males (57.0%), and 48.6% were individuals who did not complete university. In addition, 48.9% were not employed. Approximately 26.9% of the participants had household incomes of less than $19,999 per year. Finally, 70% of the participants were white. Participants with elevated BMI had mean age of 56.4±16.9 years compared to those with normal BMI (54.5±19.7 years), $p<0.001$. There were significant differences between the proportion of adults with normal and elevated BMI across gender ($p=0.006$), education ($p<0.001$), and race ($p<0.001$).

In Table 3, we found that elevated BMI in women was associated with the use of e-mail to converse with a doctor ($p=0.034$). However, there was no difference between participants with normal or high BMI in ownership of smartphone/tablet and ownership of any health/wellness-related apps. Similarly, in both genders, we did not find an association between smartphone/ tablet use for tracking progress towards a health-related goal (e.g., quitting

Table 3. Access to and use of electronic devices among women and men with normal and elevated BMI

Outcome measure	*Women*				*Men*			
	BMI				*BMI*			
	Normal	*Elevated*	χ^2	*p-value*	*Normal*	*Elevated*	χ^2	*p-value*
	%	%			%	%		
Own a smartphone	30.3	30.6	3.36	0.067	30.2	31.2	0.34	0.561
Own tablet	45.9	45.8	0.04	0.821	42.9	43.1	0.07	0.788
Have a health/wellness-related app	23.9	23.6	1.27	0.260	26.9	25.7	1.52	0.227
Use e-mail to converse with a doctor	34.4	65.6	4.50	0.034*	40.4	59.6	0.03	0.953
Use of smartphone/tablet to track health progress	34.0	34.1	0.39	0.533	35.4	36.4	3.06	0.080
Use of smartphone/tablet to make a health decision	31.6	33.4	1.64	0.201	32.1	31.2	0.39	0.529
Use smartphone/tablet to converse with health care provider	34.4	32.5	0.03	0.854	32.5	32.4	1.20	0.273

BMI: Body mass index
*$p<0.05$

smoking or increasing physical activity), making a decision about how to treat a disease or condition, and having conversations with their health care provider.

In Table 4, we found that elevated BMI in women and men was associated with sharing information from a smartphone/electronic device to a doctor (p=0.038 and p<0.001, respectively). In addition, women with elevated BMI were more likely to use an electronic device to monitor or track their health or activity (e.g., Fitbit, Apple Watch, or Garmin Vivofit) compared to those with normal BMI (p=0.030). However, we found no difference in normal and elevated BMI in the use of a computer, smartphone, or other electronic devices to look up medical/health information, go online or to send and receive email, monitor health and look up medical test results, and to monitor or track health or activity.

DISCUSSION

Comparison with previous studies

Our findings showed that women with high BMI reported using e-mail to communicate with a doctor or a doctor's office. A previous study reported that adult patients who communicated via e-mail with health care providers were more likely to be females (Kindratt *et al.*, 2021). It may be speculative, however, a possible justification for this finding could be that women having this condition of excess body weight have a greater need to use e-mail to exchange medical information with their providers compared to those of normal weight. On the other hand,

Table 4. Use of electronic devices to exchange information with health care providers among women and men with normal and elevated BMI

Outcome measure	*Women*				*Men*			
	BMI		χ^2	*p-value*	*BMI*		χ^2	*p-value*
	Normal	*Elevated*			*Normal*	*Elevated*		
	%	%			%	%		
Look for health information	32.4	30.8	0.05	0.824	32.0	30.8	2.21	0.137
Go on-line to access the Internet, or to send and receive e-mails	21.5	21.8	1.61	0.205	21.0	20.4	0.46	0.497
Health tracking	18.4	18.5	1.05	0.305	19.4	19.5	0.01	0.910
Look up medical test results	22.1	21.7	0.58	0.444	22.6	22.1	0.25	0.614
Use of an electronic device or smartphone to share information with a healthcare professional	5.7	7.1	4.29	0.038*	5.0	7.2	11.15	<0.001***
Monitoring health or activity	35.3	64.7	0.87	0.030*	41.9	58.1	1.54	0.214

BMI: Body mass index
***p<0.001, *p<0.05

another justification could be the fact that women felt a greater demand to be digitally connected with their healthcare provider, because regular and effective patient-provider communication can positively influence patients' well-being. Finally, in some ways, women are more concerned about their health (Langford *et al.*, 2020); therefore, they may be more likely than men in terms of managing decisions related to health, including that of their family members, who, in many cases, are usually children, parents, and even partners (Langford *et al.*, 2020). A previous study also showed that patients with diabetes, cardiovascular disease, or hypertension were more likely to report increased use of e-mail to exchange medical information with their health care providers (Asan *et al.*, 2018). This demonstrates that there is an interest on the part of patients to communicate with their medical provider via e-mail. Communication is an essential component of medical care, and the use of e-mail and other technological tools, such as health apps, are transforming the doctor-patient relationship (Ye *et al.*, 2010). Therefore, healthcare professionals should consider technological tools, particularly the use of e-mail, as a communication strategy with their patients. Finally, the results of the current study showed the need for an additional study that considers the development of eHealth interventions in individuals with excess body weight, in which the gender factor is considered.

Furthermore, the analyses showed that elevated BMI in both genders was associated with sharing information from a smartphone or handheld device with a doctor. Generally, people who have a health condition are more inclined to use electronic devices to share information with doctors. For example, results from an earlier analysis of the HINTS 2019 dataset found that participants who had a health condition, such as hypertension, diabetes mellitus, or cardiovascular disease, were more likely to use sensors and electronic devices to share this information with doctors than persons without any of these conditions (Shan *et al.*, 2019). However, it is worth mentioning that another previous study reported that in this population (Onyeaka *et al.*, 2021), there is a concern about withholding information from medical providers, and this could be due to existing concerns about the security and confidentiality or privacy of medical records. Confidentiality of medical information and privacy of users are critical elements in an e-health care environment considering the current context; in fact, there is previous evidence describing people's concern about privacy (Torous *et al.*, 2018). However, the retention of medical information by consumers does not always depend on concerns about the confidentiality of their electronic medical records, because there are other intervening factors such as the type of physician-patient relationship and quality of care (Yang *et al.*, 2020). Opportunities to share information with a doctor using an electronic device can undeniably help obese patients find answers to their questions and concerns, which in turn can help them make medical decisions in terms of disease prevention, management, and treatment (Langford *et al.*, 2020).

In recent decades, there has been a growing interest in the use of eHealth interventions that include categories such as telehealth, telemedicine, among others, to support behavioural change, encourage self-care and weight control (Saintila *et al.*, 2021). In general, these interventions are delivered through the use of health information technology, smartphones, health-related apps, text messaging, and personalised medicine (Mahmood *et al.*, 2019). In fact, access to and use of HIT tools can be timely and vital in the management of chronic conditions such as obesity to maintain a healthy weight over the long term (Battersby, Lawn & Pols, 2010). Moreover, there are studies that showed that tablets and smartphones can contribute to the management of chronic diseases (Kim & Lee, 2017). In the current study, as expected, we found that women with elevated BMI were more likely to use an electronic device to monitor or track their health or activity (e.g., Fitbit, Apple Watch, or Garmin Vivofit) compared to those with normal BMI. We speculate some possible justifications why overweight women use electronic devices to monitor health. For example, persons with one or more health conditions compared to those who are apparently healthy are more likely to use digital health tools (Whitehead & Seaton, 2016). Aside from that, due to women's physiology, they may need to use electronic devices to monitor or track their health more frequently than men, which in turn, allows them to have more opportunities to make decisions related to breast and cervical cancer screening, breast reconstruction after mastectomy, among other health decisions (Langford *et al.*, 2020). Our results further complement the findings of Langford *et al.*, (2020) who identified that respondents use other electronic devices beyond smartphones and tablets to monitor health (e.g., Fitbit, blood glucose meter, and blood pressure monitor). In addition, in terms of gender, Langford and colleagues found that men were less likely to use these electronic health devices to support medical decision making compared with women, which is consistent with our findings.

Finally, in the current study, although there was no difference in smartphone/tablet ownership and ownership of any health/wellness-related app between participants with normal and elevated BMI; however, results from an earlier analysis of the 2015 HINTS dataset found that individuals who were more likely to use health-related apps tended to have a BMI in the obese range, were younger, had higher income, had more education, and were Latino/Hispanic (Krebs & Duncan, 2015). In fact, this same study (Krebs & Duncan, 2015) showed a trend between higher use of health-related apps and a higher BMI; they reported that obese persons were approximately 11% more likely to use health-related apps than persons with a normal BMI. This could be due to the fact that the use of health-related applications could be useful in improving health (Comstock, 2015). Health-related apps for smartphones have become popular and are not only focused on fitness and diet, but encompassing more categories such as prevention/lifestyle, self-diagnosis, healthcare provider directories, diagnosis/education, healthy diet options and medical treatment compliance (Krebs & Duncan, 2015). The potential of technology to improve patient communication and management of chronic conditions, such as obesity, is indisputable (Pew Research Center, 2021); therefore, given the burden of obesity, it is imperative to implement policies to encourage the integration of eHealth tools into the workflow of healthcare professionals, particularly doctors, to address the health problems of users (Shan *et al.*, 2019). The use of eHealth applications has the potential to improve health outcomes among those with non-communicable diseases, especially obesity, through better control and monitoring (Whitehead & Seaton, 2016).

It is worth mentioning that the data were collected at the beginning of the COVID-19 pandemic. In fact, the social distancing and closure of stores, sports, and cultural facilities caused by the pandemic have led to a worsening of the obesity epidemic globally (León-Paucar e*t al.,* 2021). The increased prevalence of overweight and obesity could be due to decreased physical activity, dietary changes, and sedentary behaviours (Nuñez-Leyva *et al.,* 2022). Given this concern and the risk of weight gain, it is possible that the COVID-19 pandemic will contribute to the adoption of a healthy lifestyle, including the use of telehealth as a health technology to monitor and maintain a healthy weight. The pandemic has led to changes in the accessibility and availability of online platforms, and this may have impacted the results of the current study (Prescott & Prescott, 2021). On the other hand, it is possible that at the onset of the pandemic, individuals became more aware of the impact of excess body weight on physical and mental health (Ramos-Vera *et al.,* 2022). This could encourage greater use of health-related technological tools, since being aware of excess body weight is a key factor in attempts to achieve a healthy weight.

Strengths and limitations

The current study had several strengths. Firstly, our results were based on a large sample size collected from the HINTS 2020 (HINTS 5 cycle 4), a nationally representative survey. Secondly, the HINTS contained a series of questions seeking to elicit information on access to and use of health information technology, which favoured evidence on the role of smartphones and tablets in communicating with health care providers and monitoring health among those with and without excess body weight according to BMI. Thirdly, it was one of the first studies to evaluate the access to and use of health information technology in individuals with excess body weight, thus establishing a baseline knowledge on the use of HIT in the study population.

However, there were some limitations that are worth mentioning. Firstly, these were cross-sectional data. Although they were useful for examining access to and use of health information technology at a given point in time, however, they cannot provide causality information. In addition, it is possible that people's patterns of HIT use may vary over time. Secondly, the HINTS were mailed survey, thus data, such as weight and height, were self-reported. Therefore, there may be inherent reporting errors and recall bias, and responses may be limited by literacy level. In fact, self-reported BMI is known to be biased compared to measured BMI (Assari, 2020). Finally, the fact that the items that were used were constructed with response items, such as "*yes*" or "*no*", could not allow the complete capture of the frequency or intensity of HIT use in the participants. That is, binary questions were not enough to know how often a person uses his or her tablet, smartphone, or health application as this use may correspond to only once or every day (Li & Peng, 2020).

CONCLUSION

The use of HIT has the potential to improve health outcomes among individuals with obesity through better control and monitoring. The findings showed that elevated BMI in women was associated with the use of e-mail to communicate with a doctor. Additionally, elevated BMI in both genders was associated with sharing information from a smartphone and electronic devices with a doctor. Finally, women with elevated BMI were more likely to use a wearable device to monitor or track health or activity compared to those with normal BMI. Future studies should expand research in terms of health information technology-related interventions in individuals with obesity, considering the gender factor. The expansion of research into eHealth interventions is particularly important because it would favour the prevention, management, control, and treatment of obesity.

Acknowledgement

The author(s) declare that they have not received the following financial support for the research, authorship, and/or publication of this article. However, the authors wish to thank Dr. Varisier Noel and Stephane J. Saintila-Calizaya for their support during the manuscript writing process. Finally, we thank the developers and administrators of the HINTS - the National Cancer Institute. Also, it should be noted that this study does not reflect the views of the National Cancer Institute.

Authors' contributions

Saintila J and Ramos-Vera C, designed the study and wrote the protocols. Calizaya-Milla YE and Morales-García WC, performed literature searches and provided abstracts of previous research studies. Ramos-Vera C and Serpa-Barrientos A, performed statistical analysis and data interpretation. Saintila J and Hidalgo Villarreal VI, wrote the first draft of the article. All read and approved the final manuscript.

Conflicts of interest

The authors report no conflicts of interest in this work.

References

Anstey JOT, Goudge J, Gómez-Olivé, FX & Griffiths F (2018). Mobile phone use among patients and health workers to enhance primary healthcare: A qualitative study in rural South Africa. *Soc Sci Med* 198:139–147.

Asan O, Cooper F, Nagavally S, Walker RJ, Williams JS, Ozieh MN & Egede LE (2018). Preferences for health information technologies among US adults: Analysis of the Health Information National Trends Survey. *J Med Internet Res* 20(10):e277.

Assari S (2020). Differential association between actual and perceived obesity between African Americans and Whites in the United States. *Int J Epidemiol Res* 7(3):107-114.

Battersby M, Lawn S & Pols R (2010). Conceptualisation of self-management. In C. V Kralik D, Paterson B (eds). *Translating Chronic Illness Research Into Practice* (pp. 115–201). Wiley-Blackwell, New Jersey.

Booranasuksakul U, Singhato A, Rueangsri N & Prasertsri P (2019). Association between alcohol consumption and body mass index in university students. *Asian/Pacific Isl Nurs J* 4(1):57-65.

CDC (2020). *In: More obesity in U.S. rural counties than in urban counties.* From https://www.cdc.gov/media/releases/2018/s0614-obesity-rates.html [Retrieved February 21 2022].

Comstock J (2015). *In: Survey: Only 30 percent of insured consumers want to track health on a mobile device.* From https://www.mobihealthnews.com/44159/survey-only-30-percent-of-insured-consumers-want-to-track-health-on-a-mobile-device /[Retrieved November 2 2021].

DesRoches CM, Charles D, Furukawa MF, Joshi MS, Kralovec P, Mostashari F, Worzala C & Jha AK (2013). Adoption of electronic health records grows rapidly, but fewer than half of US hospitals had at least a basic system in 2012. *Health Aff* 32(8):1478–1485.

Kim BYB & Lee J (2017). Smart devices for older adults managing chronic disease: A scoping review. *JMIR mHealth uHealth* 5(5):e69.

Kindratt TB, Allicock M, Atem F, Dallo FJ & Balasubramanian BA (2021). Email patient-provider communication and cancer screenings among US adults: Cross-sectional study. *JMIR Cancer* 7(3):e23790.

Krebs P & Duncan DT (2015). Health app use among US mobile phone owners: A national survey. *JMIR mHealth uHealth* 3(4):e101.

Langford A, Orellana K, Kalinowski J, Aird C & Buderer N (2020). Use of tablets and smartphones to support medical decision making in US adults: Cross-sectional study. *JMIR mHealth uHealth* 8(8):e19531.

León-Paucar SD, Calderón-Olivos BC, Calizaya-Milla YE & Saintila J (2021). Depression, dietary intake, and body image during coronavirus disease 2019 quarantine in Peru: An online cross-sectional study. *SAGE Open Med* 9: 205031212110519.

Li L & Peng W (2020). Does health information technology promote healthy behaviors? The mediating role of self-regulation. *Health Commun* 35(14):1772–1781.

Mahmood A, Kedia S, Wyant DK, Ahn SN & Bhuyan SS (2019). Use of mobile health applications for health-promoting behaviour among individuals with chronic medical conditions. *Digit Heal* 5:2055207619882181.

Nuñez-Leyva, R. E., Lozano-López, T. E., Calizaya-Milla, Y. E., Calizaya-Milla, S. E., & Saintila, J. (2022). Excess Weight and Body Fat Percentage Associated with Waist Circumference as a Cardiometabolic Risk Factor in University Students. *Scientifica* 2022:1–8.

Onyeaka HK, Romero P, Healy BC & Celano CM (2021). Age differences in the use of health information technology among adults in the United States: An analysis of the Health Information National Trends Survey. *Artic J Aging Heal* 33(2):147–154.

Onyeaka HK, Wisniewski H, Henson P & Torous J (2020). Understanding the evolving preferences for use of health information technology among adults with self-reported anxiety and depression in the U.S. *J Behav Cogn Ther* 30(1):49–56.

Pew Research Center (2021). *In: Demographics of mobile device ownership and adoption in the United States.* From https://www.pewresearch.org/internet/fact-sheet/mobile/ [Retrieved November 2 2021].

Prescott GM & Prescott WA (2021). Health information technology utilization and impact on COVID-19 vaccination. *J Am Pharm Assoc* 61(4):e230–e232.

Ramos-Vera C, Serpa Barrientos A, Vallejos-Saldarriaga J & Saintila J (2022). Network analysis of depressive symptomatology in underweight and obese adults. *J Prim Care & Community Health* 13:215013192210969.

Saintila J, Salinas SA, Calizaya-Milla YE, Dávila R, Castellanos-Vazquez AJ, Turpo-Chaparro J, Pacheco-Espinoza JI, Apaéstegui-Huamán AK, Huancahuire-Vega S & Ruiz PG (2021). Effectiveness of a program based on telehealth in nutritional knowledge and body mass index in Peruvian university teachers. *J Prim Care Community Health* 12:215013272110237.

Shan R, Ding J, Plante TB & Martin SS (2019). Mobile health access and use among individuals with or at risk for cardiovascular disease: 2018 Health Information National Trends Survey (HINTS). *Am Heart Assoc* 8(24):e014390.

Stokes A, Collins JM, Grant BF, Scamuffa RF, Hsiao CW, Johnston SS, Ammann EM, Manson JE & Preston SH (2018). Obesity progression between young adulthood and midlife and incident diabetes: A retrospective cohort study of U.S. Adults. *Diabetes Care* 41(5):1025–1031.

Tarver WL, Menser T, Hesse BW, Johnson TJ, Beckjord E, Ford EW & Huerta TR (2018). Growth dynamics of patient-provider internet communication: Trend analysis using the health information national trends survey (2003 to 2013). *J Med Internet Res* 20(3):e109.

Torous J, Wisniewski H, Liu G & Keshavan M (2018). Mental health mobile phone app usage, concerns, and benefits among psychiatric outpatients: Comparative survey study. *JMIR Ment Heal* 5(4):e11715.

Whitehead L & Seaton P (2016). The effectiveness of self-management mobile phone and tablet apps in long-term condition management: A systematic review. *J Med Internet Res* 18(5):e97.

WHO (1998). Obesity: Prevention and Managing the Global Epidemic. Report of a WHO Consultation on Obesity. World Health Organization, Geneva.

Yang X, Parton J, Lewis D, Yang N & Hudnall M (2020). Effect of patient-physician relationship on withholding information behaviour: Analysis of health information national trends survey (2011-2018) data. *J Med Internet Res* 22(1):e16713.

Ye J, Rust G, Fry-Johnson, Y & Strothers H (2010). E-mail in patient–provider communication: A systematic review. *Patient Educ Couns* 80(2):266.

Mal J Nutr 29(2): 267-272, 2023

SHORT COMMUNICATION

Sugar craving and stress levels during different phases of menstrual cycle among university students

Nor Azwani Mohd Shukri*, **Riyadhina Husniyati Syafie & Wan Fathin Fariza Wan Mahmood**

Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia (IIUM), Pahang, Malaysia

ABSTRACT

Introduction: The menstrual cycle in women is often associated with appetite control, mood, and behavioural changes due to hormonal imbalance. However, levels of sugar craving and stress during pre- and post-menstrual periods have not been thoroughly studied. This cross-sectional study aimed to compare levels of stress and sugar cravings during different phases of menstrual cycle among university students. **Methods**: Participants aged 19–25 years were assessed for sugar craving and stress during pre- and post-menstrual periods. They were requested to fill out the Sugar Craving Assessment Tool (SCAT) and Perceived Stress Scale (PSS-10) questionnaires on the first day of menses (the pre-menses phase) by recalling how they felt throughout the past seven days. The participants completed the same set of questionnaires again two days after their menses ended (post-menses phase) by recalling how they felt within the previous two days. **Results**: Ninety-three students participated in the study. Pre-menstrual SCAT score (40.0±19.6) was higher than post-menstrual SCAT score (32.1±19.4), $t(91)=4.82$, $p<0.001$. Mean PSS-10 score was also higher before menstruation (22.8±6.2) than after menstruation (17.5±6.1), $t(91)=6.26$, $p<0.001$. There was no significant difference in mean sugar craving scores of different stress categories, either during pre-menses [$F(2,90)=1.39$, $p=0.256$] or post-menses [$F(2,90)=0.89$, $p=0.415$]. **Conclusion:** The findings indicate that levels of sugar craving and stress were higher during pre-menstrual phase compared to post-menstrual phase in young adults. However, whether sugar cravings are linked to stress during the menstrual cycle is inconclusive and requires further investigation.

Keywords: menstrual cycle, post-menses, pre-menses, stress, sugar cravings

INTRODUCTION

The menstrual cycle in women is often associated with appetite control, mood, and behavioural changes that are caused by hormonal imbalance. The effect of hormone imbalance occurs most during the few days before menstruation, known as pre-menstrual syndrome (PMS). Women during the pre-menstrual period are reported to have an increased appetite and cravings for sweet foods, such as chocolate, as well

*Corresponding author: Dr. Nor Azwani Mohd Shukri
Department of Nutrition Sciences, Kulliyyah of Allied Health Sciences,
International Islamic University Malaysia, Jalan Sultan Ahmad Shah, 25200 Kuantan, Pahang, Malaysia
Tel: (6)09-5715307; Fax: (6)09-5716776; E-mail: norazwani@iium.edu.my
doi: https://doi.org/10.31246/mjn-2022-0094

as cravings for salty flavours compared to the post-menstrual period (Gorczyca *et al.*, 2016). In a case-control study among participants with and without PMS (*n*=69), it was found that total energy and carbohydrate intakes were higher during the luteal (pre-menstrual) phase in comparison to the follicular (post-menstrual) phase (Gallon *et al.,* 2021).

Indeed, obesity prevalence among women has been reported to be consistently higher than that among men throughout the National Health and Morbidity Survey series conducted in Malaysia over the years (Institute of Public Health (IPH), 2020; IPH, 2015; IPH, 2011). These might be attributed to various factors, such as an unhealthy diet and lifestyle. However, natural physiology, specifically the menstrual cycle, may also play a role. Most women experience PMS before menstruation, causing them to be more prone to food cravings and increased consumption of high-fat foods, which may ultimately lead to weight gain over time. The term "PMS" is very synonymous with negative emotions that affect mood regulation and stress sensitivity in women, which is believed to be due to hormone levels fluctuating throughout the menstrual cycle. Research indicates that emotion dysregulation induces psychological distress, which promotes emotional eating, hence the tendency to crave comfort foods for stress relief (Guerrini-Usubini *et al.,* 2023).

In addition, sugar is a potentially addictive substance that induces the release of dopamine, a neurotransmitter that enhances pleasure and "reward-motivated behaviour" in the body (Westwater, Fletcher & Ziauddeen, 2016). This can be supported by the fact that women usually consume foods that are rich in carbohydrates, as well as fat, such as chocolates and ice cream, around the onset of menstruation (Gallon *et al.,* 2021). However, the degree of sugar cravings in relation to different stress levels during a menstrual cycle has not been widely investigated. Thus, this study was conducted to determine the levels of sugar cravings and stress during the luteal and follicular phases of the menstrual cycle in young female adults.

MATERIALS AND METHODS

Study design and participants

Female students at a university in Pahang, Malaysia, were conveniently selected based on a few inclusion criteria. These included individuals who were single (unmarried), had regular menstrual cycle, and were not experiencing any menstrual irregularities. On the other hand, individuals who were married, had irregular menstrual cycles, on medications that would affect appetite or menses or both, consuming oral contraceptives, on a weight-reducing diet, or diagnosed with type 2 diabetes mellitus were excluded from the study. Based on a 40% population prevalence of sweet cravings in women (Yanovski, 2003), a sample size calculation using one single proportion formula yielded a total of 92 study participants.

The protocol of the study was approved by the International Islamic University Malaysia Research Ethics Committee (Reference No. 504/14/11/2/2019-105). A written informed consent was obtained from each respondent before they participated in the study.

Two sets of each of the Sugar Craving Assessment Tool (SCAT) and Perceived Stress Scale (PSS-10) questionnaires were given to the research participants. A clear guideline was given to them before they completed the questionnaires. The expected start and end dates of menses were recorded for each respondent for follow-up purposes. The study participants were requested to complete one set of the questionnaires on the first day of menses, as it was expected that they would have experienced the pre-menstrual symptoms earlier. They needed to recall their feelings throughout the past seven days before menstruation started when answering the questionnaires. The study participants were requested to complete the same set of questionnaires again two days after their menses ended by recalling how they felt throughout the previous two days.

Anthropometry measurements

Self-reported height and weight measurements were collected from the study participants. The body mass index (BMI) value for each respondent was calculated using the formula: weight in kilograms divided by height in meters squared. The values were interpreted using the BMI classification adapted from the World Health Organization (WHO) (WHO, 1995).

Instruments

Sugar Craving Assessment Tool (SCAT)

The SCAT is a self-reported questionnaire for measuring cravings in individuals towards specific food types, including sweets, high fats, carbohydrates, starches, and fast foods (Wan Fathin Fariza & Nik Mazlan, 2017). The respondents were requested to scale each item listed in the questionnaire as A=Never, B=Rarely, C=Sometimes, D=Often, or E=Always/almost every day. The score for craving frequency was determined as A=0, B=1, C=2, D=3, and E=4, with the total score ranging from 0 to 120. The total score was then used to identify the craving status, where any value from 0 to 44 was categorised as "not craving", whereas 45 to 120 was considered as "craving".

Perceived Stress Scale (PSS-10)

The PSS-10 was developed by Cohen, Kamarck & Mermelstein (1983) to measure stress by assessing an individual's feelings and thoughts in the past month. It is a self-reported questionnaire in which study participants were asked how frequently they felt and thought in a certain way in the previous seven days. The total score ranged from 0 to 40. Stress levels were determined based on the PSS-10 score range: low (0 to 13), moderate (14 to 26), and high (27 to 40).

Statistical analysis

The data of this study were analysed using IBM SPSS Statistics for Windows, version 21 (IBM Corporation, Armonk, New York, USA). The demographic data were presented using descriptive analysis. Paired samples *t*-test was used to compare the means of SCAT and PSS-10 scores, while one-way analysis of variance (ANOVA) was used to determine the difference in mean SCAT scores among the different categories of stress level during pre-menses and post-menses. The statistical significance value was set at $p<0.05$.

RESULTS

Demographic data

Female students aged 19–25 years from medical and health sciences faculties participated in the study. Two-thirds of the study participants (n=62) had a normal BMI, while 16% (n=15) were underweight and 17% (n=16) were overweight or obese. The menarche age ranged from 9 to 15 years, with three-quarters (n=70) of the participants started menstruating between the ages of 11 and 13 years. A total of 86% (n=80) of the participants reported a menstrual cycle duration of 28–30 days.

Sugar craving and stress levels during pre- and post-menses

During pre-menses, 63.4% of the study participants reported having no sugar cravings, while about one-third (*n*=34) were found to crave sugar (Table 1). Meanwhile, about three-quarters of the respondents (*n*=71) reported having post-menstrual sugar cravings (i.e., during the two days after menstruation ended), while the rest indicated no sugar cravings. Three-quarters of the respondents experienced moderate stress level (*n*=69, 74.2%) while 18 (19.4%) had high stress level during the pre-menstrual period. Only a small number of them experienced low stress level (*n*=6, 6.5%) during this specific time. On the other hand, stress assessment during post-menses revealed that about two-thirds of the respondents recorded a moderate stress level (*n*=64, 68.8%), 23.7% (*n*=22) respondents encountered a low stress level, and the rest of the respondents (7.5%) experienced a high stress level (Table 1).

The mean SCAT score during pre-menses was found to be higher (40.0±19.6) compared to during post-menses (32.1±19.4), $t(91)=4.82$, $p<0.001$, although both means fell within the same category (not craving). This indicated that the study participants experienced higher sugar cravings during the pre-menstrual period compared to the post-menstrual period. Similarly, the study participants also reported an increased stress level during pre-menses, as shown by higher PSS-10 mean score (22.8±6.2), than during post-menses (17.5±6.1), $t(91)=6.26$, $p<0.001$, with both means indicating a moderate stress level.

The mean SCAT score among study participants who were categorised into low, moderate, and high stress categories showed no significant difference during pre-menstrual and post-menstrual phases (Table 2).

DISCUSSION

The present study indicated that stress level was reported to be higher during the luteal phase than during the follicular phase. In the pre-menstrual period, females usually experience negative emotions and are very sensitive to stressors or stressful conditions (Liu *et al.*, 2017). Most women undergo PMS a few days before menstruation begins. It is a psychological process where symptoms such as food cravings, mood swings, stress, and anger are presented. Stress during the luteal phase can be considered a normal physiological process that may be responded to differently by women (Lorenz, Gesselman & Vitzthum, 2017). Besides, the stress hormones cortisol and glucocorticoids play a significant role in regulating the body's response to stressful conditions. Stressors cause

Table 1: Sugar craving and stress levels during pre-menses and post-menses (*N*=93)

Category	*Pre-menses*		*Post-menses*		*p-value*[a]
	n (%)	*Mean±SD*	*n* (%)	*Mean±SD*	
Sugar craving[b]					
Not craving	59 (63.4%)	40.0±19.6	71 (76.3%)	32.1±19.4	$p<0.001$
Cravingw	34 (36.6%)		22 (23.7%)		
Stress[c]					
Low	6 (6.5%)	22.8±6.2	22 (23.7%)	17.5±6.1	$p<0.001$
Moderate	69 (74.2%)		64 (68.8%)		
High	18 (19.4%)		7 (7.5%)		

SD: Standard deviation
[a] Comparison of means measured using paired *t*-test
[b] Measured using SCAT
[c] Measured using PSS-10

Table 2 Sugar craving scores according to the stress level categories during pre- and post-menses (N=93)

Stress level	*n*	*Sugar craving scores, Mean±SD*	*F-statistics (df)*	*p-value*[a]
Pre-menses				
Low	6	27.3±19.4	1.39 (2)	0.256
Moderate	69	40.6±19.8		
High	18	42.0±18.8		
Post-menses				
Low	22	27.4±15.6	0.89 (2)	0.415
Moderate	64	33.8±20.8		
High	7	31.6±16.4		

SD: Standard deviation
[a] Comparison of means measured using one-way ANOVA test

an increase in cortisol levels in women during the luteal phase. Thus, women are observed to have higher sensitivity to stress during the luteal phase than during the follicular phase, as many studies found that the level of cortisol, the primary stress hormone, increases in response to stressful conditions (Liu *et al.*, 2017).

The current study also found that sugar craving level was significantly higher during the pre-menstrual compared to the post-menstrual period. Macedo & Diez-Garcia (2014) conducted a study regarding high-sweet-fat food cravings in women with premenstrual dysphoric disorder and found that women with stress were susceptible to sweet cravings. In addition, a study by de Souza *et al.* (2018) reported that the craving for foods containing high amounts of simple carbohydrates, salt, and fat, such as sweets, pastries, snacks, sausages, and desserts, was significantly higher among their study participants during the follicular phase (measured between the 5th and the 9th day of the menstrual cycle) as compared to the luteal phase (between the 20th and the 25th day of the menstrual cycle). Sugar-rich foods, such as chocolate and chocolate-chip cookies, accounted for the most common food cravings during the pre-menstrual period. These are perceived as "comfort foods" because they help to elevate and dampen stress-related responses. Comfort food is often suggested as a food that would give psychological and emotional well-being to the consumer and is often perceived as a food that contains high sugar and/or carbohydrate content (Westwater *et al.*, 2016). The appeal of sugar has been shown to increase under stressful conditions. With higher sensitivity towards stress during the luteal phase, females are more prone to have sugar cravings as it is perceived that sugar gives a comforting effect and may alleviate stress-related emotions (Macedo & Diez-Garcia, 2014).

Although this study demonstrated the possible effect of the menstrual cycle on sugar craving and stress levels, stress coming from external factors was not included as a potential confounder during analysis. Thus, future research should consider various environmental stressors for university students, such as academic performance pressure and financial or personal issues. In addition, the fact that there was an uneven distribution in the number of participants for each stress category (with some being very low compared to others) might have affected the current findings on sugar cravings and their potential connection with stress levels during the different phases of the menstrual cycle.

CONCLUSION

This study demonstrated that the levels of sugar craving and stress increased during pre-menses compared to post-menses, albeit within the same category (non-craving and moderate stress). PMS symptoms, such as mood swings, stress, and anger, are common in women due to hormonal imbalance. Thus, higher cravings for foods and beverages containing high sugar during that phase might indicate a natural response to manage the stressful period. However, whether sugar cravings are connected to stress levels (or vice versa) during the different menstrual phases is inconclusive and warrants further investigation.

Acknowledgement
The authors would like to sincerely thank all the study participants.

Authors' contributions

Nor Azwani MS, conceptualised the study, prepared the draft of the manuscript, reviewed, and revised the manuscript; Riyadhina Husniyati S, designed the study, collected, analysed and interpreted the data, assisted in drafting the manuscript; Wan Fathin Fariza WM, provided advice on data analysis and interpretation, and reviewed the manuscript.

Conflict of interest

The authors declare no conflict of interest.

References

Cohen S, Kamarck T & Mermelstein R (1983). A global measure of perceived stress. *J Health Soc Behav* 24:385–396.

de Souza LB, Martins KA, Cordeiro MM, Rodrigues YS, Rafacho BPM & Bomfim RA (2018). Do food intake and food cravings change during the menstrual cycle of young women? *Rev Bras Ginecol Obstet* 40(11):686–692.

Gorczyca AM, Sjaarda LA, Mitchell EM, Perkins NJ, Schliep KC, Wactawski-Wende J & Mumford SL (2016). Changes in macronutrient, micronutrient, and food group intakes throughout the menstrual cycle in healthy, premenopausal women. *Eur J Nutr* 55(3):1181–1188.

Gallon CW, Ferreira CF, Henz A, Oderich CL, Conzatti M, Ritondale Sodré de Castro J, Parmegiani Jahn M, da Silva K & Wender MCO (2021). Leptin, ghrelin, & insulin levels and food intake in premenstrual syndrome: A case-control study. *Appetite* 168:105750.

Guerrini-Usubini A, Cattivelli R, Scarpa A, Musetti A, Varallo G, Franceschini C & Castelnuovo G (2023). The interplay between emotion dysregulation, psychological distress, emotional eating, and weight status: A path model. *Int J Clin Health Psychol* 23(1):100338.

IPH (2020). *National Health and Morbidity Survey (NHMS) 2019: Vol. I: NCDs – Non-Communicable Diseases: Risk Factors and other Health Problems.* Institute for Public Health, Ministry of Health Malaysia, Kuala Lumpur

IPH (2015). *National Health and Morbidity Survey (NHMS) 2015. Vol. II: Non-Communicable Diseases, Risk Factors & Other Health Problems.* Institute for Public Health, Ministry of Health Malaysia, Kuala Lumpur.

IPH (2011). *National Health and Morbidity Survey (NHMS) 2011. Vol. II: Non-Communicable Diseases.* Institute for Public Health, Ministry of Health Malaysia, Kuala Lumpur.

Liu Q, Wang Y, Van Heck CH & Qiao W (2017). Stress reactivity and emotion in premenstrual syndrome. *Neuropsychiatr Dis Treat* 13:1597.

Lorenz TK, Gesselman AN & Vitzthum VJ (2017). Variance in mood symptoms across menstrual cycles: Implications for premenstrual dysphoric disorder. *Women's Reprod Health* 4(2):77–88.

Macedo DM & Diez-Garcia RW (2014). Sweet craving and ghrelin and leptin levels in women during stress. *Appetite* 80:264–270.

Wan Fathin Fariza WM & Nik Mazlan M (2017). Sugar craving and sugar intake pattern among Malay adults. *International J Allied Health Sci* 1(1). From https://journals.iium.edu.my/ijahs/index.php/IJAHS/article/view/43. [Retrieved May 1 2019].

Westwater ML, Fletcher PC & Ziauddeen H (2016) Sugar addiction: the state of the science. *Eur J Nutr.* 55(Suppl 2):55–69.

World Health Organization (1995). *Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee.* (1995). World Health Organization Technical Report Series, 854:1–452.

Yanovski S (2003) Sugar and fat: cravings and aversions. *J Nutr*, *133*(3):835S–837S.

Mal J Nutr 29(2): 273-283, 2023

Malaysian Healthy Diet Online Survey (MHDOS): Study rationale and methodology

Jyh Eiin Wong[1,2], Fui Chee Woon[1,3], Yit Siew Chin[1,4], Wai Siew Teh[5], Rusidah Selamat[5], Ahmad Ali Zainuddin[6], Gilly A Hendrie[7] & E Siong Tee[1*]

[1]Nutrition Society of Malaysia, Selangor, Malaysia; [2]Centre for Community Health Studies (ReaCH), Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Kuala Lumpur, Malaysia; [3]Department of Public Health Medicine, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia; [4]Department of Nutrition, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Selangor, Malaysia; [5]Nutrition Division, Ministry of Health Malaysia, Putrajaya, Malaysia; [6]Institute for Public Health, National Institute of Health, Ministry of Health Malaysia, Selangor, Malaysia; [7]Health and Biosecurity, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Adelaide, Australia

ABSTRACT

Introduction: Access to accurate and timely dietary information is of paramount importance in evaluating and developing well-targeted public health nutrition interventions. However, nationwide nutrition surveys are conducted infrequently because they are very costly to design, conduct and analyse. Dietary assessment tools, which are quick and cost- effective, are needed for population research and regular monitoring of Malaysians' dietary habits. This paper describes the rationale and methodology of the Malaysian Healthy Diet Online Survey (MHDOS) project, which aims to bridge this knowledge gap on dietary intake of Malaysian adults. The main objective of the two-year project is to develop MHDOS as a valid tool to measure compliance with the Malaysian Dietary Guidelines 2020. **Methods:** The MHDOS project has three study phases, namely (i) adaptation of an online survey and established diet quality scoring system for Malaysia, (ii) usability, validity and reliability testing of the online survey; and (iii) online survey administration in a nationwide study. The survey will be administered to approximately 10,000 Malaysian adults aged 18-59 years. **Discussion:** MHDOS consists of 38 questions that measures the quantity, quality and variety of foods consumed. Individuals will receive a diet quality score that reflects their overall compliance with the Malaysian Dietary Guidelines and feedback on how to improve their scores. The findings of the online survey, which serve to complement information between larger surveys, will be useful to measure compliance of Malaysians to national dietary guidelines and inform public health interventions.

Keywords: diet quality, dietary guidelines, online survey

---

*Corresponding author: Dr Tee E Siong
Nutrition Society of Malaysia, No. 27C, Jalan P.U. 7 (PJS 1/48), P.J. Selatan
46000 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: (6)019-3211788; Fax: (6)(03)77287426; E-mail: president@nutriweb.org.my
doi: https://doi.org/10.31246/mjn-2022-0101

INTRODUCTION

Access to timely and accurate dietary information is critical in evaluating and developing well-targeted public health nutrition interventions. Dietary information is important for the development and implementation of intervention programmes to improve dietary habits. Large-scale studies and national nutrition surveys have typically relied on traditional pen-and-paper methods such as 24-hour diet recalls, food records, and diet histories for dietary data collection. However, nationwide nutrition surveys are conducted infrequently because they are very costly to design, conduct and analyse (Micha *et al.*, 2018). In Malaysia, the last Malaysian Adult Nutrition Survey (MANS) was conducted in 2014 (IPH, 2014), ten years after the previous survey (IPH, 2008), which preclude timely reporting on the dietary status of the country. In addition, delays in making data available also hampers the timely implementation of appropriate nutrition intervention programmes.

Compared to comprehensive dietary assessment, brief tools that assess a targeted dietary habit or intake are more affordable and easier to administer, as they impose lower respondent and researcher burden in terms of data collection, processing and analysis. As adjunct measures, brief tools have high scalability and therefore can be administered at frequent intervals to measure and monitor adherence to or deviation from specific dietary patterns or dietary recommendations in public health settings (de Rijk *et al.*, 2021). Dietary assessment tools, which are quick, easy and cost-effective, are needed for population research and regular monitoring of Malaysians' dietary habits.

Online or web-based nutrition surveys are advantageous due to their cost-effectiveness, enabling more frequent and greater geographical reach for dietary data collection than traditional methods (Amoutzopoulos *et al.*, 2018). Often in an online survey, brief tools, such as short food frequency questionnaires, are incorporated to self-report habitual intake across large numbers of individuals. Diet quality indices can then be applied to these data to summarise characteristics of dietary patterns into a single score, to indicate the degree to which individuals and/or populations' eating habits comply with a set of food-based dietary guidelines (Brassard *et al.*, 2022; Hlaing-Hlaing *et al.*, 2020). High diet quality, as assessed by valid diet quality indices, is associated with reduced risk of all-cause mortality and non-communicable diseases (Morze *et al.*, 2020).

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) Healthy Diet Score Survey is one of only a few scientifically developed and validated online dietary assessment tool that is freely available to the public, in this case the Australian public. The online survey questionnaire was developed to assess intake of five food groups, beverages, variety, healthy fats, and discretionary foods, allowing for compliance check with the Australian Dietary Guidelines (Hendrie *et al.*, 2017; Hendrie, Golley & Noakes, 2018). Individuals complete the survey online, and on completion are provided with an immediate and personalised Diet Score (i.e., a number out of 100 reflecting compliance with the Dietary Guidelines) and three suggestions on how to improve their scores. The diet score has been validated against 24-hour recalls in adults, and found to provide reliable and adequate estimate of overall diet quality in Australia (Hendrie, Rebuli & Golley, 2017).

The CSIRO Healthy Diet Score offers a contextually adaptable approach to collect dietary data in a Malaysian setting given the similarities in the structure of food-based dietary guidelines between Australia and Malaysia (NCCFN, 2021; NHMRC, 2013). A contextually specific and adapted version of the survey questions and scoring system would offer a useful population assessment and intervention tool. This paper describes the rationale and methodology of the Malaysian Healthy Diet Online Survey (MHDOS) project, which aims to bridge the knowledge gap on dietary intake of Malaysian adults.

Study rationale and objectives

Globally, the COVID-19 pandemic has drastically changed the diet and lifestyles of individuals (Naja & Hamadeh, 2020), with published evidence pointing toward increasing prevalence of suboptimal intake and wider disparity in diet quality between sociodemographic groups (Ong *et al.*, 2020). Several local studies which were conducted during the pandemic (between April 2020 – June 2021) reported positive changes in eating habits among young adults (Tan, Tan & Tan, 2022), government servants (Hamzaid *et al.*, 2022) and adults (Chin, Woon & Chan, 2022), despite some observed weight gain (Tan *et al.*, 2022) and reduced physical activity (Chin *et al.*, 2022) during the lockdown periods. However, it remains unknown whether these altered nutrition behaviours were transient or long-term after the pandemic crisis.

While it is important to rapidly and regularly assess the current dietary status of the population for nutrition surveillance, monitoring and prompt intervention, it is not feasible to roll out pen-and-paper-based large-scale dietary surveys within close time intervals due to time and resource constraints (Micha *et al.*, 2018). Recognising this dietary data gap, the Research Priority Area 2: National Food and Nutrition situation under the Nutrition Research Priorities in Malaysia for the 12th Malaysia Plan (2021-2025) has set 'determine and monitor national food and nutrition situation regularly' as one of its purposes. To achieve this purpose, development of feasible and reliable methods for population-based assessment of dietary intake is one of the suggested research topics (NCCFN, 2020). Meanwhile, the government has recognised that the COVID-19 pandemic has accelerated 'new norm' in the use and reliance of digital technology in daily life (Economic Planning Unit, 2021; Noraazwa, 2021). There is an increased need and unique opportunity to measure the dietary intake of the Malaysian population using an online survey tool.

An online survey tool, namely the Malaysian Healthy Diet Online Survey (MHDOS), can serve as a cost-effective complementary measure to assess current dietary habits of Malaysian adults. In addition, the survey will raise awareness of the advice provided in the Malaysian Dietary Guidelines 2020 (NCCFN, 2021) and inform strategies to change eating habits and improve diet quality.

Therefore, the main objective of the MHDOS project is to develop an online survey and scoring system to measure compliance with the Malaysian Dietary Guidelines. The developed online survey will be examined for its usability, validity and reliability before being rolled out to examine the diet quality of Malaysian adults.

MATERIALS AND METHODS

Study design

This is an observational, cross-sectional study which involves three main study phases that are conducted between January 2022 and December 2023. They are (i) Phase 1: Adaptation of the CSIRO Healthy Diet Score scoring system to measure compliance with the Malaysian Dietary Guidelines; (ii) Phase 2: Usability, validity and reliability testing of the Malaysian Healthy Diet Online Survey (MHDOS); and (iii) Phase 3: Administrating the survey in a nationwide, full-scale study (Figure 1). The study protocol was reviewed and approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (Ref: NMRR ID-22-00158-75G).

Phase 1 started in January 2022 and involved preparation of the online survey. As part of a collaborative research agreement established between the Nutrition Society of Malaysia and CSIRO, the content of the survey was adapted from the CSIRO Healthy Diet Score survey and translated into three local languages. Using the Google Form, the usability of the online survey was tested in Phase 2 (Usability Testing) in May 2022. The online survey was disseminated through personal networks of the investigators and implied consent were taken from the participants.

Phase 2 Validity and Reliability Testing were conducted between June and October 2022. Participants were recruited from 13 states and three federal territories in Malaysia through convenience sampling by volunteer nutritionists from different states who underwent a short research training before recruitment. Written informed

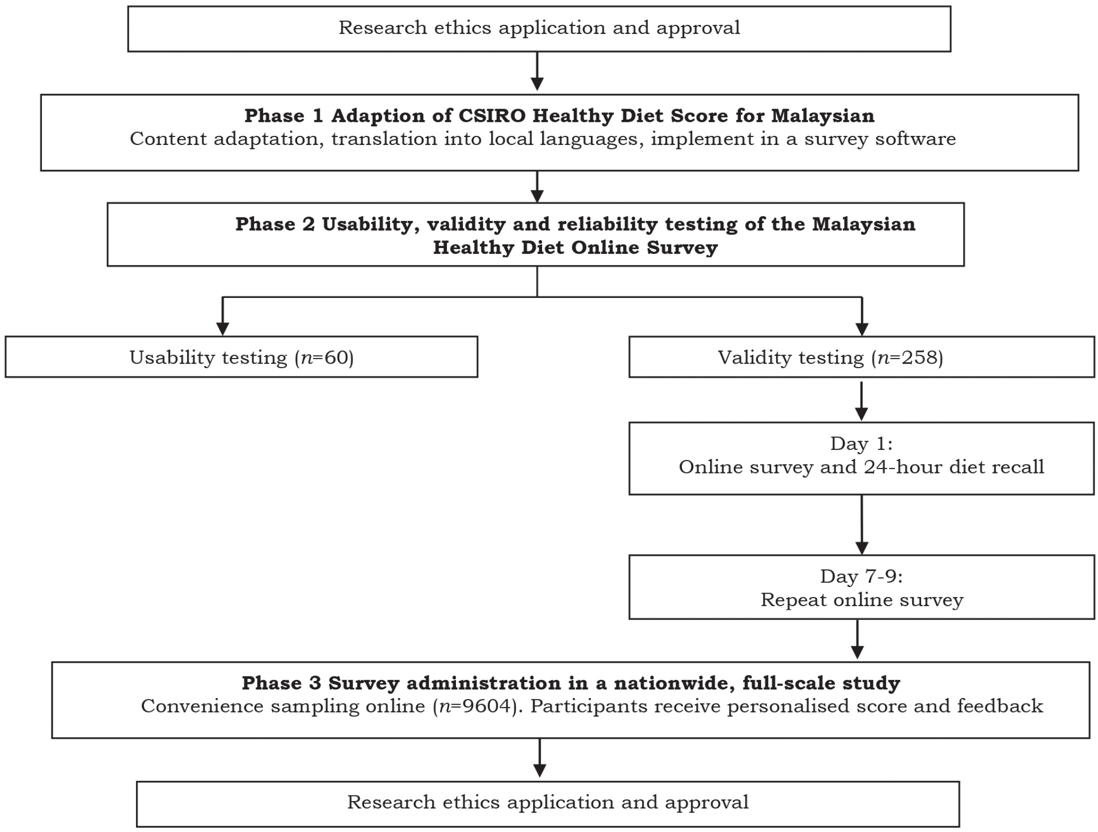


Figure 1. Flow chart of study methodology

consent were obtained from the participants prior to data collection.

Phase 3 Online Survey was conducted from December 2022 using the Alchemer (formerly known as SurveyGizmo) online survey platform. The online survey was launched through a social media campaign. On all study promotion posters and materials, there is a study link, on which interested participants could click to access the survey site. The participants are not required to sign into an account in order to fill in the survey. Implied consent is used in Phase 3 instead of written consent given the low risk involved in this study and the intent to communicate data at the population or group levels only.

Study population

This study involves Malaysian adults aged between 18-59 years, including men and non-pregnant or non-lactating women. The exclusion criteria are adults who are not able to respond to survey in either English, Malay, Mandarin, or Tamil language, not residing in Malaysia, and having dietary restrictions due to medical conditions.

Sample size estimation

For Phase 2 Usability Testing, a sample of 15 participants was deemed sufficient to uncover usability problems of a new survey, based on recommendation by Bastien (2010). Therefore, a total of 60 participants were recruited to test the usability of the four language versions of the survey. For assessment of validity and reliability, sample size was calculated assuming an expected small correlation between the online survey and reference method (ICC=0.20, 90% power). This study phase required a total of 258 participants to complete both methods of dietary assessment (Faul *et al.,* 2009).

For Phase 3 Online Survey, sample size was calculated based on a single proportion formula for estimation of prevalence adjusted for finite population (Daniel & Cross, 2018). This phase requires a minimum of 9604 samples to have 95% confidence level of capturing real value within 0.01 margin of error.

Measures and procedures

Phase 1: Adaptation of the CSIRO Healthy Diet Score for Malaysia

Phase 1 aims to adapt, translate and evaluate the content validity of the Malaysian Healthy Diet Online Survey (MHDOS). The content of the original CSIRO Healthy Diet Score survey was adapted (with permission) so that the food items reflected the local diets and the modified scoring system reflected the Malaysian Dietary Guidelines 2020 recommendations (NCCFN, 2021). Content validation and adaptation were conducted by a panel of experts in the field of nutrition. The English beta version of the adapted survey was forward-backward translated into three local languages, namely Malay, Mandarin and Tamil languages. Firstly, the English version of the adapted survey was translated into the target language by three independent translators who were native speakers of the target language, proficient in English, and with an educational background in nutrition. The translated survey was then back-translated into English by another three independent translators who were proficient in English and their native languages. The original and the back-translated surveys were reviewed by the research team to determine their consistency. The survey was transformed into a consumer grade survey using the online survey platform Alchemer (formerly Survey Gizmo, Louisville, CO, USA), hosted on a dedicated cloud server. The survey system provides end-to-end data encryption and is EU General Data Protection Regulation (GDPR) compliant (Alchemer, 2022).

Phase 2: Usability, validity and reliability testing of the Malaysian Healthy Diet Online Survey (MHDOS)

The main aim of Phase 2 is to establish the adapted survey as a valid brief dietary assessment tool for the Malaysian population.

Usability testing

The usability of the survey (for each language version) was examined using the System Usability Scale (Brooke, 1996). Participants were required to complete a 10-item questionnaire in rating their agreement with the statements that measure the perceived ease-of-use of MHDOS on a five-point Likert-scale, ranging from "0 - Strongly Disagree" to "4 - Strongly Agree". To calculate the total score, the first step was to subtract 1 from the score for each of the odd numbered (positively-worded) questions and subtract the score from 5 for each of the even numbered (negatively-worded) questions. The calculated scores for each question were summed and multiplied by 2.5 to obtain a total score ranging from 0 (very poor) to 100 (excellent perceived usability). A total score above 68 was considered as above average (Sauro & Lewis, 2016). Meanwhile, the participants were asked to provide feedback on their impression of the survey in terms of clarity of words, understanding of the terms, relevance of the items, flow of the questions, and length of the survey. Generated user feedback was incorporated iteratively in the revision of the survey tool.

Validity and reliability testing

MHDOS was evaluated for test-retest reliability and relative validity. Volunteer nutritionists from different states underwent a short research training before recruitment of participants. First, participants were invited to complete the self-administered MHDOS, followed by a multiple-pass, single 24-hour diet recall interview (as a reference method) to determine their usual food intakes for comparison with the data from MHDOS. Next, participants were reminded to complete the online survey for the second time within a two-week period. Participants who withdrew from the validity and reliability testing after the two-week interval were replaced until the required sample size was achieved.

Phase 3: Survey administration in a nationwide, full-scale study

Phase 3 aims to determine the overall diet quality of Malaysian adults and assess their compliance with the Malaysian Dietary Guidelines 2020 by using the validated MHDOS. At the beginning of the online survey, participants are presented with the study information, followed by an implied consent form. If they choose to proceed, they will be directed to answer 38 questions about their usual intake in terms of frequency (per day, week or month) and quantity (servings) for five core food groups, namely (i) vegetables; (ii) fruits; (iii) rice, other cereals, whole grain cereal-based products and tubers; (iv) fish, poultry, eggs, meat and legumes; and (v) milk and milk products. Digital portion size images will be provided to assist estimation of portion sizes. In addition, participants will be asked on their habitual intake of beverages and discretionary foods, food choices (i.e., consumption of wholegrains, types of milk, types of fat and oil consumed, trimming of fat, and water consumption), and variety of foods consumed within each core food group. The amount of core and discretionary foods consumed daily are then compared to recommended servings in the Malaysian Dietary Guidelines 2020 according to sex and physical activity levels. A nine-component diet quality score will be derived from the MHDOS.

Each of the nine components of the total diet quality score is calculated as a sub-score out of 10, except for one component (i.e., discretionary foods), which is scored out of 20. Scores range from zero to 10 for each component and 20 for discretionary foods, where a higher score reflects greater compliance with recommendations for the food group. The scores for each component are then summed to give a total diet quality score out of 100. The higher the score, the closer participants are to meeting the recommendations of the Malaysian Dietary Guidelines 2020.

The participants will also provide sociodemographic information on their sex (gender), year of birth, state of residence, ethnicity, education level, occupation, self-reported body weight and height, and lifestyle factors including physical activity level. Following completion of the survey, participants will receive their calculated diet quality score (range from 0 to 100), which reflects their compliance with the Malaysian Dietary Guidelines, as well as suggestions on how to improve their scores for each component.

Statistical analysis plan

Statistical analysis is carried out by using IBM SPSS Statistics for Windows version 25.0 (IBM Corp, Armonk, New York). Descriptive analysis will be presented as mean and standard deviation (*SD*) for continuous variables, whilst categorical variables will be presented as frequency and percentages (%).

For Phase 2 of the study, dietary data from the 24-hour diet recalls are analysed using the Nutritionist Pro™ software version 5.3.0 (Axxya System, Washington, USA) for conversion into energy and nutrient intakes. Test-retest reliability of the MHDOS is tested using Pearson's correlation and intra-class correlation (*ICC*) coefficients. As for relative validity, paired-sample t-test is carried out to determine the mean differences in the reported food group intakes, while Pearson's correlation coefficients are used to assess the strength of relationships between the first administration of MHDOS and 24-hour diet recalls. In addition, the derived diet quality score from MHDOS is examined on its association with nutrient profiles from 24-hour diet recalls to establish the construct validity of MHDOS. Bland-Altman plots is used to analyse the mean bias and 95% limits of agreement between the two methods in deriving the diet quality scores.

For Phase 3 of the study, Pearson's correlation will be used to determine the associations between continuous variables, while independent samples t-test and one-way analysis of variance (ANOVA) will be used to compare the mean diet quality score between groups. A multivariable linear mixed model will be used to determine the associations of sociodemographic characteristics and lifestyle factors with each component of the diet quality score, as well as the total score. Sociodemographic characteristics and lifestyle factors will be entered as fixed effect, while state of residence will be entered as random effect using the variance component covariance matrix. The statistical significance will be set at $p<0.05$.

DISCUSSION

This paper describes the rationale and methodology of the MHDOS project, which aims to develop a valid online dietary assessment tool to measure diet quality of Malaysian adults. This is a multi-stakeholder collaborative project by the Nutrition Society of Malaysia, Ministry of Health Malaysia and CSIRO. This project is motivated by the need for a reliable and cost-effective complementary tool to facilitate periodic collection of reliable dietary data in a Malaysian adult population setting.

Large-scale studies and national nutrition surveys in Malaysia are subject to interview-administered or paper-and-pen methods such as 24-hour diet recalls and food frequency questionnaires for dietary data collection (IPH, 2014; Poh *et al.*, 2013). While these methods are invaluable in providing in-depth and high-quality information on dietary intake, they are labour- and resource-intensive in collection, processing and analysis. The complexity and burden associated with these methods ultimately limit the capacity of population-based dietary surveys to provide timely and up-to-date dietary data. New technology or digital-based dietary tools, such as online surveys and mobile applications, provide viable alternatives to address some of the limitations inherent in conventional dietary assessment methods (Bell *et al.*, 2017; Cade, 2017). While MHDOS is not a 'high end' innovation, the online survey represents a large improvement on what is currently practised in terms of ease and efficiency of dietary data collection and processing.

The MHDOS is a newly developed online dietary assessment tool that was adapted from the CSIRO Healthy Diet Score survey (Hendrie *et al.*, 2017). It was tested for its validity as a dietary assessment tool before being rolled out as a full-scale nationwide survey. MHDOS assesses the quantity, quality, and variety of foods consumed by individuals and includes coloured images of foods to facilitate the estimation of portion size. Being accessible on desktop and mobile devices, researchers can collect real-time dietary data from large samples regardless of time and geographical location with lower costs and burden. For instance, the CSIRO Healthy Diet Score survey has successfully captured data from over 230,000 Australians since it was launched in 2015 (Hendrie *et al.*, 2021). Another valuable feature of the MHDOS, is the potential to generate a score that reflects individuals' overall compliance with the Malaysian Dietary Guidelines 2020, as well as provide individual feedback on how to improve their diet quality. While this process is currently manual, it is possible to integrate an automated reporting system in the future, which can provide personalised feedback in real time upon completion of the survey.

The MHDOS has the potential to serve as a complementary survey tool to collect individual-level dietary data in a cost-effective, accurate and timely manner. The data generated from the survey enhance the monitoring of dietary intakes and measure the degree of adherence to the national dietary guidelines (NCCFN, 2021). Meanwhile, the data can be used to identify the disparities in diet quality among different socioeconomic groups and ascertain population groups who might be at nutritional risk due to inadequate or excessive intake of specific food groups. This information can be furnished periodically to assist healthcare professionals and policy makers in designing and implementing appropriate nutrition intervention programmes to improve the overall diet quality of the Malaysian population. When the online survey is administered over time, the data can discern temporal and spatial changes in dietary patterns of Malaysian adults. This information will be useful to monitor and evaluate the impact of implemented nutrition policies, interventions and programmes.

A number of main limitations need to be considered regarding the design of the MHDOS project. First, this study is subject to selection bias due to the use of convenience sampling. While conscious effort will be made to encourage inclusive participation from different sex, ethnicity and states, it is likely that participants who volunteered in the study are those who are health-conscious or digitally savvy, while disadvantaged populations may be under-covered. Second, we acknowledge that the usefulness of MHDOS, like all other online survey tools, is constrained by illiteracy, limited internet connectivity, and access to computers. Internet availability, accessibility and affordability remains a concern among adults in low-resource urban settings, despite their reception to technology adoption (Lim *et al.*, 2022). Nonetheless, with the improving trend in digital literacy and commitment for ubiquitous and low-cost internet access (Economic Planning Unit, 2021), MHDOS will prevail as a promising alternative population-based tool for dietary assessment. Finally, besides establishing the validity and roll out of the survey, it is also crucial to ensure the sustainability of the MHDOS beyond the project timeline. There is a need to secure survey funding through public-private partnerships, sponsors or other options to ensure streamlining or effective continuity of the survey in the long term.

CONCLUSION

We envisage that the Malaysian Healthy Diet Online Survey will be useful to provide insights about the population's dietary intake between larger national surveys. In addition to providing timely evidence on compliance to the new national dietary guidelines, the survey will also help to inform public health strategies and intervention to improve the diets of Malaysians.

Acknowledgement

The authors would like to thank the Director General of Health Malaysia for the permission to publish this paper. This study is funded by the Nutrition Society of Malaysia. CSIRO provided in-kind contributions including access to survey and expertise.

Authors' contributions

Wong JE, Chin YS, Tee ES and Hendrie GA conceptualised and designed the study; Woon FC, Teh WS, Rusidah S, and Ahmad Ali Z provided research training and/or coordinated data collection; Wong JE prepared the first draft of the manuscript and all co-authors revised the manuscript for important intellectual content. All authors approved the final version of the manuscript to be published.

Conflict of interest

The authors declare no conflict of interest.

References

Alchemer (2022). *In: Enterprise Quality Data Security.* From https://www.alchemer.com/security. [Retrieved July 25 2022].

Amoutzopoulos B, Steer T, Roberts C, Cade J, Boushey C, Collins C, Trolle E, De Boer E, Ziauddeen N & Van Rossum C (2018). Traditional methods v. new technologies–dilemmas for dietary assessment in large-scale nutrition surveys and studies: a report following an international panel discussion at the 9th International Conference on Diet and Activity Methods (ICDAM9), Brisbane, 3 September 2015. *J Nutr Sci* 7:e11.

Bastien JC (2010). Usability testing: a review of some methodological and technical aspects of the method. *Int J Med Inform* 79(4):e18-e23.

Bell W, Colaiezzi BA, Prata CS & Coates JC (2017). Scaling up dietary data for decision-making in low-income countries: New technological frontiers. *Adv Nutr* 8(6):916-932.

Brassard D, Elvidge Munene LA, St-Pierre S, Guenther PM, Kirkpatrick SI, Slater J, Lemieux S, Jessri M, Haines J, Prowse R, Olstad DL, Garriguet D, Vena J, Vatanpatast H, L'Abbe MR & Lamarche B (2022). Development of the Healthy Eating Food Index (HEFI)-2019 measuring adherence to Canada's Food Guide 2019 recommendations on healthy food choices. *Appl Physiol Nutr Metab* 47(5):595-610.

Brooke J (1996). SUS: A "quick and dirty" usability scale. In PW Jordan, B Thomas, BA Weerdmeester & AL McClelland (eds). *Usability Evaluation in Industry* (pp. 189-194). Taylor and Francis, London.

Cade JE (2017). Measuring diet in the 21st century: Use of new technologies. *Proc Nutr Soc* 76(3):276-282.

Chin YS, Woon FC & Chan YM (2022). The impact of Movement Control Order during the COVID-19 pandemic on lifestyle behaviours and body weight changes: Findings from the MyNutriLifeCOVID-19 online survey. *PLoS One* 17(1):e0262332.

Daniel WW & Cross CL (eds) (2018). *Biostatistics: A Foundation for Analysis in the Health Sciences.* John Wiley & Sons, New York.

de Rijk MG, Slotegraaf AI, Brouwer-Brolsma EM, Perenboom CWM, Feskens EJM & de Vries JHM (2021). Development and evaluation of a diet quality screener to assess adherence to the Dutch food-based dietary guidelines. *Br J Nutr* 1-11.

Economic Planning Unit (2021). *Malaysia Digital Economy Blueprint.* Economic Planning Unit, Prime Minister's Department, Putrajaya.

Faul F, Erdfelder E, Buchner A & Lang AG (2009). Statistical power analyses using G* Power 3.1: tests for correlation and regression analyses. *Behav Res Methods* 41(4):1149-1160.

Hamzaid NH, Gumisi ZGR, Ahmad Helme SK, Azmi N & Shahril MR (2022). Lifestyle and psychological factors affecting eating habits and physical activity among government servants in the states with the highest cumulative cases in Malaysia during the COVID-19 pandemic. *Front Public Health* 10:816530.

Hendrie GA, Baird D, Golley RK & Noakes M (2017). The CSIRO Healthy Diet Score: An online survey to estimate compliance with the Australian Dietary Guidelines. *Nutrients* 9(1):47.

Hendrie GA, Golley RK & Noakes M (2018). Compliance with dietary guidelines varies by weight status: A cross-sectional study of Australian adults. *Nutrients* 10(2):197.

Hendrie GA, Lyle G, Mauch CE, Haddad J & Golley RK (2021). Understanding the variation within a dietary guideline index score to identify the priority food group targets for improving diet quality across population subgroups. *Int J Environ Res Public Health* 18(2):378.

Hendrie GA, Rebuli MA & Golley RK (2017). Reliability and relative validity of a diet index score for adults derived from a self-reported short food survey. *Nutr Diet* 74(3):291-297.

Hlaing-Hlaing H, Pezdirc K, Tavener M, James EL & Hure A (2020). Diet quality indices used in Australian and New Zealand adults: A systematic review and critical appraisal. *Nutrients* 12(12):3777.

IPH (2008). *Malaysian Adult Nutrition Survey (MANS) 2003 Vol. 2: General Findings.* Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, Kuala Lumpur.

IPH (2014). *Malaysian Adult Nutrition Survey (MANS) 2014 Vol. I: Methodology and General Findings.* Institute for Public Health, National Institutes of Health, Ministry of Health Malaysia, Kuala Lumpur.

Lim SC, Kataria I, Ngongo C, Usek VS, Kudtarkar SR, Chandran A & Mustapha FI (2022). Exploring the impact of COVID-19 movement control orders on eating habits and physical activity in low-resource urban settings in Malaysia. *Glob Health Promot* 17579759221091197.

Micha R, Coates J, Leclercq C, Charrondiere UR & Mozaffarian D (2018). Global dietary surveillance: Data gaps and challenges. *Food Nutr Bull* 39(2):175-205.

Morze J, Danielewicz A, Hoffmann G & Schwingshackl L (2020). Diet quality as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension score, and health outcomes: A second update of a systematic review and meta-analysis of cohort studies. *J Acad Nutr Diet* 120(12):1998-2031.e15.

Naja F & Hamadeh R (2020). Nutrition amid the COVID-19 pandemic: a multi-level framework for action. *Eur J Clin Nutr* 74(8):1117-1121.

NCCFN (2021). *Malaysian Dietary Guidelines 2020.* National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Putrajaya.

NHMRC (2013). *Australian Dietary Guidelines.* National Health and Medical Research Council, Canberra.

Noraazwa AR (2021). Jalinan Digital Negara (JENDELA): Bringing high quality digital connectivity to all Malaysians. In K Khaneeza (eds). *The National Digital Infrastructure Plan* (pp. 3-9). The Malaysian Communications and Multimedia Commission, Selangor.

Ong MM, Ong RM, Reyes GK & Sumpaico-Tanchanco LB (2020). Addressing the COVID-19 nutrition crisis in vulnerable communities: Applying a primary care perspective. *J Prim Care Community Health* 11:2150132720946951.

Poh BK, Ng BK, Siti Haslinda MD, Nik Shanita S, Wong JE, Budin SB, Ruzita AT, Ng LO, Khouw I, Norimah AK (2013). Nutritional status and dietary intakes of children aged 6 months to 12 years: findings of the Nutrition Survey of Malaysian Children (SEANUTS Malaysia). *Br J Nutr*. 110 (Suppl 3): S21-35.

Sauro J & Lewis JR (eds) (2016). *Quantifying the User Experience: Practical Statistics for User Research.* Morgan Kaufmann, Cambridge, MA.

Tan ST, Tan CX & Tan SS (2022). Changes in dietary intake patterns and weight status during the COVID-19 lockdown: A cross-sectional study focusing on young adults in Malaysia. *Nutrients* 14(2):280.

Mal J Nutr 29(2): 285-295, 2023

Dietary supplement intakes among adults living in Kota Kinabalu during the COVID-19 pandemic: A cross-sectional study

Fredrica Li Ling Vun, Yasmin Beng Houi Ooi & Ban-Hock Khor*

Nutrition Programme, Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Sabah, Malaysia

ABSTRACT

Introduction: During the coronavirus 2019 (COVID-19) pandemic, the public may seek a non-pharmacological approach, such as dietary supplements, to prevent or manage COVID-19. Therefore, this study aimed to evaluate the use of dietary supplements during the COVID-19 pandemic among adults in Kota Kinabalu. **Methods:** This cross-sectional study recruited 213 adults living in Kota Kinabalu through convenient sampling from October 2021 to March 2022. A validated questionnaire was used to evaluate their perception on the use of dietary supplements, and the types of dietary supplements consumed before and during the COVID-19 pandemic. **Results:** One-hundred sixty-one (75.6%) adults reported that they were told to consume dietary supplements during the COVID-19 pandemic, primarily from close family members (64.0%) and social media (58.4%). One-hundred and thirty-two (62%) adults were consuming dietary supplements and 46 (34.8%) of them only started taking them during the COVID-19 pandemic. The reasons for taking dietary supplements during the COVID-19 pandemic included enhancing the immune system (83.6%) and for prevention of COVID-19 infection (64.4%). The most common dietary supplements consumed during the COVID-19 pandemic were vitamin C (90.2%), followed by multi-vitamin and mineral (32.6%), and fish oil (25.8%). After adjusting for age, sex, education level, and income level, Kadazan-Dusun adults were most likely to consume dietary supplements (adjusted odds ratio = 2.369, 95% CI: 1.070 - 5.248, p=0.034). **Conclusion:** There was an increase in the number of adults consuming dietary supplements during the COVID-19 pandemic, which was likely driven by information sharing via family members and social media.

Keywords: COVID-19, dietary supplement, minerals, vitamins

INTRODUCTION

The coronavirus disease 2019 (COVID-19) was caused by the novel severe acute respiratory syndrome coronavirus 2. It was first reported in China in late 2019 and then spread to other countries at an alarming speed. The World Health Organization (WHO) declared COVID-19 a global health emergency on 30 January 2020 and the outbreak was declared a global pandemic on 11 March 2020 (Velavan & Meyer, 2020). In Malaysia, the first case of COVID-19 was reported on 25 January 2020. Since then, Malaysia was hit by a total of five waves of COVID-19 until this day. The first wave started on 25 January and lasted until 16

*Corresponding author: Khor Ban Hock, PhD
Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia
Tel: (6)018-6699066 E-mail: khorbanhock@gmail.com
doi: https://doi.org/10.31246/mjn-2022-0096

February 2020, involving only tourists from China. The second wave began on 27 February following a religious gathering and the wave lasted until 30 June 2020. The third wave of COVID-19 occurred on 8 September 2020 with a sudden surge of new cases due to the Benteng Lahad Datu cluster in Sabah and Tembok cluster in Kedah (Rampal & Liew, 2021). Although the cases began to decline by early March 2021, the spread of the Delta variant led to another surge of new cases starting in mid-April 2021 that peaked at the end of August 2021 with about 20,000 new cases reported daily. The fifth wave of COVID-19 in Malaysia was predominantly caused by the Omicron variant that reached its peak in February and March 2022 with about 30,000 new cases reported daily (Dong, Du & Gardner, 2020).

At the beginning of the COVID-19 pandemic, preventive measures, such as physical social distancing, wearing a face mask, and hand washing were recommended to reduce the risk of contracting the virus, and most Malaysians were reported to have complied with these necessary precautions (Azlan *et al.*, 2020). When COVID-19 vaccination became available, it became the primary tool used to reduce the incidence and severity of COVID-19; Malaysia has one of the highest COVID-19 vaccination rates globally as most Malaysians have been vaccinated against COVID-19 (COVIDNOW, 2022; Ng *et al.*, 2022). The manifestations of COVID-19 typically are fever, sore throat, fatigue, cough, and dyspnoea. The standard of care for individuals with COVID-19 includes supportive care measures such as hydration, oxygenation, and ventilation, while an antiviral therapy, namely Ritonavir-boosted Nirmatrelvir can be prescribed to selected patients (Gavriatopoulou *et al.*, 2021).

An optimal nutritional status is critical to support the immune system to defend against pathogenic organisms including viruses. Although several studies have reported that malnutrition and micronutrient deficiencies were associated with increased severity of COVID-19 and lower survivability (Beigmohammadi *et al.*, 2021; Hemilä & De Man, 2021; Kurtz *et al.*, 2021; Rubin, 2021), there is insufficient data from well-designed randomised clinical trials to support the recommendations of using dietary supplements to prevent or treat COVID-19 (National Institute of Health, 2021). Nevertheless, there is a growing interest in consuming dietary supplements to enhance the immune function during the COVID-19 pandemic, although it is not substantiated by supporting evidence. Several studies conducted in Turkey (Altun, Ermumcu & Kurklu, 2021), Sri Lanka (Francis, Sooriyaarachchi & Jayawardena, 2022), Middle Eastern countries (Mukattash *et al.*, 2022), and Egypt (Khabour & Hassanein, 2021) have reported the usage of dietary supplements during the COVID-19 pandemic. Before the COVID-19 pandemic, the latest nationwide National Health and Morbidity Survey (NHMS) 2019 reported that 13.8% of Malaysian adults purchased dietary supplements in the past month (IPH, 2020). However, to the best of our knowledge, the usage of dietary supplements during the COVID-19 pandemic among the general population in Malaysia has not been previously reported. Therefore, the present study aimed to investigate the use of dietary supplements among adults in Kota Kinabalu, Sabah during the COVID-19 pandemic.

MATERIALS AND METHODS

Study design

A cross-sectional study using an online survey was conducted in Kota Kinabalu between October 2021 to March 2022 (24 weeks). Convenience sampling was used to recruit respondents. The link to the online survey was distributed through social media such as Instagram and WhatsApp. The study followed the Declaration of Helsinki and the protocol was approved by the Medical Research Ethics Committee of Universiti Malaysia Sabah (UMS/FPSK6.9/100-6/1/95). The study background and aims, and scope of questions asked were all stated at the beginning of the online survey. Before respondents indicated their consent to continue with the online survey, they were provided with statements in Google Form that their participation was voluntary. Before commencing with the online survey, respondents were informed that all data collected would be used solely for research purposes, and their agreement for data sharing and publication was obtained.

Survey instrument

The questionnaire underwent content validation by five experts, including an internal medicine physician, a pharmacist, two nutritionists, and a dietitian; and the item-content validity index obtained was 1.0 for all questions. This questionnaire was pre-tested in a face-to-face pilot test using ten respondents who met the inclusion criteria to determine the readability and understandability of the questionnaire for laypersons. The time to complete the questionnaire was 10–15 minutes. The questionnaire was available in three languages, namely English, Malay, and Chinese. The questionnaire included three sections. The first section contained questions on sociodemography (age, sex, ethnicity, marital status, education background, and personal monthly income), height, weight, medical history, vaccination status, and COVID-19 status. The second section contained 16 questions concerning respondents' perception of dietary supplements and traditional supplements, and their reasons for taking or not taking supplements. The third section covered the type of supplements taken, which were divided into three types of supplements (vitamin, mineral, and non-vitamin and -mineral). All questions were reported for two different periods: before and during the COVID-19 pandemic. The questionnaire was self-administered.

Sampling strategy and respondents

Eligible respondents were invited to participate in the survey through social media (Instagram and Whatsapp). The survey had to be conducted online due to the enforced COVID-19 pandemic lockdown restrictions and the inability to conduct face-to-face interviews. All respondents voluntarily participated in the study and were exposed to the study's aims and objectives before filling out the survey. The inclusion criteria were: (1) participants aged 20 years old and above; and (2) living in Kota Kinabalu. Participants were excluded if: (1) aged 19 years old and below; and (2) pregnant women. The sample size was calculated using the formula by Daniel (1999). Based on the expected prevalence of dietary supplement use at 47% during the second wave of COVID-19 as reported by Mukattash *et al.* (2022) and a precision of 5%, the calculated sample size was 195.

Statistical analysis

Data were analysed using SPSS software, version 26.0 (IBM SPSS Statistics Inc., Chicago, IL, USA). The prevalence of dietary supplement and traditional supplement use among the adults in Kota Kinabalu was analysed using descriptive analysis. Logistic regression was used to determine the associations of sociodemographic profiles with the intake of dietary supplements during the COVID-19 pandemic. Statistical significance was set at p-value <0.05.

RESULTS

Sociodemographic characteristics

A total of 213 adults participated in this study and their sociodemographic characteristics are shown in Table 1. The majority of the respondents were aged 20 – 29 years (55.9%), females (79.3%), Chinese (44.6%), single (62.4%), bachelor's degree holders (67.1%), and had a personal monthly income of RM 2,500 and below (61.5%).

Table 1. Respondents' sociodemographic characteristics (*N*=213)

Characteristics	*n (%)*
Age (years)	
20 – 29	119 (55.9)
30 – 39	33 (15.5)
40 – 49	32 (15.0)
50 – 59	24 (11.3)
60 – 69	5 (2.3)
Sex	
Male	44 (20.7)
Female	169 (79.3)
Ethnic group	
Kadazan-Dusun	68 (31.9)
Chinese	95 (44.6)
Malay	20 (9.4)
Others	30 (14.1)
Marital status	
Single	133 (62.4)
Married	80 (37.6)
Education background	
Primary	5 (2.3)
Secondary	20 (9.4)
Pre-university	12 (5.6)
Diploma	27 (12.7)
Bachelor's degree	143 (67.1)
Master's degree	6 (2.8)
Personal monthly income (RM)	
0 – 2500	131 (61.5)
2501 – 5000	40 (18.8)
5001 – 7500	28 (13.1)
≥ 7501	14 (6.6)

RM: Ringgit Malaysia

Dietary supplement intake patterns

Most of the respondents (*n*=161, 75.6%) reported that they had been told to take dietary supplements during the COVID-19 pandemic (Table 2). The sources of information were mainly their close family members (64.0%), social media (58.4%), and friends (42.9%). Almost everyone was told to consume vitamin C (95.7%), followed by multivitamins (34.8%) and omega-3 fatty acids (15.5%).

Table 2. Information on dietary supplement during COVID-19 pandemic

Responses	*n (%)*
Have been told to take dietary supplements during COVID-19 pandemic	
Yes	161 (75.6)
No	52 (24.4)
Sources of information on dietary supplements during COVID-19 pandemic[†]	
Close family members (i.e., parents and siblings)	103 (64.0)
Social media	94 (58.4)
Friends	69 (42.9)
Mass media (i.e., newspaper, magazine, etc.)	61 (37.9)
Relatives	60 (37.3)
Healthcare professionals (i.e., doctors and nurses, etc.)	37 (23.0)
Colleagues	27 (16.8)
Retail pharmacy staff	17 (10.6)
Type of dietary supplements told to consume during COVID-19 pandemic[†]	
Vitamin C	154 (95.7)
Multivitamins	56 (34.8)
Omega-3 fatty acids	25 (15.5)
Vitamin D	18 (11.2)
Zinc	12 (7.5)
Others	5 (3.1)

[†]Only for respondents who answered "Yes" in the first question (*n*=161) and more than one option may be chosen

About two-thirds of the respondents (*n*=132, 62.0%) reported taking dietary supplements, and 46 (34.8%) of them only started taking dietary supplements during the COVID-19 pandemic (Table 3). Most of the respondents (84.1%) taking dietary supplements were aware that their choices of dietary supplements were registered with the Ministry of Health, Malaysia. The respondents mostly purchased their dietary supplements from retail pharmacies (69.7%), friends or relatives who were distributors or agents (33.3%), and online shopping platforms (29.5%).

The types of dietary supplements consumed by the respondents before and during the COVID-19 pandemic are presented in Figure 1(a). Vitamin C was the most popular dietary supplement before (*n*=78, 59.1%) and during (*n*=119, 90.2%) COVID-19 pandemic, followed by multivitamin and multimineral (before COVID-19, *n*=36, 27.3%; after COVID-19, *n*=43, 32.6%), and fish oil (before COVID-19, *n*=39, 29.5%; after COVID-19, *n*=34, 25.8%). The frequency of consumption of all types of dietary supplements, except fish oil, had increased during the COVID-19 pandemic.

The reasons for the respondents to take and not take dietary supplements are shown in Figure 1(b). Strengthening the immune system was the most common reason (83.6%) for taking

Table 3. Patterns of dietary supplement intake during COVID-19 pandemic

Responses	*n (%)*	*Median (IQR)*
Currently taking dietary supplements		
Yes	132 (62.0)	
No	81 (38.0)	
Timing of consumption of dietary supplements†		
Before COVID-19 pandemic	86 (65.2)	
During COVID-19 pandemic	46 (34.8)	
Changes in dietary supplement intake patterns, during COVID-19 pandemic compared to before the pandemic‡		
Type of dietary supplements increased	20 (23.2)	
Amount/dosage of dietary supplements increased	6 (7.0)	
Maintained the same intake of dietary supplements	54 (62.8)	
Type of dietary supplements decreased	2 (2.3)	
Amount/dosage of dietary supplements decreased	4 (4.7)	
Aware that the dietary supplements consumed were registered with Ministry of Health†		
Yes	111 (84.1)	
No	21 (15.9)	
Sources of dietary supplements†,§		
Retail pharmacy	92 (69.7)	
Chinese traditional medicine store	12 (9.1)	
Clinic or hospital	15 (11.4)	
Online shopping platform	39 (29.5)	
Friends or relatives who were distributors or agents	44 (33.3)	
Monthly expenses on dietary supplements (RM)†		50 (150)

IQR: interquartile range; RM: Ringgit Malaysia
†Respondents who were taking dietary supplements (*n*=132)
‡Respondents who consumed dietary supplements before COVID-19 pandemic (*n*=86)
§More than one option may be chosen

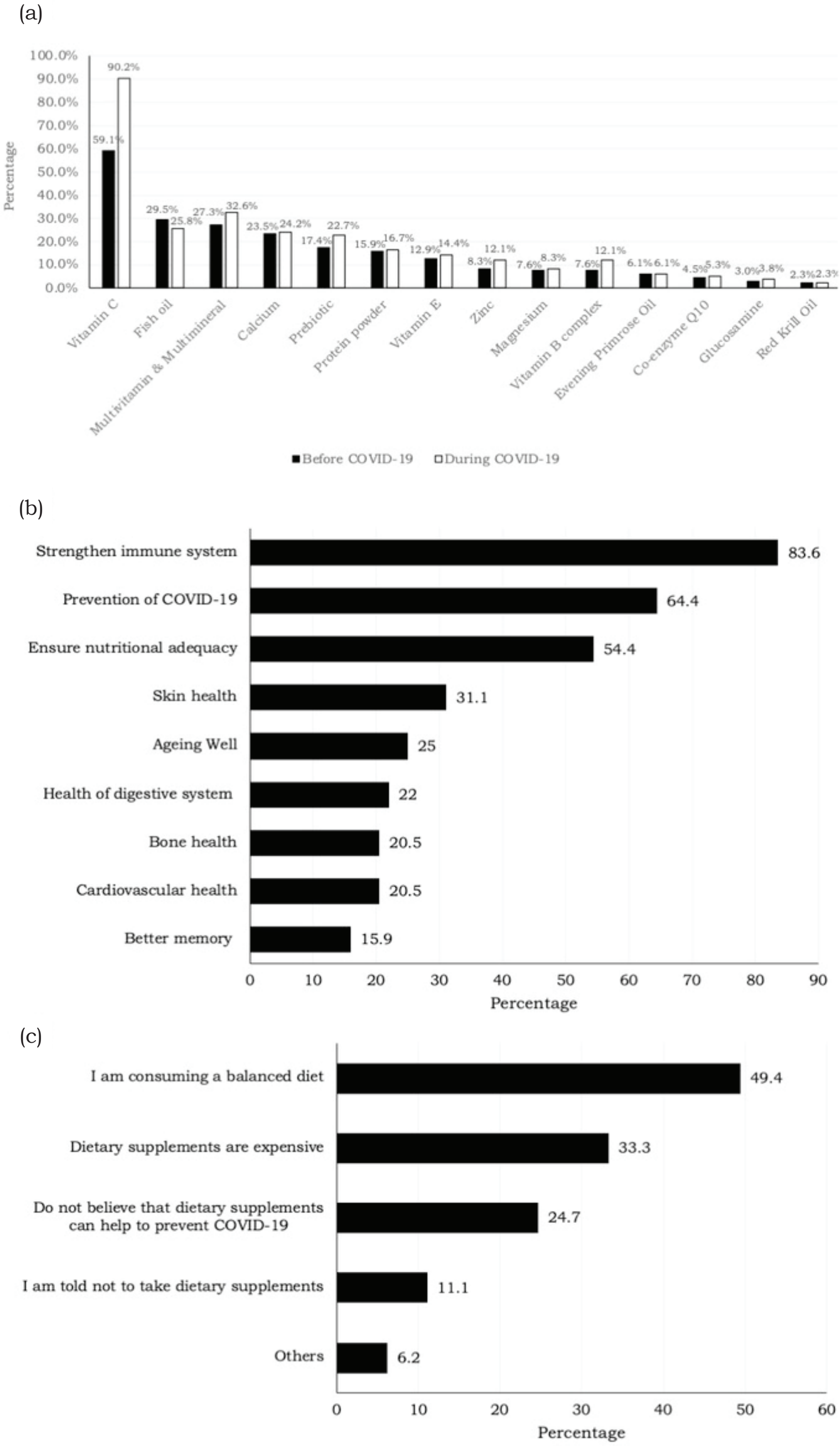


Figure 1. Patterns of dietary supplement intakes: (a) types of supplements; (b) reasons for taking; and (c) reasons for not taking

dietary supplements, followed by prevention of COVID-19 (64.4%) and ensuring nutritional adequacy (54.5%). Most respondents who did not take dietary supplements reported that they believed they were consuming a balanced diet (49.4%), dietary supplements were expensive (33.3%), and did not believe that dietary supplements could help to prevent COVID-19 (24.7%), as presented in Figure 1(c).

Sociodemographic factors and dietary supplement intakes

The associations between sociodemographic factors and dietary supplement intake are presented in Table 4. Simple logistic regression showed that the age group of 30–39 years (*OR*=0.324, 95% *CI*: 0.129, 0.815, *p*=0.017) or being married (*OR*=0.408, 95% *CI*: 0.223, 0.745, *p*=0.004) were less likely to take dietary supplements, while Kadazan-Dusuns (*OR*=2.661, 95% *CI*: 1.251, 5.662, *p*=0.011) or Chinese (*OR*=2.391, 95% *CI*: 1.187, 4.816, *p*=0.015) were more likely to take dietary supplements. Further analysis using multiple logistic regression found that only the Kadazan-Dusun ethnic group was 2.4 times more likely to take dietary supplements than other ethnic groups (adjusted *OR*=2.369, 95% *CI*: 1.070, 5.248, *p*=0.034). No other factors were significantly associated with dietary supplement intake.

Table 4. Associations between sociodemographic factors and dietary supplement intake

Variables	*Simple logistic regression*		*Multiple logistic regression*	
	OR (95%CI)	*p-value*	*adj. OR (95%CI)*	*p-value*
Age (years)				
20 – 29	1.00 (reference)		1.00 (reference)	
30 – 39	0.324 (0.129, 0.815)	0.017*	1.670 (0.378, 7.367)	0.498
40 – 49	0.636 (0.208, 1.944)	0.428	4.240 (0.897, 20.05)	0.068
50 – 59	1.379 (0.403, 4.714)	0.609	3.576 (0.686. 18.64)	
Sex				
Female	1.00 (reference)		1.00 (reference)	
Male	0.713 (0.365, 1.394)	0.323	0.664 (0.314, 1.406)	0.285
Marital status				
Single	1.00 (reference)		1.00 (reference)	
Married	0.408 (0.223, 0.745)	0.004*	0.889 (0.262, 3.019)	0.850
Education background				
Diploma and below	1.202 (0.655, 2.204)	0.553	0.734 (0.339, 1.592)	0.434
Bachelor's degree and above	1.00 (reference)		1.00 (reference)	
Ethnic group				
Kadazan-Dusun	2.661 (1.251, 5.662)	0.011*	2.369 (1.070, 5.248)	0.034*
Chinese	2.391 (1.187, 4.816)	0.015*	1.628 (0.758, 3.498)	0.212
Others	1.00 (reference)		1.00 (reference)	
Personal monthly income (RM)				
≤ 2500	1.00 (reference)		1.00 (reference)	
2501–5000	0.514 (0.246, 1.077)	0.078	1.793 (0.678, 4.738)	0.239
> 5000	1.544 (0.574, 4.153)	0.389	0.935 (0.290, 3.010)	0.910

adj: adjusted; CI: confidence interval; OR: odds ratio; RM: Ringgit Malaysia
*$p<0.05$

DISCUSSION

In the present study, we found that there was an increase in dietary supplement intakes during the COVID-19 pandemic, particularly dietary supplements with immunomodulating effects such as vitamin C, zinc, vitamin Bs, and probiotics. One-third of the adults consuming dietary supplements only started taking them during the COVID-19 pandemic. Interestingly, we found that the number of adults consuming fish oil supplements had reduced during the COVID-19 pandemic, while other dietary supplements showed an increasing trend. Although it was expected that dietary supplement intakes would increase during the COVID-19 pandemic, this study provides facts and figures on the dietary supplement consumption patterns among adults living in Kota Kinabalu, which is generally understudied.

Several studies have examined the intake of dietary supplements among Malaysians before the COVID-19 pandemic. The Malaysian Adult Nutrition Survey 2014 is a nationwide survey, and it was found that 28.1% of adults consumed vitamin and mineral supplements such as vitamin C and multivitamin/multimineral, while 34% of adults consumed food supplements such as fish oil, royal jelly, and spirulina (Zaki *et al.*, 2018). The NHMS 2019 reported that 13.8% of Malaysian adults purchased dietary supplements in the last one month before the interview, while the prevalence for adults in Sabah was 10.1% (IPH, 2020). Another study reported that 55.4% of government employees in Putrajaya consumed dietary supplements (Mohd Asri, Abu Saad & Adznam, 2021). In the present study, we observed a higher prevalence (40.4%) of adults consuming dietary supplements before the COVID-19 pandemic than the one reported by NHMS 2019 for Sabah. There are several possible explanations for this discrepancy. Firstly, the current study was conducted in Kota Kinabalu instead of the whole state of Sabah, and the use of dietary supplements is known to be higher in urban compared to rural areas. Secondly, the NHMS 2019 assessed the purchase of dietary supplements in the past month instead of the habit of consuming dietary supplements.

In the present study, 62% of adults in Kota Kinabalu reported that they consumed dietary supplements during the COVID-19 pandemic and this finding seems to be consistent with an earlier study that reported a prevalence of 55.3% in dietary supplement usage among healthcare workers in Pulau Pinang, Malaysia during the COVID-19 pandemic (Lee *et al.*, 2021). Consistent with our findings, Lee and colleagues (2021) also reported that vitamin C was the most common dietary supplement consumed by the participants. Similarly, a multinational survey conducted in Middle Eastern countries, including Lebanon, Saudi Arabia, Palestine, Jordan, and the United Arab Emirates, reported that 46.6% of participants consumed dietary supplements for the prevention of COVID-19, and the most common dietary supplements used were vitamin C, vitamin D, and zinc (Mukattash *et al.*, 2022). On the contrary, other studies reported a much lower prevalence of dietary supplement use during the COVID-19 pandemic. Khabour & Hassanein (2021) observed that the percentages of dietary supplement users among Egyptian adults for vitamins C, D, A, and Bs were 27%, 17%, 13%, and 13%, respectively. Another study conducted in Sri Lanka found that only 25.5% of participants took dietary supplements regularly, while 32.6%, 14.5%, and 27.4% of participants occasionally, rarely, and never took dietary supplements, respectively. Similarly, vitamin C was the most consumed dietary supplement in this population as well (Francis *et al.*, 2022). Our current findings and findings by these other researchers showed that vitamin C was the most common dietary supplement consumed during the COVID-19 pandemic.

Although the consumption of vitamin C has no effect on the prevention of common cold, it has a modest effect in reducing the duration of common cold symptoms (Hemilä & Chalker, 2013). Despite a low level of vitamin C being a risk factor for COVID-19 mortality (Arvinte, Singh & Marik, 2020), there is insufficient evidence from well-designed randomised controlled trials to support the use of vitamin C supplements for the treatment of COVID-19 (Rawat *et al.*, 2021). In fact, one randomised controlled trial demonstrated that COVID-19 patients receiving vitamin C and zinc supplements did not have a reduced duration of symptoms, instead they experienced more side effects such as diarrhoea, stomach cramp/pain, and nausea (Thomas *et al.*, 2021). A prospective cohort study showed that supplemental vitamin C intakes were significantly associated with the risk of kidney stones among men, but not women (Ferraro *et al.*, 2016). Therefore, it is critical for healthcare workers to disseminate the correct information on dietary supplements to the public, particularly on the potential health risks from megadoses.

In the present study, only 23% of the participants claimed that they had received information on dietary supplements from healthcare workers, while family members and social media were their primary sources of information. These findings corroborate the results of studies conducted in Middle Eastern countries that the consumption of dietary supplements was mainly influenced by lay information sources promoted on social media (Mukattash *et al.*, 2022). Nowadays, social media are used for other purposes beyond social interaction, such as advertising, marketing, business solutions, education, and knowledge dissemination. However, the overall quality of content on social media regarding nutrition information was found to be extremely low (Kabata *et al.*, 2022). This could lead to misleading nutrition information being disseminated, and potential toxicity and adverse effects of dietary supplements not being conveyed to the public.

Our study had several strengths and limitations. Firstly, to the best of our knowledge, this was the first study to assess the intake of dietary supplements among the general public in Malaysia during the COVID-19 pandemic. Secondly, a questionnaire validated by five experts was used in this study. However, this study is limited by its external generalisation to other areas in Malaysia, because it was conducted in Kota Kinabalu, which has a unique sociodemographic profile such as the mosaic of ethnic groups that are not found in Peninsular Malaysia. The sample size was relatively small as compared to other online surveys, albeit having met the calculated number. In addition, respondents recruited for this study were generally young as this study was carried out online to comply with the standard operating procedures during the COVID-19 pandemic. Older people are generally less likely to be active and/or competent users of online platforms. Another limitation of this study was more female respondents were recruited and health-seeking behaviours, such as consuming dietary supplements, could vary between men and women. We also did not collect information on the dosage of dietary supplements consumed by the respondents. Despite these limitations, this study still provided new insights into the patterns of dietary supplement intake among Malaysians during the COVID-19 pandemic.

CONCLUSION

The present study found that more than half of the adults living in Kota Kinabalu took at least one dietary supplement, and one-third of them only started taking dietary supplements during the COVID-19 pandemic. The majority of the adults were told to take dietary supplements and this information was mainly from their family members and social media. Most adults taking dietary supplements believed that this practice could strengthen the immune function and prevent COVID-19 infection, despite there being no evidence to support such claims. These findings highlighted the important role of nutrition professionals in conveying the correct information related to dietary supplements to the public. In addition, it is important for healthcare professionals in clinical practice to assess the intake of dietary supplements during the COVID-19 pandemic, as some dietary supplements will have interactions with medications and could cause harmful effects if consumed excessively.

Acknowledgement

We would like to thank the five experts for the content validation and ten respondents for the pre-testing of the questionnaire used in this study. We would also like to thank all respondents for their time in participating in this study. This study was self-funded.

Authors' contributions

Vun FLL, conducted the study, led the data collection, performed data analysis, and wrote the original draft; Ooi YBH, conceptualised the study, validated the methods, and reviewed and edited the draft; Khor BH, conceptualised the study, performed data analysis, and wrote the original draft.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Altun HK, Ermumcu MSK & Kurklu NS (2021). Evaluation of dietary supplement, functional food and herbal medicine use by dietitians during the COVID-19 pandemic. *Public Health Nutr* 24(5):861-869.

Arvinte C, Singh M & Marik PE (2020). Serum levels of vitamin C and vitamin D in a cohort of critically ill COVID-19 patients of a North American community hospital intensive care unit in May 2020: a pilot study. *Med Drug Discov* 8:100064

Azlan AA, Hamzah MR, Sern TJ, Ayub SH & Mohamad E (2020). Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia. *PLoS One* 15(5):e0233668.

Beigmohammadi MT, Bitarafan S, Abdollahi A, Amoozadeh L, Salahshour F, Soltani D & Motallebnejad ZA (2021). The association between serum levels of micronutrients and the severity of disease in patients with COVID-19. *Nutrition* 91:111400.

COVIDNOW (2022). In: Vaccinations in Malaysia. Last updated 18 Aug 2022, 2:02 am. From: https://covidnow.moh.gov.my/vaccinations/ [Retrieved August 18 2022].

Daniel WW (1999). *Biostatistics: A foundation for analysis in the health sciences*. 7th Ed. John Wiley & Sons, New York.

Dong E, Du H & Gardner L (2020). An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis* 20(5):533-534.

Ferraro PM, Curhan GC, Gambaro G & Taylor EN (2016). Total, dietary, and supplemental vitamin C intake and risk of incident kidney stones. *Am J Kidney Dis* 67(3):400-407.

Francis TV, Sooriyaarachchi P & Jayawardena R (2022). Usage of nutritional supplements to improve immunity during the COVID-19 pandemic: An online survey. *Clin Nutr Open Sci* 43:6-19.

Gavriatopoulou M, Ntanasis-Stathopoulos I, Korompoki E, Fotiou D, Migkou M, Tzanninis IG, Psaltopoulou T, Kastritis E, Terpos E & Dimopoulos MA (2021). Emerging treatment strategies for COVID-19 infection. *Clin Exp Med* 21(2):167-179.

Hemilä H & Chalker E (2013). Vitamin C for preventing and treating the common cold. *Cochrane Database Syst Rev* 2013(1):CD000980

Hemilä H & De Man AM (2021). Vitamin C and COVID-19. *Front Med* 7:559811

IPH (2020). *National Health and Morbidity Survey (NHMS) 2019: Vol. II: Health Care Demand.* Institute for Public Health (IPH), National Institutes of Health, Ministry of Health Malaysia.

Kabaa P, Winniczuk-Kabata D, Kabata PM, Jaśkiewicz J & Połom K (2022). Can Social Media Profiles Be a Reliable Source of Information on Nutrition and Dietetics? *Healthcare* 10(2):397.

Khabour OF & Hassanein SF (2021). Use of vitamin/zinc supplements, medicinal plants, and immune boosting drinks during COVID-19 pandemic: A pilot study from Benha city, Egypt. *Heliyon* 7(3):e06538.

Kurtz A, Grant K, Marano R, Arrieta A, Feaster W, Steele C & Ehwerhemuepha L (2021). Long-term effects of malnutrition on severity of COVID-19. *Sci Rep* 11(1):1-8.

Lee HT, Loh HC, Ramlee SNL & Looi I (2021). Oral dietary supplements use among healthcare workers during the COVID-19 pandemic in Malaysia. *Prog Microbes Mol Bio* 4(1):a0000236.

Mohd Ashri MH, Abu Saad H & Adznam SNÁ (2021). Socio-Demographic Characteristics, Body Weight Status and Energy Intake among Users and Non-Users of Dietary Supplements among Government Employees in Putrajaya, Malaysia. *Nutrients* 13(7):2248.

Mukattash TL, Alkhalidy H, Alzu'bi B, Abu-Farha R, Itani R, Karout S, Khojah HM, Khdour M, El-Dahiyat F & Jarab A (2022). Dietary supplements intake during the second wave of COVID-19 pandemic: a multinational middle eastern study. *Eur J Integr Med* 49:102102.

National Institute of Health (2021). *In: Dietary Supplements in the Time of COVID-19: Fact Sheet for Health Professionals.* From: https://ods.od.nih.gov/factsheets/COVID19-HealthProfessional/ [Retrieved 20 July 2022].

Ng JWJ, Vaithilingam S, Nair M, Hwang LA & Musa KI (2022). Key predictors of COVID-19 vaccine hesitancy in Malaysia: An integrated framework. *PLoS One* 17(5):e0268926.

Rampal L & Liew BS (2021). Malaysia's third COVID-19 wave-a paradigm shift required. *Med J Malaysia* 76(1):1-4.

Rawat D, Roy A, Maitra S, Gulati A, Khanna P & Baidya DK (2021). Vitamin C and COVID-19 treatment: A systematic review and meta-analysis of randomized controlled trials. *Diabetes Metab Syndr* 15(6):102324.

Rubin, R. (2021). Sorting out whether vitamin D deficiency raises COVID-19 risk. *JAMA* 325(4):329-330.

Thomas S, Patel D, Bittel B, Wolski K, Wang Q, Kumar A, Il'Giovine ZJ, Mehra R, McWilliams C, Nissen SE & Desai MY (2021). Effect of high-dose zinc and ascorbic acid supplementation vs usual care on symptom length and reduction among ambulatory patients with SARS-CoV-2 infection: the COVID A to Z randomized clinical trial. *JAMA Netw Open* 4(2):e210369.

Velavan TP & Meyer CG (2020). The COVID-19 epidemic. *Trop Med Int Health* 25(3):278-280.

Zaki NM, Rasidi MN, Awaluddin SM, Hiong TG, Ismail H & Nor NM (2018). Prevalence and characteristic of dietary supplement users in Malaysia: data from the Malaysian Adult Nutrition Survey (MANS) 2014. *Glob J Health Sci* 10(12):127-135.

Mal J Nutr 29(2): 297-306, 2023

The influence of PROP taster status on habitual sweet food consumption and dietary intake amongst obese and non-obese adults

Ahmad Riduan Bahauddin[1*], Zalilah Mohd Shariff[2], Nazamid Shaari[3] & Roselina Karim[3]

[1]*Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Sabah, Malaysia*; [2]*Department of Nutrition and Dietetics, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Selangor, Malaysia*; [3]*Department of Food Technology, Faculty of Food Science and Technology, Universiti Putra Malaysia, Serdang, Malaysia*

ABSTRACT

Introduction: Ability to taste 6-n-propylthiouracil (PROP) predicts both taste sensitivity and food preferences, with PROP tasters being more sensitive to sweet taste in foods, which may lead to less intake of sugary foods. However, when obesity progresses, the individual's sense of taste and eating patterns may change. The aim of this study was to evaluate if PROP taster status affected habitual sweet food consumption and nutritional intake in obese and non-obese people. **Methods:** A total of 88 obese and 92 non-obese Malay male and female participants aged 20-45 years were classified into PROP non-tasters, medium tasters, or supertasters by using PROP filter paper screening procedure. Sweet food consumption was assessed using food frequency questionnaire (FFQ), while dietary intake was measured by using 3-day food diary. Data were analysed using General Linear Model (GLM) Analysis of Covariance (ANCOVA) to compare for differences and associations among variables. **Results:** Overall, there was no significant association between body mass index groups and PROP taster status ($p>0.05$). No significant differences were found on any habitual sweet food intake and dietary intake according to PROP taster status in both obese and non-obese participants ($p>0.05$). However, there was a significant difference ($p<0.05$) in fruit intake according to PROP taster status among obese participants. **Conclusion:** The findings suggest that PROP taster status does not play a role in nutrient intakes among obese and non-obese individuals.

Keywords: dietary intake, obesity, PROP taster status, sweet food consumption

INTRODUCTION

The availability of various types of energy-dense food that are cheap and palatable have contributed to overconsumption among consumers. It is notable that most foods that are high in fat and sugar contents tend to provide pleasurable effect and are often significantly associated with weight gain and chronic diseases (Luger *et al.*, 2017). A study by Teo *et al.* (2021) showed that individuals with higher energy-dense consumption had significantly higher body weight and body mass index (BMI), as well as increased serum cholesterol and risk for hypertension.

*Corresponding author: Dr Ahmad Riduan Bahauddin
Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Sabah, Malaysia
Tel: (6)088-320000 ext.: 8730; Fax: (6)(088)320259; E-mail: a_riduan@ums.edu.my
doi: https://doi.org/10.31246/mjn-2022-0103

Moreover, it was reported in several countries, such as Spain, Brazil, and France, that reducing energy-dense food intake could decrease mortality rate due to cardiovascular disease or non-communicable diseases (Blanco-Rojo *et al.,* 2019). Therefore, finding a useful biomarker in individuals who are at risk to certain dietary pattern could provide a useful approach in developing effective and reliable intervention programmes for the prevention of obesity and chronic diseases.

Taste is a primary aspect in determining our food preferences and dietary changes. However, inter-individual variations on taste perception are wide and complex as the perception of taste modalities appears to be mediated by many different mechanisms (Proserpio *et al.*, 2017; *Tepper et al.*, 2017). The relationship between taste perception and dietary behaviour or eating habit is always triggered by taste sensitivity. People with low taste sensitivity needs higher stimuli or component to achieve the optimal point, which stimulates the hedonic component of taste sensation known as palatability or pleasantness. For instance, individuals who are sensitive to bitter taste may avoid eating brassica vegetables, while those who are less sensitive to fatty taste are more tempted to eat burger and pizza more frequently (Barajas-Ramirez *et al.*, 2016; Deshaware & Singal, 2017).

The ability to taste bitterness of 6-n-propylthiouracil (PROP) is one of best known examples of taste variability influenced by genetic, and it has been used as a general index of oral chemosensory perception, particularly taste sensitivity (Tepper *et al.*, 2019). Many research have shown that PROP tasters are more sensitive to various taste modalities compared with PROP non-tasters. It has been hypothesised that PROP tasters dislike foods with intense sensory qualities of sweet and fattiness, which consequently influence their dietary behaviours and weight regulation. Furthermore, several studies have suggested that PROP non-tasters show higher preferences for dietary sweet and fat (Tepper *et al.*, 2017; Keller *et al.,* 2014), therefore more likely to report lower diet quality and have higher risk of cardiovascular diseases (Sharafi *et al.*, 2018).

Notably, obesity or weight status may affect individuals' taste perception and dietary intake. Many studies have reported that obese participants have lower taste sensitivity compared to non-obese participants (Hardikar *et al.*, 2017). It was speculated that obese individuals tend to have higher preference for sweetened and fatty foods compared to non-obese participants as they need intense taste/flavour to achieve their hedonic breakpoint (Donaldson *et al.*, 2009; Proserpio *et al.*, 2017). However, this assumption is not well explained as findings in previous studies have been inconsistent. Several factors were highlighted for the inconsistencies such as metabolic signal disruption, cognitive eating behaviour, and genetic background (Dastan *et al.*, 2015; Guido *et al.*, 2016). In regard to genetic background, many studies have demonstrated that PROP taster status is a reliable indicator for individuals' taste perception, food intake and preferences (Nagai *et al.*, 2017, Dioszegi *et al.*, 2019).

We hypothesised that PROP taster status could explain the variation in food consumption among obese and non-obese individuals. Therefore, the objective of this study was to explore the effect of PROP taster status on habitual sweet food consumption and dietary intake of sweet and fatty foods among obese and non-obese participants.

MATERIALS AND METHODS

Participants and data collection

This exploratory study used a comparative cross-sectional design, with respondents recruited using a purposive sampling technique. The participants were recruited around Universiti Putra Malaysia (UPM) campus and Serdang district area. The inclusion criteria for participants included aged 20-45 years, in good health, no chronic diseases, no food allergies, not taking any medications that interfered with taste or olfactory perception, not pregnant or lactating, with BMI more than 30 kg/m^2 for obese participants, while BMI less than 18.5 kg/m^2 and not more than 25 kg/m^2 for non-obese participants (WHO, 2021). Participants were screened using a questionnaire prior to their admittance in this study. The appropriate sample size was determined by calculating power using the G*Power 3 software (Faul *et al.*, 2007). To attain 80% statistical power with a medium effect size and a type I error of 0.05, 65 participants per group was required (Choi, 2014). All participants provided written informed consent and the study was approved by the Ethics Committee for Research Involving Human Subjects, Research Management Centre, UPM [Ref. No. RMC/1.4.18.1 (JKEUPM)/ F2]. All data collection was carried out from March until October 2019.

PROP taster status determination

PROP taster status was determined via the paper disc screening test based on Zhao, Kirkmeyer & Tepper (2003). This method employed two paper discs, one impregnated with sodium chloride (NaCl) (1.0mol/l) and the other with PROP solution (0.50mmol/l). Participants were instructed to place the paper disc in the centre of their tongue for 1 minute and then remove the paper. NaCl paper discs were evaluated first, followed by PROP; participants were required to cleanse their palates with water and plain biscuits before tasting another paper disc. They were asked to rate the bitterness intensity of PROP and saltiness of NaCl using general Labelled Magnitude Scale (gLMS). Participants who rated the PROP disc's intensity on the gLMS between 20 and 100 mm were categorised as medium tasters (MT), whereas those who rated less than 20 mm were classified as non-tasters (NT), and those who rated more than 100 mm as supertasters (ST). However, if the PROP disc rating was borderline, the NaCl rating was used to reconfirm the participant's actual PROP taster status. If a participant's PROP rating was borderline at 20mm and the NaCl disc rating was much lower (at least a 30mm difference on the gLMS), the participant was then classified as a non-taster; if participant rated the PROP at 100mm and gave a much higher rating to the NaCl, he/she was then classified as a supertaster.

Habitual food intake measurement

Food frequency questionnaire (FFQ) was used to measure habitual sugary food intake among the participants. The FFQ for sugary food was adapted from Nik Shanita, Norimah & Abu Hanifah (2012) with slight modifications, where food items were arranged based on their food category and sensory characteristics similarities, respectively. Several additional Malaysian food items that were classified as high-sugar foods (i.e., >15% of energy from total sugar) were also included (Sigman-grant & Morita, 2003; Sia *et al.*, 2013). In total, 42 sugary food items were included in the sugary food FFQ, which were regrouped further into five food groups.

Participants were asked regarding the frequency of intake for each of the food items over the past two months and the number of servings per intake. The participants were thoroughly briefed on the correct procedure of filling up the FFQ. They were asked to describe the intake of their food/meal using standardised serving, which included either natural portions (e.g., 1 slice of pizza, 1 slice of orange, and 1 whole banana) or usual household measurements (e.g., 1 medium bowl of rice, 1 tablespoon of sugar, and 1 glass of full cream milk). A standard Malaysian food serving booklet was given to all the participants as guidance for food serving sizes. The frequency of intake for each food item was reported based on servings per day. Conversion into servings per day was calculated by multiplying the conversion factor of the frequency of intake with the number of servings per intake for each subject (Norimah *et al.*, 2008).

Dietary intake measurement

Three days food diary was used to measure the dietary intake of each subject. Food intake was recorded for two days during weekday and one day during weekend. Participants were briefed on how to fill in the food record. During the briefing, participants were asked to record all the foods that they have consumed during their previous meal (e.g., breakfast) as their practice. All drinks and foods that they have consumed were recorded in household measurements. Participants were asked, where possible, to weigh all the foods they consumed or used standard metric measuring cups or common Malaysian food serving sizes (e.g., cup, glass, Chinese bowl) to record their food intake. They were also asked to report the brand of foods consumed, type of foods (e.g., white or whole meal bread), whether fat or any other seasonings were added, method of cooking, and amount consumed per meal. Besides, if food was consumed from a new recipe or recently created by them, participants were asked to include the recipe and report the amount of each food ingredient used in the cooking (e.g., half, quarter). Apart from that, the Malaysian food portion size and measurement booklet was given to the participants as reference for meal measurement/serving purpose. The three days food records were analysed by using Nutricalc software (Nuricalc Limited, West Buckland, Devon). Information on the nutrient content of foods were obtained mainly from the Nutrient Composition of Malaysian Foods (Tee *et al.*, 1997) and also manufacturer's nutritional information (e.g., nutrition labelling). Means of energy intake (kJ), macronutrient components (gram of total fat, protein, carbohydrate) and total sugar intake were calculated. For any food items that were not available in the standard data, calculations were done based on the ingredients used in the recipe.

Statistical analysis

General Linear Model (GLM) Analysis of Covariance (ANCOVA) was used to compare the nutritional intake and habitual food intake differences related to PROP taster status and also BMI status. The independent variables were PROP taster status and BMI group, whereas the dependent variables were mean reported intake from each of the food groups and also mean nutrient intake. Covariates included in these models were age and sex. In addition, post-hoc comparisons were done with Scheffe test to compare any differences among PROP taster status. Chi-square was used to evaluate any association between categorical variables. All analyses were conducted using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corporation, Armonk, NY, USA), whereby *p*-value ≤ 0.05 was considered as statistical significance.

RESULTS

Participants' characteristics

The number of participants involved in this study was 180. They comprised of 92 non-obese participants (24 males; 68 females) and 88 obese (30 males; 58 females) participants. Participants' characteristics are shown in Table 1. The mean age of the subjects was 25.8±5.7 years with majority of the participants aged 20 to 35 years old. The BMI range in this current study was 19.0 to 45.5kg/m^2, with a mean of 27.6±6.7kg/m^2. The distribution for each PROP taster status among the participants are summarised in Table 1. There was no significant association between BMI status and PROP taster status based on chi-square test conducted (p>0.05). Additionally, the number of participants were distributed equally in both obese and non-obese groups for each PROP taster status involved in this study.

The association between PROP taster status and habitual sweet food consumption among obese and non-obese participants

As illustrated in Table 2, the mean daily intake (serving size) of sweet foods were not significantly different (p>0.05) between PROP taster groups for both obese and non-obese participants. In fact, there was no effect of BMI status or PROP taster status on the consumption of sweet foods (p>0.05). In addition, there was no significant interaction between BMI status with PROP taster status for each food group intake (p>0.05) based on 2-way ANCOVA test. Interestingly, we found that STs had higher fruit intake than other tasters among obese participants (p<0.05).

The effect of PROP taster status on habitual fatty food intake among obese and non-obese participants

Table 3 shows the mean macronutrients

Table 1. Participants' characteristics between obese and non-obese groups

	Non-obese (n=92)	*Obese (n=88)*	*p-value*
Age (year)[a]	26	28	ns
Weight (kg)[a]	88.9±7.1	58.2±11.0	<0.001
Height (cm)[a]	163.0±6.4	163.5±6.5	ns
BMI (kg/m^2)[a]	21.8±2.4	33.4±3.6	<0.001
Gender [b]			
Male	24 (26.1)	30 (34.1)	ns
Female	68 (73.9)	58 (65.9)	
Marital status[b]			
Yes	56 (60.9)	20 (22.7)	ns
No	36 (39.1)	68 (77.3)	
Prop taster status			
Super taster	40 (43.5)	38 (41.2)	ns
Medium taster	35 (38.0)	27 (30.7)	
Non-taster	17 (18.5)	23 (26.1)	

ns: not significant
[a] Mean±SE; means differences analysed by *t*-test
[b] n (%); variables association analysed by Fisher exact test

Table 2. Daily intake (in standard servings) of sweet food groups in obese and non-obese participants according to PROP taster status

Type of sweet food	*Standard serving*	*Obese subject*				*Non-obese participants*			
		ST	*MT*	*NT*	*p-value*	*ST*	*MT*	*NT*	*p-value*
Self-prepared drink	Glass	0.53±0.16	0.55±0.09	0.68±0.18	0.796	0.35±0.04	0.34±0.04	0.40±0.18	0.858
Processed beverages	Glass	0.14±0.03	0.20±0.04	0.13±0.02	0.385	0.36±0.24	0.10±0.02	0.06±0.13	0.446
Bakery products and confectionary	Piece	0.30±0.05	0.34±0.06	0.51±0.18	0.278	0.26±0.04	0.32±0.07	0.25±0.12	0.745
Traditional cake	Piece	0.06±0.01	0.06±0.02	0.07±0.03	0.919	0.03±0.01	0.04±0.01	0.03±0.01	0.573
Fruit	Piece	0.44±0.13	0.27±0.11	0.12±0.03	0.044	0.19±0.04	0.23±0.07	0.12±0.03	0.491

ST: supertaster; MT: medium taster; NT: non-taster
Data reported as mean±standard deviation, significant differences at $p<0.05$ by post-hoc Scheffe test; within group

and sugar intakes among obese and non-obese participants according to PROP taster status. Results from 2-way ANCOVA test showed that there were no associations between BMI status and PROP taster status with dietary and sugar intakes ($p>0.05$). In addition, there was also no interaction between BMI status with PROP taster status for each macronutrient and sugar intakes among the participants ($p>0.05$). When the data were stratified by BMI status, similar outcomes were observed for the intakes of all macronutrients and sugar among the participants, where there was no significant difference between PROP taster groups in both groups ($p>0.05$). However, we observed distinctive variation in nutrient intakes where the amount of intake was higher among NTs for obese participants. This pattern was also observed among MTs for non-obese participants across all components. Surprisingly, STs showed higher sugar intake in both groups, but the observations were insignificant.

DISCUSSION

The purpose of this study was to test the associations between PROP taster status and BMI status with habitual sweet and dietary intakes. The hypothesis that PROP taster status may be associated with human food preference and nutritional intake was first proposed by Drewnowski & Rock (1995). Since then, several studies have been conducted in investigating this hypothesis, particularly on food preferences among individuals, resulting in mixed findings. The present study extended previous studies by focusing on habitual food intake and nutritional status that were more relevant to body weight maintenance. In addition, this present study also took into consideration the variation of BMI status, which could drive the effect of PROP taster status among individuals.

The current study found that supertasters comprised the most prominent individuals in both obese and non-obese groups. Additionally, our finding also showed that the number of participants were distributed somewhat equally in both obese and non-obese groups for each PROP taster status. This finding somewhat

Table 3. Daily energy, macronutrients and sugar intakes in obese and non-obese participants according to PROP taster status

Dietary intake	*Obese*				*Non-obese*			
	ST	*MT*	*NT*	*p-value*	*ST*	*MT*	*NT*	*p-value*
Energy (kcal)	1931±108	1830±81	2129 ±202	0.317	1707±77	1848±78	1808±1256	0.438
Carbohydrate (g/day)	235±15.6	220±10.2	266±33.1	0.312	216±11.2	236±11.7	224±19.6	0.464
Protein (g/day)	80±4.5	71±4.2	83±6.2	0.286	64±3.4	67±3.5	67±5.2	0.867
Fat (g/day)	73±4.4	71±4.6	82±6.0	0.309	65±3.0	70±3.5	70±4.8	0.458
Sugar Intake (g/day)	36±3.3	35±3.6	33±4.2	0.863	37±3.8	36±4.3	24±4.5	0.170

ST: supertaster; MT: medium taster; NT: non-taster
Data reported as mean±standard deviation, significant differences at $p<0.05$ by post-hoc Scheffe test; within group

contradicted with earlier understanding which supported the idea that supertasters tended to be thinner (ectomorph), whereas non-tasters were more likely to have heavier body type (endomorph) (Guido *et al.*, 2016). However, several follow-up studies conducted among various populations corroborated with our findings, which found no association between BMI and PROP taster status (Barajas-ramírez *et al.*, 2016; Borazon *et al.*, 2012), whereby the proportion of supertasters was highest in their studied population (Dastan *et al.*, 2015). This disparity in research findings could be attributed to variances in the prevalence of PROP taster status across the population, driven by disparities in age spans and geographic dispersion. It could also be because of the different cut-off scores for categorising taste status (Hanim *et al.*, 2020).

As regards food consumption, surprisingly, our results demonstrated that there was no significant association between PROP taster status and habitual sweet food consumption among obese and non-obese participants. Previous data surrounding this area are conflicting, with some studies finding mild association between PROP taster status and habitual sweet food intake (Turner-McGrievy *et al.*, 2013, Yang *et al.*, 2019), while others finding no association (Barazon *et al.*, 2009; Catanzaro, Chesbro & Velkey, 2013; Deshaware & Singhal, 2017). Even more challenging was the fact that most studies involving PROP taster status and food consumption were circulating on food preferences among younger age and the Western population. Among children, studies by Mennella, Pepino & Reed (2006) and Keller & Tepper (2014) have reported greater intake and liking of sweet foods in PROP taster compared with non-taster children. A recent study by Hanim *et al.* (2020) also showed that there was no significant relationship between PROP rating and sweet food preference among Malaysian university students. Thus, different age group and habitual culture differences could plausibly influence individuals' habitual food consumption rather than PROP taster status (Catanzaro *et al.,* 2013).

The present study found no associations between PROP taster status with dietary and sugar intakes in both BMI groups. Previous research has demonstrated a mild association between PROP taster status and dietary intake, particularly on energy and sugar intakes; however, another study which was in line with this current work observed no association (Nagai *et al.*, 2017). To the best of our knowledge, this is the first study measuring the association between PROP taste status and dietary intake variables by considering BMI status among the participants. Interestingly, although the results did not show any statistical significance, we observed that the dietary and sugar intake patterns were consistent across PROP status among obese and non-obese participants. In obese non-tasters, energy intake and all macronutrient components were higher; however, in non-obese participants, this tendency was inverted, and medium tasters had the most. These dietary intake patterns corroborated with findings from Yacknious & Guinard (2002) and Borazon *et al.* (2012). Recently, a study by Hilmy *et al.* (2022) showed that there was no association between dietary intake and PROP score among their young adult participants, which is also in line with our findings.

Notably, the consumption of sugar was higher among the supertasters and medium tasters in both obese and non-obese groups, but no significant differences were obtained. This finding was most striking among the supertasters, who have higher taste sensitivity, which leads them to be a sweet disliker. Mennella *et al.* (2006) reported that children who had genotypes that are associated with higher bitter sensitivity liked beverages with higher sugar content and reported greater use of sugar in cereals compared with children who had bitter insensitive genotypes. In the present study, we reported supportive relationships when classifying participants by PROP phenotype, but genotype was not included. The reason for these inconsistencies across studies is not known. Albeit several studies suggesting that PROP tasters may be less likely to comply with dietary strategies as they consume less bitter-tasting cruciferous vegetables and salad greens, they may seek to mask bitter taste by the addition of fat, sugar or salt (Sharafi *et al.,* 2013*;* Keller *et al.*, 2014).

The extent that PROP taster status affects inter-individual variability in dietary status and habitual food intake remains inconclusive. PROP taster status failed to show any association with both measurements in this study. Surprisingly, we observed some interesting patterns in habitual food intake or dietary intake among PROP taster status, but the direction between both measurements was inconsistent. Similarly, Kamphuis & Westerterp-Plantenga (2003) demonstrated that there were no differences with respect to macronutrient selection and energy intake between PROP tasters and PROP non-tasters, but PROP tasters had higher hedonic values and intake on the high-fat lunch menu. This could suggest that PROP status might not have an ultimate role in food intake and preference when sensory hedonics are optimised, whereby macronutrient and energy might not be affected. In addition, in everyday life, human food consumption are based on sensory characteristics, but not determined by the nutrient content in food products (Proserpio *et al.*, 2017).

The present findings need to consider some limitations. Firstly, the present study only focused on healthy young adults, thus our findings may not be generalised to other groups (e.g., elderly subjects). Secondly, a larger sample size should be considered in future studies as a greater sample size could represent a larger population and result in statistically significant differences among PROP taster groups. Thirdly, the differences in approaches of evaluating dietary or habitual food intakes should not be overlooked. Dietary record only covered three days of food consumption, generating a distinct snapshot on dietary measurement in this study, which could result in a variation within the findings.

CONCLUSION

The present study found that PROP taster status did not influence individuals' habitual food intake (either fatty foods or sweet foods) and also energy and macronutrient intakes. This could suggest that PROP taster status does not directly affect human food intake and preferences. However, the results from this study support that this phenotype marker could have a linkage in human eating behaviour, but other factors, such as age and culture, might work together or overshadow this function.

Acknowledgement

This study was supported by the UPM Research University Grant Scheme (RUGS) and UMS Young Lecturer Grant Scheme.

Authors' contributions

Ahmad Riduan B, participated in the experimental design, data collection and analysis, and drafted the manuscript; Nazamid S and Zalilah MS, involved in conceptualising the study and advised the data analysis; Roselina K, contributed on study design and supervised the data collection and analysis. All authors listed as authors have substantially contributed to the work.

Conflict of interest

The authors have no conflict of interest to declare.

References

Barajas-Ramirez JA, Quintan-Castro R, Oliart-Ros RM & Angulo-Guerrero O (2016). Bitter taste perception and TAS2R38 genotype: Effects on taste sensitivity, food consumption and anthropometry in Mexican adults. *Flavour Fragr J* 31(4):310-318.

Blanco-Rojo R, Sandoval-Insausti H, López-Garcia E, Graciani A, Ordovas JM, Banegas JR, Rodríguez-Artalejo F & Guallar-Castillón P. Consumption of ultra-processed foods and mortality: A national prospective cohort in Spain. *Mayo Clin Proc* 94(11):2178-2188.

Borazon EQ, Villarino BJ, Magbuhat RMT & Sabandal ML (2012). Relationship of PROP (6-n-propylthiouracil) taster status with body mass index, food preferences, and consumption of Filipino adolescents. *Food Res Int* 47(2):229-235.

Catanzaro D, Chesbro EC & Velkey AJ (2013). Relationship between food preferences and PROP taster status of college students. *Appetite* 68:124-131.

Choi SE (2014). Racial differences between African Americans and Asian Americans in the effect of 6-n-propylthiouracil taste intensity and food liking on body mass index. *J Acad Nutr Diet* 14(6):938-944.

Dastan SD, Degerli N, Dastan T, Yildiz F, Yildi Y, Durna YM & Karan T (2015). Phenylthiocarbamide taste perception as a possible genetic association marker for nutritional habits and obesity tendency of people. *Pak J Pharm Sci* 28(3 Suppl):1141-1150.

Deshaware S & Singhal R (2017). Genetic variation in bitter taste receptor gene TAS2R38, PROP taster status and their association with body mass index and food preferences in Indian population. *Gene* 627:363-368.

Diószegi J, Llanaj E & Ádány R (2019). Genetic background of taste perception, taste preferences, and its nutritional implications: A systematic review. *Front Genet* 10:1272.

Donaldson LF, Bennett L, Baic S & Melichar JK (2009). Taste and weight: Is there a link? *Am J Clin Nutr* 90(3):800S-803S.

Drewnowski A & Rock CL (1995). The influence of genetic taste markers on food acceptance. *Am J Clin Nutr* 62(3):506-511.

Faul F, Erdfelder E, Lang AG & Buchner A (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 39(2):175-191.

Guido D, Perna S, Carrai M, Barale R, Grassi M & Rondanelli M (2016). Multidimensional evaluation of endogenous and health factors affecting food preferences, taste and smell perception. *J Nutr Health Aging* 20(10):971-981.

Hanim AS, Ruhaya H, Norkhafizah S & Marina AM (2020). Relationship between PROP (6-n-propylthiouracil) taster status and preference for different taste food groups among university students. *Malays Appl Biol* 49(5):53-59.

Hardikar S, Höchenberger R, Villringer A & Ohla K (2017). Higher sensitivity to sweet and salty taste in obese compared to lean individuals. *Appetite* 111 :158-165.

Hilmy SHA, Hasan R, Saddki N & Manaf MA (2022). Relationship between 6-n-propylthiouracil (PROP) taster status, dietary intake and dental caries among young adult subjects. *Mal J Nutr* 28(1):087-096.

Keller KL, Olsen A, Cravener TL, Bloom R, Chung WK, Deng L, Lanzano P. & Meyermann K. (2014). Bitter taste phenotype and body weight predict children's selection of sweet and savory foods at a palatable test-meal. Appetite, 77, 115-123.

Kamphuis MM & Westerterp-Plantenga MS (2003). PROP sensitivity affects macronutrient selection. *Physiology & Behavior* 79(2):167-172.

Luger M, Lafontan M, Bes-Rastrollo M, Winzer E, Yumuk V & Farpour-Lambert N (2017). Sugar-sweetened beverages and weight gain in children and adults: a systematic review from 2013 to 2015 and a comparison with previous studies. *Obesity Facts* 10(6):674-693.

Mennella JA, Pepino MY and Reed DR (2006). Genetic and environmental determinants of bitter perception and sweet preferences. *Pediatrics* 115(2):e216–e222.

Nagai A, Kubota M, Morinaga K & Higashiyama Y (2017). Food acceptance and anthropometry in relation to 6-npropylthiouracil sensitivity in Japanese college women. *Asia Pac J Clin Nutr* 26(5):856-860.

Nik Shanita S, Norimah AK & Abu Hanifah S (2012). Development and validation of a food frequency questionnaire (FFQ) for assessing sugar consumption among adults in Klang Valley, Malaysia. *Mal J Nutr* 18(3):283-293.

Norimah AK, Safiah M, Jamal K, Siti H, Zuhaida H, Rohida S & Azmi MY (2008). Food consumption patterns: Findings from the Malaysian Adult Nutrition Survey (MANS). *Mal J Nutr* 14(1):25–39.

Proserpio C, Laureati M, Invitti C, Cattaneo C & Pagliarini E (2017). BMI and gender related differences in cross-modal interaction and liking of sensory stimuli. *Food Qual Prefer* 56:49-54.

Sharafi M, Hayes JE & Duffy VB (2013). Masking vegetable bitterness to improve palatability depends on vegetable type and taste phenotype. *Chemosens Percept* 6(1):8-19.

Sharafi M, Rawal S, Fernandez ML, Huedo-Medina TB & Duffy VB (2018). Taste phenotype associates with cardiovascular disease risk factors via diet quality in multivariate modeling. *Physiology & Behaviour* 194:103-112.

Sia BT, Low SY, Foong WC, Pramasivah M, Khor CZ & Say YH (2013). Demographic differences of preference, intake frequency and craving hedonic ratings of sweet foods among Malaysian subjects in Kuala Lumpur. *Malaysian J Med Health Sci* 9(1):55–64.

Sigman-Grant M & Morita J (2003). Defining and interpreting intakes of sugars. *Am J Clin Nutr* 78(4):815S-826S.

Tee ES, Mohd Ismail N, Mohd Nasir A & Khatijah I (1997). Nutrient composition of Malaysian foods. Kuala Lumpur: Institute Medical for Research.

Teo PS, van Dam RM, Whitton C, Tan LWL & Forde CG (2021). Consumption of foods with higher energy intake rates is associated with greater energy intake, adiposity, and cardiovascular risk factors in adults. *J Nutr* 151(2):370-378.

Tepper BJ, Melis M, Koelliker Y, Gasparini P, Ahijevych KL & Tomassini Barbarossa I (2017). Factors influencing the phenotypic characterization of the oral marker, PROP. *Nutrients* 9(12):1275.

Turner-McGrievy G, Tate DF, Moore D & Popkin B (2013). Taking the bitter with the sweet: Relationship of supertasting and sweet preference with metabolic syndrome and dietary intake. *J Food Sci* 78(2):S336-S342.

WHO (2021). *In: Obesity and Overweight.* Fom https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [Retrieved June 9 2021].

Yang Q, Kraft M, Shen Y, MacFie H & Ford R (2019). Sweet liking status and PROP taster status impact emotional response to sweetened beverage. *Food Qual Prefer* 75:133-144.

Yackinous CA & Guinard JX (2002). Relation between PROP (6-n-propylthiouracil) taster status, taste anatomy and dietary intake measures for young men and women. *Appetite* 38(3):201-209.

Zhao L, Kirkmeyer SV & Tepper BJ (2003). A paper screening test to assess genetic taste sensitivity to 6-n-propylthiouracil. *Physiology & Behaviour* 78(4-5):625-633.

Mal J Nutr 29(2): 307-320, 2023

Binge eating disorder and food addiction occurrences among adult Jordanian women with obesity

Zainab Zueter & Rima Hussein Mashal*

Department of Nutrition and Food Technology, Faculty of Agriculture, the University of Jordan, Amman, Jordan.

ABSTRACT

Introduction: The aim of the study was to estimate the occurrences of binge eating disorder (BED) and food addiction (FA) in Jordanian women with obesity and to explore their relationships with selected potential risk factors for obesity. **Methods:** A descriptive case series design that involved a total of 842 women with obesity was conducted. The occurrences of BED and FA were evaluated using the Questionnaire on Eating and Weight Patterns-5 (QEWP-5) and Yale Food Addiction Scale 2.0 (YFAS 2.0). **Results:** The overlapping of BED and FA (BED+FA) was the most frequent category constituting 53.7%. The second highest category was BED comprising 25.0%, followed by FA comprising 9.0%. Body mass index (BMI) and waist circumference (WC) were significantly higher in the BED+FA group as compared to all other groups. The FA group (41.3%) had significantly the lowest level of sleeping hours. BED (58.0%) and BED+FA (66.1%) groups were significantly higher in consuming more than three snacks per day. BED and/or FA-free group had significantly higher level of water intake of >5 cups/day. **Conclusions:** The frequencies of BED and FA were relatively high among obese Jordanian women. The study demonstrated an overlap between BED and FA, highlighting its associations with increased BMI and WC in a selected sample of obese women. The study suggested that BED, FA, and the overlapping of both conditions were associated with greater tendencies towards an unhealthy pattern of eating practices, fluid intake, and sleeping habits.

Keywords: binge eating disorder, food addiction, obesity, women

INTRODUCTION

More than half of the adult population in developed countries are currently overweight or obese. Globally, the prevalence of obesity has increased by almost three times between 1997 and 2016. According to the World Health Organization (WHO) report in 2020, 39.0% of adults were overweight, and 13.0% were obese (Haththotuwa, Wijeyaratne & Senarath, 2020). Many studies on the prevalence of obesity in Jordan revealed an increase in the obesity rate over the years. Khader *et al.* (2008) reported that the prevalence rate of obesity increased with age and varied by gender. The prevalence of overweight and obesity were 36.2% and 28.1% for men, and 28.8% and 53.1% for women, respectively, in northern Jordan (Khader *et al.*, 2008). Recently, it has been reported that the prevalence of overweight and obesity has reached an alarming rate of about 60.0% among

*Corresponding author: Rima Hussein Mashal
Department of Nutrition and Food Technology, Faculty of Agriculture, The University of Jordan
Amman, Jordan
Tel: +962-6-5355000-22406, E-mail: rima@ju.edu.jo
doi: https://doi.org/10.31246/mjn-2022-0073

men and women according to their body mass index (BMI) (Ajlouni *et al.*, 2020). One of the explanations for this increase in obesity rate over recent decades is environmental factors, particularly the availability of highly varied, palatable, and fattening foods that are associated with an increasing rate of eating disorder episodes. Other factors, such as lack of education, lack of resources, and increased pressure from the media, may also contribute to the increase in eating disorders and cause individuals to have distorted body figures (Myers & Wiman, 2014).

Eating disorders (EDs) are groups of disorders that are characterised by an ongoing disturbance of eating or eating-related behaviours, which lead to changes in the consumption or absorption of food, and significantly impair physical health or psychosocial functioning, leading to severe negative consequences (Myers & Wiman, 2014). According to a Citrome review, the most common ED in America is binge eating disorder (BED), with a prevalence of 2.6%. This prevalence rate is higher than the combined prevalences of anorexia and bulimia (Citrome, 2015). BED is one of the most recent eating disorders officially recognised by the Diagnostic and Statistical Manual of Mental Disorders (DSM–5) (Black & Grant, 2014). BED affects approximately half of the people with obesity (BMI ≥ $30kg/m^2$) and it is notably more common in women (3.5%) than in men (2.0%) (Citrome, 2015). BED can be described as a pattern of binging that occurs in the absence of regularity of compensatory behaviours, such as vomiting or laxative abuse (Citrome, 2015). There are also a variety of associated characteristics, such as fast consumption, eating until uncomfortably full, and eating without being hungry, eating alone, and feeling depressed or guilty (Myers & Wiman, 2014).

Disordered eating attitudes and behaviours consist of a number of various constructs, including negative attitudes towards weight and shape, unhealthy weight control behaviours, and binge eating (Hayes *et al.,* 2018). Individuals who do not meet the criteria for an eating disorder may engage in some forms of disordered eating behaviours, which in turn can increase the risk of eating disorders (Yu & Tan, 2016). It has been previously suggested that food addiction (FA) may be a sub-type of disordered eating and may indicate higher eating disorder severity. However, it has been proposed that BED may significantly overlap with the construct of FA (Burrows *et al.,* 2017). FA, according to the Food Addiction Institute, is a condition when one has no control over eating certain foods (Myers & Wiman, 2014). A craving for highly-palatable foods may lead to eating-related issues, such as obesity and eating disorders. Additionally, repetitive addictions that lead to excessive consumption could theoretically contribute to obesity and antagonise weight loss efforts (Gearhardt, Boswell & White, 2014). Although BED and FA share many characteristics, such as reduced control and continued use despite adverse consequences, the two disorders may be distinct. FA is mainly biochemical in nature.

There is probable evidence for the involvement of a range of neurotransmitters and hormones in eating disorders. Numerous investigations have revealed that obese patients exhibit a disruption in the dopamine system similar to that previously described in drug addiction (Gearhardt *et al.*, 2014). The Yale Food Addiction Scale (YFAS), a tool used to assess FA, was created in 2009 after all the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) guidelines for substance dependence were modified to be applicable to eating behaviours (Gearhardt *et al.*, 2014). A study showed that the prevalence of FA was 5.4% (6.7% in females and 3.0% in males, respectively) and increased with obesity status in Canada (Pedram *et al.*, 2013). In contrast, a study that involved a representative German sample showed that younger individuals with obesity exhibited a higher prevalence rate of FA (17.2%) (Hauck *et al.*, 2017). A systematic review study concluded that weighted mean prevalence of FA, as diagnosed using the YFAS scale, was 19.9% and exhibited more than double in people with obesity as compared to individuals with healthy body weights. The authors also indicated that FA was more frequent in females as compared to males (12.2% and 6.4%, respectively) (Pursey *et al.*, 2014).

In Jordan, a cross-sectional survey that was undertaken using an online YFAS scale during the COVID-19 pandemic revealed that the prevalence of FA was 21.5% among individual adults; about 76.4% were diagnosed as severely food addicted (Musharbash *et al.*, 2021). In addition, most of the prevalence studies on BED or FA among Jordanian adults were done by using online surveys (Musharbash *et al.*, 2021) and were focused on special target groups such as adolescents (Mousa *et al.*, 2010); therefore, this might increase the risk of misdiagnosis of cases. To our knowledge, no previous study in Jordan has examined the prevalences of BED and FA in obese women by using a paper-based questionnaire filled in face-to-face by the researcher. Therefore, the main aim of the present descriptive study design was to estimate the occurrences of BED and FA in a sample of Jordanian women with obesity. The secondary aim was to explore the relationships of BED and FA with selected variables (i.e., socio-demographics, anthropometric characteristics, eating and sleeping patterns, and water intake) as potential risk factors for obesity in Irbid, Jordan.

MATERIALS AND METHODS

A descriptive case series design was conducted among obese women who visited a private nutrition and counselling centre for the purpose of losing weight. The centre was located in Irbid, a city in northern Jordan.

Inclusion and exclusion criteria

A convenient sample of 842 women with obesity (BMI ≥30kg/m^2) was included in the study. Recruitment was undertaken over an eight-month period in 2021/2022. Prior to the commencement of the study, a study invitation flyer was distributed to all women on their first booking appointment at the nutrition and counselling centre throughout the study period. Women who expressed interest to participate in the study were recruited face-to-face at their first visit by the researcher, before receiving any weight management or counselling programme. Exclusion criteria were as follows: BMI ≤29.9 kg/m^2, specific diseases, such as major cardiovascular diseases, type II diabetes, polycystic ovary syndrome (PCOS), thyroid dysfunction, chronic renal failure, chronic liver diseases, renal calculi, depression, pregnancy, and on anti-depressant drugs.

Ethical approval

The protocol was approved by the Institutional Review Board (IRB) of the Deanship of Scientific Research at the University of Jordan (No.56-2022), and in accordance with the ethical guidelines described in the Declaration of Helsinki. All data were collected a confidential manner. Written informed consent was obtained from all participants before their interview.

Data collection

A set of questionnaires were used to collect data regarding eating and weight patterns, BED, and FA. To assess BED, a weight pattern questionnaire (QEWP-5) was used, while FA was assessed using YFAS 2.0. To standardise the tools of assessment, to measure their reliability, and to meet the Jordanian cultural norms, a pilot study on the face validity of the survey instruments was conducted. The BED and FA assessment tools were translated into Arabic and content validity was assessed. The questionnaires were tested by a panel of academics in psychology, nutrition, and Arabic literature. The questionnaires were filled in face-to-face by the researcher using a paper-based questionnaire. In the current study, Cronbach's alpha for QEWP-5 and YFAS 2.0 were 0.87 and 0.81, respectively.

Demographic questionnaire

Demographic and lifestyle characteristics of the participants were obtained through a constructed questionnaire, which provided information on age, education level, smoking status, employment, family history of FA and BED, sleeping hours, use of medications, as well as questions about certain eating habits and fluid intake.

Assessment of binge eating disorder

To assess BED, a previously translated and validated eating and weight patterns questionnaire (QEWP-5) was used based on the new DSM-5 criteria. The QEWP-5 questionnaire is a screening tool that can be used in research or clinical settings to identify persons who may have BED (Yanovski *et al.*, 2015). The QEWP-5 contained 26 items to screen respondents for BED. It also recorded episodes of 'subjective-binge eating'. In order to meet the criteria for BED, patients must have recurrent episodes of binging, which was defined as an excessive intake of food and a feeling of losing control. This eating episode should occur on an average of once per week for the last three months. The episodes must be accompanied by severe distress (Yanovski *et al.*, 2015).

Assessment of FA

The main diagnostic tool for FA was the standardised YFAS 2.0. The YFAS 2.0 scale composed of 35 items and used eleven criteria based on the DSM-5 criteria for addictive disorders. The scale counts indicated the number and severity of dependence symptoms. They ranged from never (0) to every day (7). FA was diagnosed with at least three symptoms and met the clinically significant criteria (Meule & Gearhardt, 2019).

Assessment of physical activity

The physical activity level of the participants was evaluated using the "General Practice Physical Activity Questionnaire" (GPPAQ) and subjects were grouped into four categories: inactive, moderately inactive, moderately active, and active (Heron *et al.*, 2014).

Anthropometric measurements

Body weight, height, and waist circumference (WC) were measured and recorded by a well-trained nutritionist according to standardised procedures. Weight and body fat percent were measured by a body composition scale analyser (InBody 570, South Korea). Height was measured using a stadiometer and was recorded to the nearest millimeter (mm). BMI was then calculated using the following equation: BMI = weight/height^2 (kg/m^2). BMI equal to or greater than 30 kg/m^2 was indicative of obesity. Waist circumference was measured using a flexible nonstretch tape; the tape was placed at the narrowest part between the iliac bones and the lowest rib bones. Waist circumferences were measured to the nearest 0.1 centimeter (cm). A measurement above 88 cm was considered as central obesity (Lee, 2010).

Statistical analysis

Statistical analysis was performed using the IBM SPSS Statistics for Windows version 20.0 (IBM, Corp, Armonk, New York, USA). Categorical variables were compared using the Pearson's chi-square test and continuous variables were compared using the one-way analysis of variance (ANOVA). The assessment of normality of the data is a prerequisite for many statistical tests; therefore, the Shapiro-Wilk test was used to test normality for all predictors. Based on the normality test, group differences were examined using parametric and non-parametric analyses as appropriate. Multivariate analysis was performed to determine the factors associated with BED. Data were presented as mean ± standard error of mean (SEM) and frequency distribution.

RESULTS

Based on the participants' responses to QEWP-5 and YFAS 2.0, participants were classified into four groups as BED group (participants who met the QEWP-5 criteria), FA group (participants who met the YFAS 2.0 criteria), BED+FA group (participants who had an overlapping of BED and FA), and BED and/or FA-free group (if participants did not meet the diagnostic criteria of the QEWP-5 and YFAS 2.0). Figure 1 summarises the frequency distribution of BED, FA, and FA coincident with BED among the full sample of women with obesity. As presented in Figure 1, among the 842 respondents whose data were analysed, 86% (*n*=725) of women with obesity exhibited BED or FA or both BED+FA, while only 13.9% (*n*=117) did not meet any of the examined BED and FA criteria. About 23.5% of the participants (BED: *n*=198) had met the criteria for BED only, whereas 9.0% (FA: *n*=75) had met

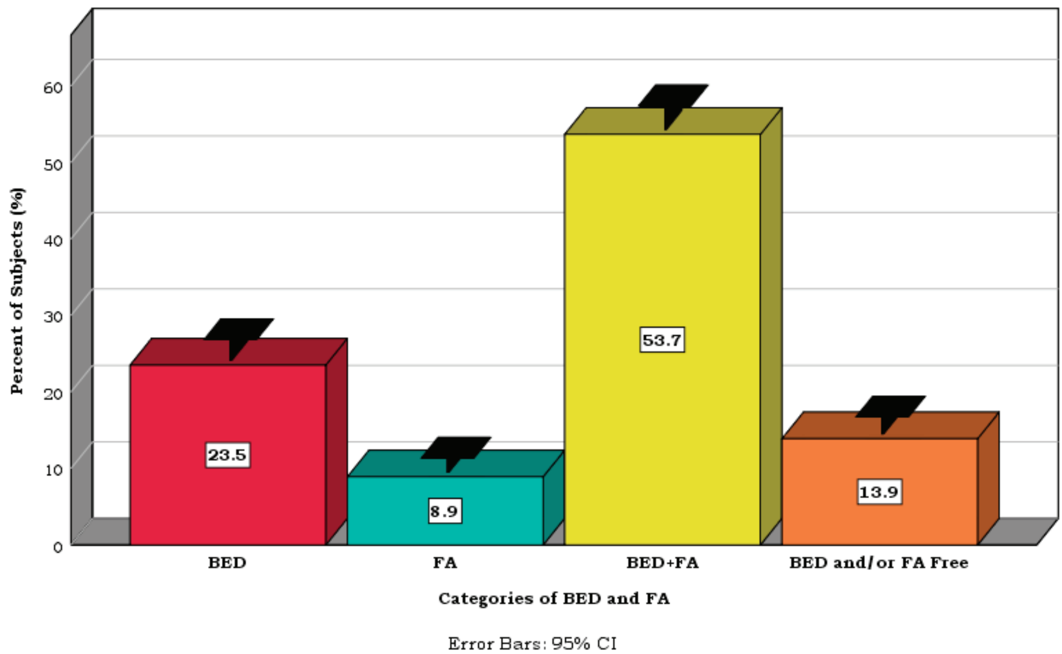


Figure 1. The frequency of binge eating disorder and food addiction in a sample of women with obesity

the criteria for FA only. Across the whole sample, the prevalence of overlapping BED and FA was found to be 53.6% (BED+FA: *n*=452). In fact, the frequency of women who had BED regardless of the presence of FA in the full sample was 79.0% (*n*=650). Of those with BED, 69.5% had met the criteria for FA as well (BED+FA: *n*=452).

Table 1 presents differences in selected anthropometric parameters in the studied population by BED and FA groups. Mean BMI was significantly higher in the overlapping BED and FA group (BED+FA) as compared to those from the BED and/or FA-free group (34.48±0.18 kg/m^2 and 33.43±0.32 kg/m^2, respectively; *p*=0.013). WC was

Table 1. Anthropometric, demographic and lifestyle characteristics of participants by eating disorder groups

Variables	*BED n=198 n (%)*	*FA n=75 n (%)*	*BED+FA n=452 n (%)*	*BED and/or FA- free n=117 n (%)*	*Total n=842 n (%)*	*p[b]*
Age (y)[a]	29.1±0.5	29.0±0.8	29.8±0.3	29.4±0.6	29.5±0.2	0.499
BMI (kg/m^2)[a]	33.7±0.2	33.7±0.4	34.4±0.1*	33.4±0.3*	34.1±0.1	0.013
WC (cm)[a]	96.3±0.6	95.2±1.2*	98.0±0.5*	95.7±1.2	97.0±0.3	0.010
Body fat (%)[a]	47.6±0.3	47.7±0.5	47.3±0.2	47.4±0.4	47.4±0.1	0.879
Marital status						0.596
Married	118 (59.5)	45 (60.0)	286 (63.3)	67 (57.3)	516 (61.3)	
Single	78 (39.3)	29 (38.7)	156 (34.5)	50 (42.7)	313(37.2)	
Divorced	2(1.0)	1 (0.7)	7 (1.5)	0 (0.0)	10 (1.2)	
Widowed	0 (0.0)	0 (0.0)	3 (0.6)	0 (0.0)	3 (0.3)	
Education						0.022
< High school	17 (8.6)	8 (10.8)	49 (10.8)	20 (17.0)	94 (11.2)	
High school	64 (32.3)	10 (13.3)	134 (29.6)	34 (29.0)	242 (28.7)	
Diploma	20 (10.1)	10 (13.3)	37 (8.2)	13 (11.2)	80 (9.5)	
Bachelor	80 (40.4)	43 (57.3)	205 (45.4)	42 (36.0)	370 (43.9)	
Graduate	17(8.6)	4 (5.3)	27 (6.0)	8 (6.8)	56 (6.6)	
Employment						0.405
Yes	60 (30.3)	22 (29.3)	123 (27.2)	41 (35.0)	246 (29.2)	
No	138 (69.7)	53 (70.7)	329 (72.8)	76 (65.0)	596 (70.8)	
Smoking						0.029
Yes	43 (21.7)	21 (28.0)	142 (31.4)	25 (21.4)	231 (27.4)	
No	155 (78.3)	54 (72.0)	310 (68.6)	92 (78.6)	611 (72.6)	
Physical activity						0.302
Light	55 (27.8)	21 (28.0)	128 (28.3)	47 (40.2)	251 (29.8)	
Moderate	88 (44.4)	33 (42.3)	204 (45.1)	45 (38.5)	370 (44.0)	
Active	55 (27.8)	21 (28.0)	120 (26.5)	25 (21.3)	221 (26.2)	
Sleeping hours						0.037
< 6 hours/day	59 (29.7)	31 (41.3)	119 (26.3)	40 (34.1)	249 (29.5)	
> 6 hours/day	139 (70.2)	44 (58.6)	333 (73.6)	77 (65.8)	593 (70.4)	

y: years; BMI: body mass index; WC: waist circumference; BED: participants who met the binge eating disorder criteria; FA: participants who met the food addiction criteria; BED+FA: participants who had an overlapping of BED with FA; BED and/or FA-free: participants who did not meet the diagnostic criteria of BED and FA

[a]Mean±SEM

*Mean group differences by one-way ANOVA or Mann-Whitney U test based on normality. Statistical significance at *p*≤0.05.

significantly higher in the overlapping BED and FA group (BED+FA) as compared to the FA group (98.00±0.50 cm and 95.28±1.24 cm, respectively; p=0.010). However, there was no significant difference in body fat percentage among the four group categories.

The demographic and lifestyle characteristics by groups from the BED and FA categories are presented in Table 1. There were no significant differences between groups regarding age, marital status, employment, and physical activity (p>0.05). The age of the participants (N=842) was similar across all groups of BED and FA categories, with an average of 29 years. Education levels differed significantly across groups (χ^2 =21.69, p=0.022, df=12), with the BED and FA groups reporting a higher education level (Bachelor's degree) than participants in the BED and/or FA-free group; however, 44.0% of the sample had a Bachelor's degree across all groups. Regarding smoking, majority of the participants from all groups were non-smokers, accounting for 72.6% (n=611), while 27.4% (n=231) were current smokers. Smoking status differed significantly across groups (χ^2=9.02, p<0.029, df=3), with the overlapping BED and FA group (BED+FA) (31.4%) reporting more smokers than participants in the BED, FA, and BED and/orFA-free groups (21.7%, 28.0%, and 21.4%, respectively; p<0.05). About 29.5% (n=249) of the participants reported sleeping hours of <6 hours/day and 70.4% (n=593) had sleeping hours of >6 hours/day (p=0.037). Among all groups of the BED and FA categories, the FA group had a significantly lower level of sleeping time

Table 2. General eating pattern of participants by eating disorder groups

Variables	*BED n=198 n (%)*	*FA n=75 n (%)*	*BED+FA n=452 n (%)*	*BED-and/or-FA-free n=117 n (%)*	*Total n=842 n (%)*	*p*
Number of meals						0.011*
1 meal	22 (11.1)	18 (24.0)	76 (16.8)	26 (22.2)	142 (16.8)	
2 meals	133 (67.2)	36 (48.0)	247 (54.6)	65 (55.6)	481 (57.1)	
3 meals	43 (21.7)	21 (28.0)	129 (28.6)	26 (22.2)	219 (26.0)	
Skipping meals						0.008*
Breakfast (B)	63 (31.8)	13 (17.3)	135 (29.9)	29 (24.8)	240 (28.5)	
Lunch (L)	3 (1.5)	4 (5.3)	20 (4.4)	3 (2.6)	30 (3.6)	
Dinner (D)	67 (33.8)	19 (25.3)	92 (20.4)	33 (28.2)	211 (25.0)	
B & L	5 (2.5)	5 (6.7)	26 (5.7)	7 (6.0)	43 (5.1)	
B & D	17 (8.6)	13 (17.3)	50 (11.0)	18 (15.4)	98 (11.6)	
None	43 (21.7)	21 (28.0)	129 (28.5)	27 (23.0)	220(18.5)	
Number of snacks						<0.001*
None	3 (1.5)	6 (8.0)	2 (0.5)	12 (10.3)	23 (2.8)	
One snack	19 (9.6)	9 (12.0)	33 (7.3)	31 (26.5)	92 (10.9)	
Two snacks	61 (30.8)	26 (34.7)	118 (26.1)	20 (17.0)	225(26.7)	
≥ 3 snacks	115 (58.0)	34 (45.3)	299 (66.1)	54 (46.2)	502(59.6)	
Dining out						<0.001
Never	21 (10.6)	13 (17.3)	54 (12.0)	37 (31.6)	125(14.8)	
1-3/month	65 (32.8)	15 (20.0)	113 (25.0)	49 (41.9)	242(28.8)	
1-3/week	94 (47.5)	36 (48.0)	217 (48.0)	24 (20.5)	371 (44.0)	
4-7/week	18 (9.0)	11 (14.7)	68 (15.0)	7 (6.0)	104 (12.4)	

BED: participants who met the binge eating disorder criteria; FA: participants who met the food addiction criteria; BED+FA: participants who had an overlapping of BED with FA; BED and/or FA-free: participants who did not meet the diagnostic criteria of BED and FA.
*Pearson's Chi-square test (χ^2); statistically significance at p≤0.05

(<6 hours/day), accounting for 41.3% (*n*=31) as compared to BED, BED+FA, and BED and/or FA-free groups (29.7%, 26.3%, and 34.1%, respectively).

The number and percent of subjects in each group across the various categories for eating pattern are presented in Table 2. The majority of the total sample (57.0%) ate only two meals per day; however, the BED group tended (67.2%) to consume two meals more frequently as compared to the FA, overlapping BED and FA (BED+FA), and BED and/or FA-free groups (48.0%, 54.6%, and 55.6%, respectively; $p<0.05$). Among the consumed meals, breakfast (28.5%) and dinner (25.0%) were the most skipped meals by all participants, whereas lunch (3.6%) was rarely skipped. However, there was a significant difference in the number of meals and snacks and dining out between groups. The BED group was significantly the highest in consuming two meals (67.0%) compared with all other groups ($p=0.011$). Regarding the number of snacks, approximately 60.0% of the women with obesity reported consuming ≥3 snacks/day. The overlapping BED and FA group (BED+FA) was the highest in consuming three snacks or more per day, followed by the BED group with a frequency of 66.0% and 58.0%, respectively ($p<0.001$). Dining out 1-3 times per week was significantly higher in all BED and FA groups (BED, FA, and BED+FA), with a frequency of approximately 48.0% as compared to 20.0% in the BED and/or FA-free group ($p<0.001$). Interestingly, the FA and overlapping BED and FA (BED+FA) groups reported dining out four to seven times per week, with a frequency of 15.0% as compared to the BED and/or FA-free group, where the frequency was only 6.0%. The associations between water intake, obesity, and categories of BED and FA are illustrated in Figure 2. Drinking one to three cups of water per day was significantly higher in all categories

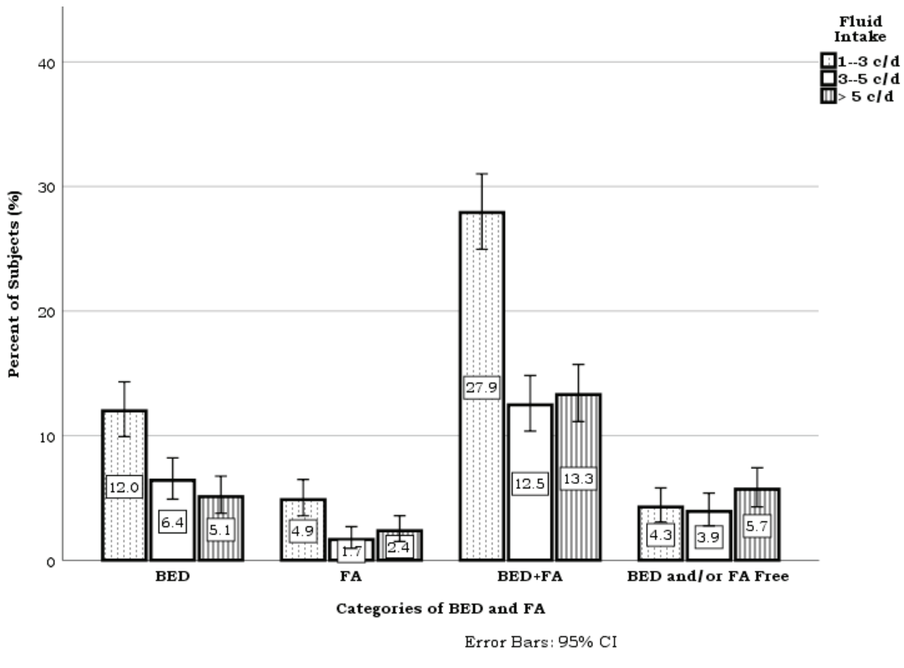


Figure 2. Associations between fluid intake and categories of binge eating disorder and food addiction among study population

of BED and FA groups (BED, FA, and BED+FA), with a frequency ranging from 51.0-54.0% as compared to 30.7% in the BED and/or FA-free group (p<0.001). Conversely, within groups, the BED and/or FA-free group had a significantly higher level of water intake of > 5 cups/ day, with a frequency of 41.0% (n=48) as compared to the BED, FA, and BED+FA groups [21.7% (n=43 out of 198), 26.6% (n=20 out of 75), and 24.8% (n=112 out of 452), respectively].

The relative risks (RR) for obese women with BED as compared to obese women without BED in the presence of selected predictors are presented in Table 3. The model was adjusted for age and education level. When all predictors were entered into the model, only FA scores, number of snacks, and sleeping hours were significantly related to BED risk. Higher FA scores significantly increased the risk of developing BED [*RR*: 1.23 (1.16-1.29), p<0.001]. Our data showed that obese participants who had three or more snacks per day [*RR*: 2.17 (1.39-3.37), p=0.001] were significantly at a higher risk of developing BED. After controlling for FA scores, obese participants who had a fluid intake of 1-3 cups/day [*RR*: 1.51 (1.16-2.12), p=0.017] were at a significantly increased risk of developing BED.

DISCUSSION

Binge eating disorder can have functional consequences, such as difficulty in adapting to new roles, reduced quality of life, and decreased life satisfaction due to health problems, increased overall morbidity and mortality, increased use of healthcare resources, and weight gain and obesity (Myers & Wiman,

Table 3. Associations between binge eating disorder and selected indicators among study population

Indicators[a]	*Relative Risk OR (95% CI)*	*p*
Food addiction scores (FA)	1.23 (1.16-1.29)	<0.001
Smoking	1.17 (0.78-1.77)	0.436
Yes		
No		
Physical activity	1.22 (0.80-1.86)	0.333
Active		
Inactive		
Number of meals	0.98 (0.64-1.48)	0.926
4 meals		
3 meals		
Number of snacks	2.17 (1.39-3.37)	0.001
≥ 3 snacks		
<3 snacks		
Sleeping hours	1.55 (1.14-2.23)	0.017
<6 hours/day		
>6 hours/day		
Fluid Intake	1.51 (1.16-2.12)**	0.019
3 cups/day		
>3 cups/day		

[a]Logistic regression test; dependent variable: binge eating disorders
Data presented as RR (odd ratios (OR) + 95% CI). Statistically significance at p<0.05
**Adjusted for FA scores

2014). Recently, it has been reported that one in ten individuals suffers from FA. This figure may be doubled among individuals with obesity as shown in a large community sample (Minhas *et al.*, 2021). However, existing research evidence suggested that there is an overlap between BED and the construct of FA (Burrows *et al.,* 2017). In the present study, approximately 86.0% of the total sample of women with obesity had BED, FA, and overlapping BED and FA. The highest frequency was observed in the group that had BED coincident with FA (BED+FA), which accounted for 53.7% of the total sample. Our observations were consistent with previous data, which revealed that 92.0% of individuals with BED met the food addiction criteria (Carter, Van Wijk & Rowsell, 2019). A recent study showed that 61.5% of their sample met both the BED and FA criteria (Fauconnier *et al.*, 2020). Carter *et al.* (2019) reported that high rates of FA symptoms were observed in individuals with BED, which may highlight the overlap between FA symptoms and clinical features of BED. However, our multivariate analysis showed that increased score of FA was significantly associated with increased risk of BED in obese women. The mechanism by which FA is related to BED risk is not fully understood.

In a previous meta-analysis that analysed 25 studies and included a total of 196,211 overweight/obese participants, of which 60.0% were females, the mean prevalence of FA was 19.9%. Furthermore, the mean prevalence of FA was even more pronounced in 14 studies, accounting for 24.9% in overweight/obese individuals (Pursey *et al.*, 2014). However, only 9.0% of obese women met the YFAS 2.0 criteria for FA in the present study. On the other hand, of those with BED, 69.5% of them met the criteria for FA. This variation in the prevalence rate of FA may be related to cultural theories concerning the effect of exposure to a western diet on the risk of developing eating disorders, which have been focused on eating disorder-specific factors. These factors include media influences, body image ideals, as well as peer and familial pressures on appearance (Myers & Wiman, 2014).

Smoking is a common risk behaviour among individuals with ED, which has been reported as an appetite/weight control strategy (Anzengruber *et al.*, 2006). About one third of our overall sample were current smokers, and the overlapping BED and FA group (BED+FA reported the highest number of smokers. These findings were consistent with that of Anzengruber and colleagues (2006), who found that women with ED had higher rates of smoking and a greater level of nicotine dependence than controls (Anzengruber *et al.*, 2006). A systematic review revealed that individuals with BED and bulimia nervosa were significantly more likely to be life-long smokers than healthy controls. A possible explanation for these results may be that cigarette smoking is being used by ED individuals as a behavioural strategy to suppress appetite, compensate for overeating, cope with body dissatisfaction, and manage weight or appetite changes due to withdrawal symptoms (Solmi *et al.*, 2016).

As we mentioned previously, the FA group had a significantly lower level of sleeping hours (<6 hours/day) as compared with all other groups. This result matches those observed in earlier studies, which reported that sleep deprivation was associated with increased food intake and appetite. Benedict *et al.* (2012) demonstrated that acute sleep deprivation increases the reward response to food cues, regardless of weight or blood sugar level. The explanation for this result may be the impact of impulsivity and its effect on insomnia (Benedict *et al.*, 2012). Our data showed that the proportion of obese women who had a daily sleeping time of less than six hours in the BED group was lower than that in the BED and/orFA-free group. However, the likelihood of having BED was significantly higher in obese women who had a daily sleeping time of less than 6 hours (p<0.05). Trace *et al.* (2012) reported that sleep problems were associated with binge eating and obesity in adult Swedish women. A possible explanation for these observations may be related to environmental stressors, depression, or underlying biological mechanisms (Trace *et al.*, 2012).

The present study found that the overlapping BED and FA group (BED+FA) had a significantly higher BMI and WC than that in all other groups. The occurrence of FA with BED could be a sign of more severe BED, associated with factors such as stronger negative affect, more frequent binge eating episodes, and an earlier onset of problematic eating behaviours (Gearhardt *et al.*, 2014).

The current study also found that the BED group was the highest in consuming just two meals and skipping meals, especially breakfast or dinner; whereas the overlapping BED and FA group (BED+FA) was the highest in consuming more than three snacks per day as compared to the BED and/or FA-free group. The BED and/or FA-free group had a tendency to consume no snacks or only one snack per day. This finding confirms that the decreased number of main meals led to an increase in the number of snacks. Our data also showed that obese women who frequently consumed more than or equal to three snacks per day could face more than twice the risk of BED compared to those who consumed less than three snacks per day [RR: 2.17 (1.39-3.37), p=0.001]. Accordingly, it has been reported that women who were at a high risk of developing ED had a higher frequency of skipping meals and consuming snacks (Gandhi & Battalwar, 2019). Masheb & Grilo (2006) investigated eating habits in overweight patients with BED and reported that patients who ate three meals per day had significantly weighed less and had fewer binge-eating episodes than those who did not regularly eat three meals each day. A possible explanation for this result could be that skipping main meals increases cravings and leads to overeating.

All of the BED and FA groups in this study tended to dine out more frequently than the BED and/or FA-free group, especially the FA and overlapping BED and FA (BED+FA) groups. In line with our results, a large study revealed that FA was positively associated with fast foods (Lemeshow *et al.*, 2018). A cross-sectional study showed that the prevalence of fast food addiction among a sample of adults was high (30.0%) and that fried chicken was the favourite quick food for many of them (49.2%). It seems possible that both personal and socio-cultural factors may increase fast food addiction (Arumugam *et al.*, 2015). Although there is little evidence supporting the fact that fast food has an addictive potential, its high fat and salt contents can trigger addictive-like behavioural or biological reactions due to its unnaturally high rewarding levels (Gearhardt *et al.*, 2014).

In line with previous studies, the current study showed that women with obesity who consumed less amount of water were more likely to exhibit BED and/or FA. Hart *et al.* (2005) reported that only 17.0% of patients with ED had adequate amounts of fluids as recommended. The authors have also observed that fluid intake was inversely related to BMI in patients with ED (Hart *et al.*, 2005). Additionally, a study found that drinking 17oz. (550ml) of water prior to eating a meal was associated with a lower number of calories consumed by 13.0% of participants as compared with a control group (Davy *et al.*, 2008). One possible explanation could be that increasing water intake may delay gastric emptying, thus increasing sensations of fullness and thermogenesis, which leads to reduced snacking and binge eating (Davy *et al.*, 2008).

The strength of this study is that it was the first study to examine the prevalences of both BED and FA in Jordanian obese women by using paper-based questionnaires filled in by a trained interviewer in a face-to-face setting. Additionally, a descriptive well-designed case series using well-validated assessment tools provided information that allowed researchers to develop hypotheses towards further advanced studies. The present study had the advantage of using a large sample size, and this allowed for more precise estimates of the occurrences of BED and FA. However, the present study had some limitations including the descriptive case series design that had some sources of bias such as selection bias, lack of generalisability, lack of a control group, and inability to show cause and effect associations.

CONCLUSION

This study revealed that the occurrence of binge eating disorder was relatively high among a sample of Jordanian women with obesity. The study demonstrated the overlap between BED and FA in a selected sample of obese women. Although the study was descriptive, it suggested that BED, FA, and the overlapping of BED and FA, in particular, were associated with greater tendencies towards unhealthy pattern of eating practices, fluid intake, and sleeping habits. The increased risk of BED in this sample of obese women appeared to be associated with FA and other obesity-related risk factors such as unhealthy characteristics of eating patterns and sleeping habits. Therefore, further research is needed to identify the overlapping BED and FA, and to explore its distinctive underlying mechanisms in obese individuals.

Acknowledgement

This work was supported by the Deanship of Scientific Research/Faculty of Graduate Studies, The University of Jordan. The authors would like to extend their acknowledgements to all study participants and study team members for their time and efforts in implementing the research.

Authors' contributions

Zueter Z, conceptualised the study, conducted the study, performed data collection in the city of Irbid, prepared the draft of the manuscript; Mashal RH, served as an advisor, designed the study, carried out the validation tests for the questionnaires, performed data analysis and interpretation, and reviewed the manuscript.

Conflict of interest

We have no relationships, financial or otherwise, that might lead to a conflict of interest.

References

Ajlouni K, Khader Y, Batieha A, Jaddou H & El-Khateeb M (2020). An alarmingly high and increasing prevalence of obesity in Jordan. *Epidemiol Health* 42:e2020040.

Anzengruber D, Klump KL, Thornton L, Brandt H, Crawford S, Fichter MM, Halmi KA, Johnson C, Kaplan AS & LaVia M (2006). Smoking in eating disorders. *Eat Behav* 7(4):291-299.

Arumugam B, Suganya A, Nagalingam S & Suveka V (2015). Fast food addiction–The junk enslavement. IAIM 2(1):62-70.

Black DW & Grant JE (2014). *DSM-5® guidebook: the essential companion to the diagnostic and statistical manual of mental disorders.* American Psychiatric Publishing, Inc., Washington.

Benedict C, Brooks SJ, O'Daly OG, Almen MS, Morell A, Åberg K, Gingnell M, Schultes B, Hallschmid M & Broman J (2012). Acute sleep deprivation enhances the brain's response to hedonic food stimuli: an fMRI study.

J Clin Endocr 97(3):E443-E447.

Burrows T, Skinner J, McKenna R & Rollo M (2017). Food addiction, binge eating disorder, and obesity: Is there a relationship? *Behav Sci* 7(3):54.

Carter JC, Van Wijk M & Rowsell, M (2019). Symptoms of 'food addiction'in binge eating disorder using the Yale Food Addiction Scale version 2.0. *Appetite* 133:362-369.

Citrome L (2015). A primer on binge eating disorder diagnosis and management. *CNS Spectr* 20(S1):41-51.

Davy BM, Dennis EA, Dengo AL, Wilson KL & Davy KP (2008). Water consumption reduces energy intake at a breakfast meal in obese older adults. *J Am Diet Assoc* 108(7):1236-1239.

Fauconnier M, Rousselet M, Brunault P, Thiabaud E, Lambert S, Rocher B, Challet-Bouju G & Grall-Bronnec M (2020). Food addiction among female patients seeking treatment for an eating disorder: Prevalence and associated factors. *Nutrients* 12(6):1897.

Gandhi J & Battalwar R (2019). Eating habits and night snacking patterns of young women at risk for eating disorders. *Int J Physiol Nutr Phys Educ* 4(1):1136-1141.

Gearhardt AN, Boswell RG & White MA (2014). The association of "food addiction" with disordered eating and body mass index. *Eat Behav* 15(3):427-433.

Hart S, Abraham S, Luscombe G & Russell J (2005). Fluid intake in patients with eating disorders. *Int J Eat Disord* 38(1):55-59.

Haththotuwa RN, Wijeyaratne CN & Senarath U (2020). Worldwide epidemic of obesity. In TA Mahmood, Sabaratnam A, Frank AC (eds). *Obesity and Obstetrics (Second Edition)* (pp. 3-8). Elsevier.

Hauck C, Weiß A, Schulte EM, Meule A & Ellrott T (2017). Prevalence of 'food addiction'as measured with the Yale Food Addiction Scale 2.0 in a representative German sample and its association with sex, age and weight categories. *Obes Facts* 10(1):12-24.

Hayes JF, Balantekin KN, Altman M, Wilfley DE, Taylor CB & Williams J (2018). Sleep patterns and quality are associated with severity of obesity and weight-related behaviors in adolescents with overweight and obesity. *Child Obes* 14(1):11-7.

Heron N, Tully MA, McKinley MC & Cupples M E (2014). Physical activity assessment in practice: A mixed methods study of GPPAQ use in primary care. *BMC Fam Pract* 15(1):1-9.

Khader Y, Batieha A, Ajlouni H, El-Khateeb M & Ajlouni K (2008). Obesity in Jordan: prevalence, associated factors, comorbidities, and change in prevalence over ten years. *Metab Syndr Relat Disord* 6(2):113-120.

Lee RD (2010). *Nutritional assessment.* RD Lee & DC Nieman. McGraw-Hill, New York.

Lemeshow AR, Rimm EB, Hasin DS, Gearhardt AN, Flint AJ, Field AE & Genkinger JM (2018). Food and beverage consumption and food addiction among women in the Nurses' Health Studies. *Appetite* 121:186-197.

Masheb RM & Grilo CM (2006). Eating patterns and breakfast consumption in obese patients with binge eating disorder. *Behav Res Ther* 44(11):1545-1553.

Meule A & Gearhardt AN (2019). Ten years of the Yale Food Addiction Scale: a review of version 2.0. *Curr Addict Rep* 6(3):218-228.

Minhas M, Murphy CM, Balodis IM, Samokhvalov AV & MacKillop J (2021). Food addiction in a large community sample of Canadian adults: prevalence and relationship with obesity, body composition, quality of life and impulsivity. *Addiction* 116(10):2870-2879.

Mousa TY, Al-Domi HA, Mashal RH & Jibril MA (2010). Eating disturbances among adolescent school girls in Jordan. *Appetite* 54:196–201.

Musharbash RM, Elsahoryi NA, McGrattan A, Al-Alam S & Badawi L (2021). Prevalence of food addiction during Covid-19 pandemic in Amman, Jordan: A cross sectional study. *J Nutrition and Food Processing* 4(4).

Myers LL & Wiman AM (2014). Binge eating disorder: A review of a new DSM diagnosis. *Res Soc Work Pract* 24(1):86-95.

Pedram P, Wadden D, Amini P, Gulliver W, Randell E, Cahill F, Vasdev S, Goodridge A, Carter JC & Zhai G (2013). Food addiction: Its prevalence and significant association with obesity in the general population. *PLoS One* 8(9):e74832.

Pursey KM, Stanwell P, Gearhardt AN, Collins CE & Burrows TL (2014). The prevalence of food addiction as assessed by the Yale Food Addiction Scale: A systematic review. *Nutrients* 6(10):4552-4590.

Solmi M, Veronese N, Sergi G, Luchini C, Favaro A, Santonastaso P, Vancampfort D, Correll CU, Ussher M & Thapa-Chhetri N (2016). The association between smoking prevalence and eating disorders: A systematic review and meta-analysis. *Addiction* 111(11):1914-1922.

Trace SE, Thornton LM, Runfola CD, Lichtenstein P, Pedersen NL & Bulik CM (2012). Sleep problems are associated with binge eating in women. *Int J Eat Disord* 45(5):695-703.

Yanovski SZ, Marcus MD, Wadden TA & Walsh BT (2015). The questionnaire on eating and weight patterns-5 (QEWP-5): An updated screening instrument for binge eating disorder. *Int J Eat Disord* 48(3):259-261.

Yu Z & Tan M (2016). Disordered eating behaviors and food addiction among nutrition major college students. *Nutrients* 8(11):673

Mal J Nutr 29(2): 321-331, 2023

The influence of perceived value and gender on local food consumption intentions in the northeastern cluster of Thailand

Meesubthong Chatcharawan[1], Meesuptong Jaruporn[2*] & Udomsamuthirun Pongkaew[3]

[1]*Faculty of Business Administration, Huachiew Chalermprakiet University,Samutprakan Province, Thailand;* [2]*Department of Digital Marketing, Faculty of Management Science, Loei Rajabhat University, Loei province, Thailand*; [3]*Faculty of Science, Srinakharinwirot University, Bangkok Thailand*

ABSTRACT

Introduction: Local food, which represents a country's culture, can be gradually forgotten due to various factors. This study investigated the perceived value of local food and the influence of gender on consumer behaviour regarding the intention to eat local food. **Methods:** A quantitative survey was conducted using random systematic sampling at a fixed periodic interval. A sample of 2,000 consumers from Thailand's upper northeastern region was chosen. Structural equation modelling was used to assess the relationships between perceived value, attitude towards eating, and intention to eat. **Results:** The relevant parameters identified the positive influence of perceived value and attitude towards eating behaviour on the intention to eat local food. The factor loading of attitude towards eating behaviour moderated the effect of the perceived value of local food on the intention to eat local food. Females had less perceived value for their intention to eat local food than males did. **Conclusion:** The perceived value of local food had the greatest positive impact on attitude towards eating behaviour. Moreover, the difference in gender in the eating behaviour of local food showed that females were more likely to control their food consumption than males were. To increase the intention to eat local food, local food vendors should focus on factors that influence attitudes and use food storytelling to increase consumers' awareness on the benefits of local food.

Keywords: food consumption, gender, intention, local food, perceived value

INTRODUCTION

Local food is the basis of consumption culture for any area. The local cuisine provides a wonderful source of balanced nutrients for the body and reflects the customs and traditions of a nation. However, the younger generation tends to consume less traditional food than the

*Corresponding author: Dr Meesuptong Jaruporn
Department of Digital Marketing, Faculty of Management Science, Loei Rajabhat University
Loei province, Thailand
Tell: 66945288958; Fax: 6642-835231; E-mail: Jaruporn.mee@Lru.ac.th
doi: https://doi.org/10.31246/mjn-2022-0051

older generation (Rahmat *et al*., 2021). The diversity of nationalities residing in communities has resulted in food-created cultures of different nations within the local community. This affects the local way of life, which has been inherited over many generations and is now gradually disappearing. Food consumption behaviours are more diverse in today's society and people have more choices for consumption. However, there are also weaknesses in the quality of local food. Therefore, standards are accepted in response to the needs of a wide range of consumer groups, such as the quality of ingredients, hygienic production processes, intensive distribution, and targeted customers (Belletti, Casabianca & Marescotti, 2012). In Thailand, well-known Thai food blends have fundamental tastes: sweet, spicy, sour, bitter, and salty (Pongsawatmanit, 2020). However, each region of Thailand has its own special taste. In particular, northeastern cuisine is very famous among Thai people and foreigners, such as *somtam,* which can be easily bought as street food (Srisongka & Yanasugondha, 2019). The understanding of local food consumption as street food on people's perceptions and behaviours has been examined (Choe & Kim, 2018). Therefore, we investigated the links between eating behaviour and the influence of perceived value on local food.

Previous research found that different genders have different behaviours with regard to consuming local food (Somnasang & Moreno-Black, 2000; Rakinaung, Jerayingmongkol & Sanguanprasit, 2015). This study examined informational attitudes related to gender on perceived value and attitude towards eating behaviour on the intention to eat local food. One approach to understanding people's behaviours and intentions can be found in Davis's model, known as the technology acceptance model (TAM), which explains new ways to assess user demand and define perceived usefulness and perceived use (Davis, 1989). Scholars have examined this relationship using structural equation modelling (SEM). To understand gender differences in local food consumption behaviours, we constructed a model with the parameters of the perceived value of local food (PL), attitude towards eating behaviour (AE), and intention to eat local food (IE) to identify differences in gender with regard to eating behaviour of local food. SEM enables the analysis of latent variables and their relationships, offering the opportunity to analyse the dependencies of psychological constructs.

The PL defines the degree to which a consumer believes that local food benefits from local herbs, vegetables, and natural food ingredients. Consumers are concerned about healthier lifestyles and environmental issues (Petrescu, Vemeir & Petrescu-Mag, 2020). Food quality can involve the appearance of food, such as food decoration, food packaging design, product description, and other factors after purchasing in addition to consuming the food, such as the taste, food hygiene, and feeling of satisfaction. Therefore, perceived value reflects an outcome of usage and illustrates the primary incentive to adopt a new behaviour. Local food has a special taste, so individuals who are unaccustomed to it may be motivated to adopt a new behaviour. PL in new food-related decision-making represents the potential benefits of seeking better, more delicious food. PL involves consumers' due diligence regarding whether the kind of value set embedded in a particular food matches their individual lifestyle. Perceived value has been described in many studies on food satisfaction, such as through emotional perspectives (Raji & Zainal, 2016; Hasan, 2022), perceived food quality (Hasan, 2022), and portion value (Hasan, 2022). Therefore, the quality value (QV), emotional value (EV), and portion value (PV) of food are important factors in the perceived value of local food in this research.

An AE is a psychological, evaluative response towards a particular food in positive and/or negative terms based on affective, behavioural, and cognitive information. In this situation, behavioural and cognitive information are the complex terms that encourage new mindsets that transcend the intention of consuming local food. Visitors who perceive high quality and taste are likely to have a positive attitude towards local food at a destination (Choe & Kim, 2018). Consumers generally hold positive attitudes towards safe food, notably in terms of safety, quality, nutrition, and flavour. They are willing to spend more on food that is safe (Liu, Pieniak & Verbeke, 2013). Ingredients, nutritional information, and additives are the most important cues for food safety and nutrition; while packaging, food origin, and production type are the most important cues for food environmental effects. Local food cuisine promotes the preservation of local resources, which contributes to the taste, texture, and smell of the dish, achieved via the use of natural resources. Many plant food items are also used as medicinal ingredients and are part of the local health belief system (Phengphol, 2011). Some ingredients in local food are simple herbs that are easy to find in the area. While the cooking process is convenient and quick, the taste is distinct, and the food is rich in nutrients. Local people use wild food because it is more delicious and tastes better than cultivated food (Somnasang & Moreno-Black, 2000). In this research, we fit local food into functional foods; therefore, the attitude towards eating behaviour is seen as a response to the characteristics of cooking (CC), the eating style of individuals (ES), and the storytelling of food (ST). Functional foods and attitude towards eating behaviour are associated with hedonic eating values (Nystrand & Olsen, 2020). Therefore, cooking behaviour, cooking knowledge, and food security status are related to functional foods (Czup, 2020). Eating style and lifestyle are associated with a different profile of attitudes and behaviour of consumers that differs between males and females (Wah, 2016). Taste is another important factor; food made with wild ingredients is preferred by villagers because it grows naturally, contains more nutrients, including vitamins and protein, and is lower in fat (Kivela *et al.*, 1999). Based on the theory of planned behaviour (TPB), people's behaviours and intentions can be described. Therefore, the IE is related to the cognitive dissonance of attitudes towards nutrition, which may be changed by understanding the cooking method (CM) and health benefits with sustainability (SF).

Based on the relevant literature, locals and tourists coexist in the current situation given the resilience of local food in the face of constant change. This research aimed to preserve local food wisdom, while also improving it to make it more modern and acceptable to today's society. The TAM model is a powerful theoretical framework for studying technology acceptance and usage. The TAM is used in food service industry management by integrating it with social factors that can provide insight for developing food industry strategies (Jun *et al.*, 2021). The influence of parameters that have both direct and indirect effects was investigated, so a SEM was appropriate for our model in which the relationships between PL, IE, and AE were tested for direct and indirect effects on causal relationships. The conceptual framework on the influence of the perceived value of local food and attitude towards eating behaviour on the intention to eat local food is provided in Figure 1. We defined the parameters: P defines the degree to which a consumer believes that local food benefits from local herbs, vegetables, and natural food ingredients; IE is relevant to the cognitive dissonance of the attitude towards nutrition; AE is a psychological, evaluative response towards a particular food in positive and/or negative terms.

The objective of the study was to study the influence of the perceived value of local food on the intention to eat local food under the effect of gender moderated by attitude towards eating behaviour.

This research could help preserve the benefits of local food consumption in Thailand and promote local dishes internationally, which can help local food vendors create higher incomes and job opportunities for local people. Moreover, the relatively low capital expenditures of local food businesses are attractive for certain types of sellers. This study could also provide information for local food vendors and consumers to be aware of their appropriate roles in association with government authorities, such as food hygiene.

MATERIALS AND METHODS

This study received ethical approval from the Human Research Ethics Committee of Loei Rajabhat University, Thailand. (Reference Number: HE 023/2563). All participants were given information about the study and consent was indicated by voluntarily completing the questionnaire. All data remained anonymous.

Sampling method and sample size

A quantitative survey was conducted at a fixed periodic interval with systematic random sampling of local food consumers by hand at all major markets and food streets in five provinces in the upper northeastern cluster of Thailand. The selected sample comprised 2,000 consumers of local food. The population in 2020 in this region was as follows: 1,567,983, 517,434, 422,041, 513,316, and 638,736 for *Udon Thani*, *Nong Khai*, *Bueng Kan*, *Nong Bua Lamphu*, and *Loei*, respectively.

The sample for this research was calculated using the formula of Taro Yamane with a 95% confidence level. The formula used was $n = \frac{N}{1+Ne^2}$, where n is the sample size required and N is the size of the population; e is the allowable error. After calculating the sample size, the number of samples from each province was ascertained to be 400. The respondents for this study were selected using a probability sampling approach. This study was conducted from June 2020 to May 2021.

The first few questions concerned participant demographics to gather information that could be linked to our observation variables. To achieve the goals of the study, a questionnaire on the perceived value of local food, attitude towards eating behaviour, and intention to eat local food was constructed using a five-point Likert scale for each variable. A content validity test using the index of item-objective congruence (IOC) technique found that the IOC values of the questionnaire were 0.50 or higher, which were acceptable given the present criteria. Thirty sets of questionnaires were distributed to test reliability with Cronbach's alpha coefficient. The reliability of each observation variable was approximately 0.920-0.924, which was greater than 0.70 and accepted as the present criteria (Hair *et al.*, 2010).

Statistical analyses

The statistical software IBM SPSS Amos (IBM Corporation, Armonk, NY, USA) was used for data analysis. Descriptive statistics of categorical variables were presented as frequencies and percentages, while observation variables were presented as means and standard deviations. Amos software was used for confirmatory factor analysis and SEM. We investigated the parameters according to our research model with the test for multivariate normality on the skewness and kurtosis of each observation variable: sustainable food (SF), CM, storytelling (ST), eating style (ES), characteristics of cooking (CC), EV, QV, and PV. Our parameters showed skewness in the range of -0.695 to -1.142 and kurtosis in the range of -0.344 to 0.837, which agreed with the normality of -3 to +3 skewness (Finney & DiStefano, 2006) and -3 to +3 kurtosis (Westfall & Henning, 2013). The test for multicollinearity and the correlation estimate of pairs of observation variables were calculated and showed that the correlation factors were positive and in the range of -0.370-0.6694 with $p<0.01$. Values less than 0.8 were agreed upon (Hair *et al.*, 2010). The KMO and Bartlett's tests yielded KMO=0.901 (KMO > 0.5) and Bartlett's test with $p<0.05$ (Hair *et al.*, 2010). The confirmatory factor analysis (CFA) results provide a reference point to construct validity tests and a better understanding of the measurement results (Hair *et al.*, 2010). Based on the CFA results, we analysed the convergent validity, discriminant validity, and reliability of all the items. All indicators loaded on the proposed constructs were significant ($p<0.001$). Composite construct reliability (CR) estimates ranged from 0.850 to 0.933, above the recommended cut-off of 0.70 (Fornell & Larcker, 1981) and were acceptable. The average variance extracted (AVE) had to be greater than the 0.50 cut-off for all proposed constructs (Bagozzi & Yi, 1988); the results from 0.507 to 0.751 satisfied the requirements.

We investigated gender differences by separating the samples into two groups: male and female. We repeated the same model with a different group of interested parties. Our population in each group, males (769) and females (1,231), agreed with the observed variables of the SEM calculation method that required 10-20 times the observed variables (Jackson, 2001). The SEM calculation was conducted on a sample of 769 males. The data demonstrated that the other fit indices also fitted reasonably well (p=0.053; CMIN/DF=1.770; GFI=0.994; AGFI=0.980; CFI=0.997; RMSEA=0.032). All the standardised path coefficients are shown in Figure 3. For males, we found that the perceived value of local food influenced the intention to eat local food by 0.475. We also computed a sample of 1,231 females using the SEM calculation. The SEM indices fitted well (p=0.39; CMIN/DF=1.05; GFI=0.998; AGFI=0.992; CFI=1.000; RMSEA=0.007) and were deemed satisfactory (Figure 3).

RESULTS

Descriptive statistics were used to summarise the participants. The demographic profiles of the respondents are summarised in Table 1. The respondents consisted of 61.5% females and 38.5% males, most of whom were 20-39 years old (50.9%). The education level for some were lower than a bachelor's degree (42.3%), while some held a bachelor's degree (44.5%). The occupations were dispersed among students (24.5%), personal business (24.0%), private sector (18.9%), and government sector (13.5%). Most of the students were university and adult education students.

SEM was used to assess the relationships between the potential factors presented as moderated parameters. Figure 1 explains our model, illustrating the direction of impact on the standardised path coefficients. The standardised chi-square per degrees of freedom value was 1.179 lower than

Table 1. Demographic characteristics of respondents

Categories	*Frequency*	*Percent*
Sex		
Male	769	38.5
Female	1,231	61.5
Age		
Less than 20 years old	262	13.1
20-39 years old	1,018	50.9
40-59 years old	559	27.9
More than 60 years old	161	8.1
Education level		
Lower than bachelor's degree	846	42.3
Bachelor's degree	890	44.5
Higher than bachelor's degree	264	13.2
Occupation		
Student	491	24.5
Government sector	270	13.5
Private sector	378	18.9
Personal business	480	24.0
Housewife	48	2.4
Farmer	136	6.8
Other	197	9.9
Province		
Udon Thani	400	20.0
Nong Khai	400	20.0
Bueng Kan	400	20.0
Nong Bua Lam	400	20.0
Loei	400	20.0

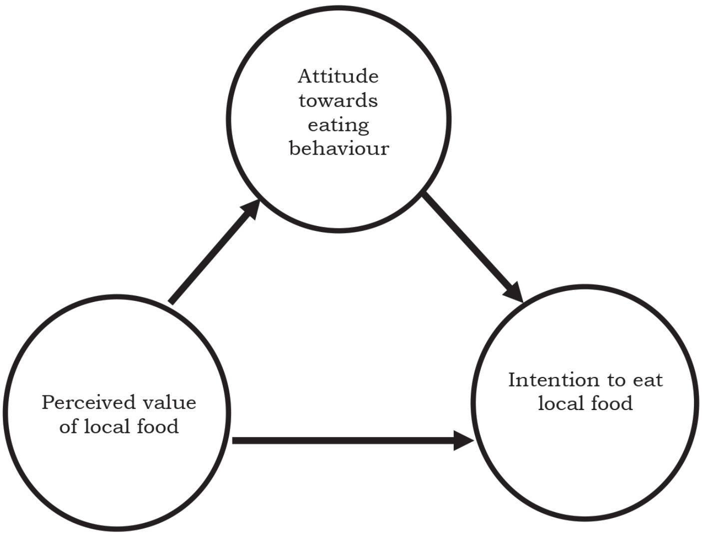


Figure 1. Conceptual framework for the research

the cut-off standard of 3.0 (Hair *et al.,* 2010) and the fit was confirmed to be acceptable. Additionally, the chi-square (9.434) with eight degrees of freedom and the data in the model showed a good fit. Data for the structural model demonstrated that the other fit indices also fitted reasonably well (GFI=0.999; AGFI=0.995; CFI=1.000; RMSEA=0.009) and were deemed satisfactory. All the standardised path coefficients are shown in Figure 2. All influence loadings are shown in Table 2. The perceived value of local food was

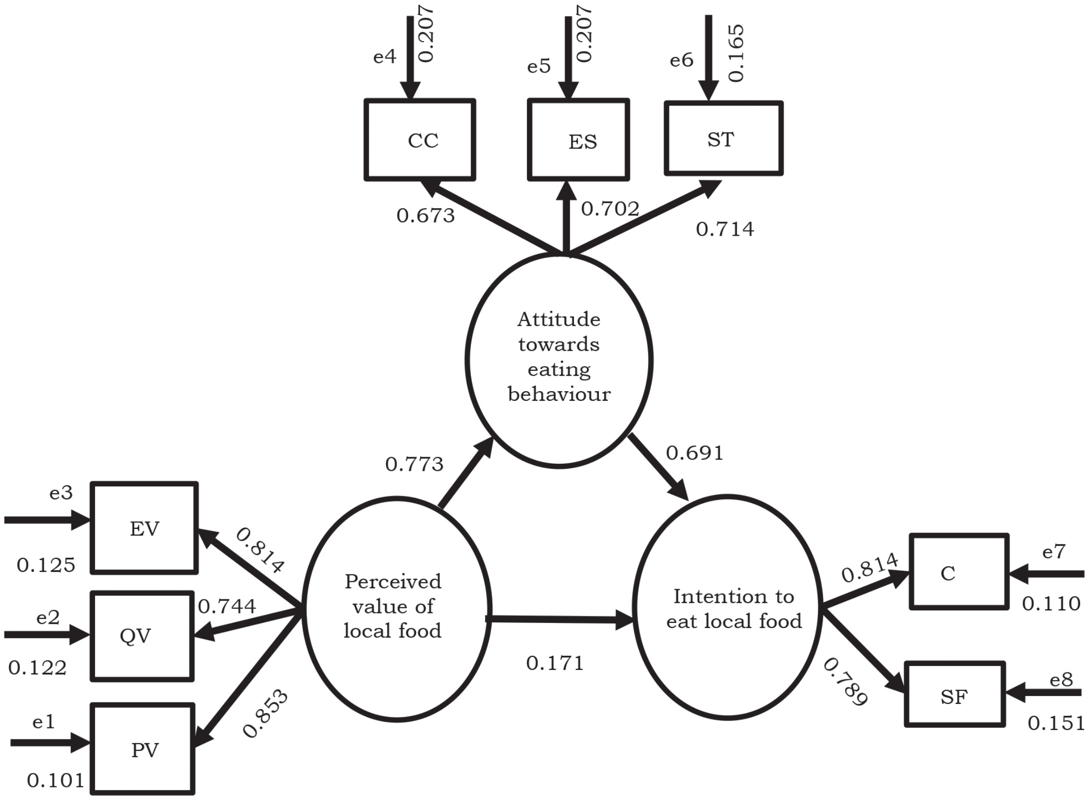


Figure 2. Structural equation model with loadings

QV = Quality value
EV = Emotion value
PV = Portion value
CC = Characteristics of cooking
ES = Eating style of individuals
ST = Storytelling of food
SF = Sustainable food
CM = Cooking method

Table 2. Direct effect, indirect effect, and total effect of the model's parameters

	Perceived value			*Attitude towards eating*		
Parameters	*Direct effect*	*Indirect effect*	*Total effect*	*Direct effect*	*Indirect effect*	*Total effect*
Attitude towards eating	0.773		0.773			
Intention to eat	0.171	0.534	0.705	0.691		0.691
Perceived value	0.814		0.814			

shown to have a positive effect on the intention to eat local food. However, the value for gender was 0.171, which was less than that of the other branch of consideration. The perceived value of local food had the highest positive effect on the attitude towards eating behaviour, with a standardised coefficient of 0.733. The factor loading for attitude towards eating behaviour moderated the effect of the perceived value of local food on the intention to eat local food. The effect was equal to 0.534, which was higher than the direct effect of 0.171. For gender consideration, the perceived value of local food influenced the intention to eat local food by 0.023 in females and this was less than the perceived value in males at 0.475.

DISCUSSION

Local food is a type of food that benefits health and nutrition. Its relationship with two specific diet-related diseases, obesity and diabetes, shows positive impacts on health and nutrition (Ferrer *et al.*, 2011). These results imply consumers' beliefs that local food which benefits from local herbs, numerous vegetables, and natural food are an important determinant of attitudes. The results also suggested that consumers' attitude towards eating behaviour influences their behaviours for the preservation of local resources and environmentally friendly dining out behaviour for local food. To increase the intention to eat local food, consumers must be motivated and develop an attitude towards eating behaviour that encourages it. Consumers believe that local food contains more ingredients derived from local plants; these items are also used as medicinal plants and are part of the local health belief system (Phengphol, 2011). The key motivators for healthier food choices towards a more socioculturally grounded diet include an understanding of food intake and the perceived benefit of healthy eating. Attitude towards eating behaviour moderates the effect of the perceived value of local food on the intention to eat local food and is an effective factor in stimulating consumer behaviour. According to cognitive dissonance theory, when contradictions between views and behaviours are present or when emotional conflicts emerge, people are more inclined to demonstrate behaviours that correspond to their attitudes or beliefs (Festinger, 1957). The food cognitive dissonance (FCD) framework can be employed to anticipate how food-related attitude change is influenced by dissonance. This approach can drive research that leads to the creation of effective nutrition programmes and/or messaging to encourage healthy eating.

In the context of COVID-19 in Thailand, there were restrictions on tourists going to certain provinces, so no feedback was available in this regard. The positive effects with attitude towards eating reflected the behaviours of local consumers aged 20-39 years old, who represented the new lifestyle of the local population. Food safety and sustainability were the identifiable parameters that confirmed the behaviours of consumers. This emphasised the importance of attitude towards eating behaviour in a structural relationship. Consistent with previous research, it was found that Chinese tourists were encouraged to eat local cuisine because of its sensory appeal (Suntikul, Pratt & Chong, 2020). According to Kuma & Smith (2018), attitude towards local food can be predicted by health consciousness, concern for the environment, and concern for local economy. We found that local food was usually arranged as street food, which involved food that was prepared or cooked in a short time and with sufficient portion to satisfy the appetites of young Thai people. Consumers appreciated the nutritious,

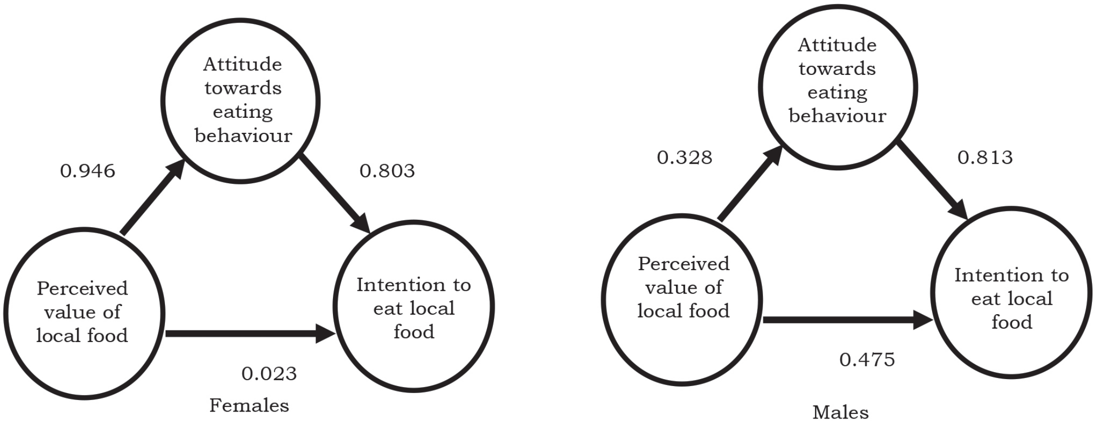


Figure 3. The standardised path coefficients of SEM calculation with males and females

natural, and fresh ingredients, as well as the beautiful decoration, sustainable containers used, and quality value. These factors influenced consumer behaviour and had an impact on perceived value and attitude towards eating behaviour. A positive attitude towards behaviour was also affected by naturally seasoned ingredients, natural herbs with a simple cooking process, sitting on a mat to eat according to the local eating style, and bamboo containers of sticky rice. Thus, local food had a way of telling the story of the local people and their culture, which they learnt and experienced from the older generation, and became their own intellectual knowledge.

Gender is a factor of concern in the TPB. Factors related to the eating behaviours of men and women have been investigated and may have some effect on gender differentiation. Somnasang & Moreno-Black (2000) found that women had greater knowledge than men in terms of recognition, gathering knowledge, preparation and consumption knowledge, and uses of local food. Females were more likely than males to control their food consumption by consuming healthy food. Furthermore, women reportedly had better eating habits/behaviours than men (Rakinaung *et al*., 2015). Figure 3 shows that the female group's attitude towards eating behaviour enhanced higher consumption compared to males. Consistent with previous research results, female students appeared to be much more controlled in their eating habits than male students, and males had a proclivity for unrestrained eating behaviours, which could lead to obesity (Khor, Cobiac & Skrzypiec, 2002). Similar to eating an unhealthy diet, this raises the risk of non-communicable diseases. This finding agrees with the low link between perceived value and the intention to eat local food, especially among females, as they are more concerned about food safety and nutritional value than males. Therefore, for some determinants, psychological and emotional factors have a significant impact on the eating behaviours that gender differences manifest (Khor, *et al.*, 2002).

CONCLUSION

The perceived value of eating local food differed among men and women, as women prioritised food consumption control more than men. Besides, the intention to consume local food varied among different ages. To activate the intention of local food consumption, related organisations should mediate a positive attitude towards local food consumption among target groups. In the private sector, local food vendors should focus on factors that influence attitudes towards healthy food and use marketing promotion to increase consumers' awareness on the benefits of local food. As a result, this increases the chance for Thai local food to be promoted and preserved on a global scale, so bolstering Thailand's legitimate tourism economy and giving locals more prospects for employment and greater incomes.

Acknowledgement

We appreciate the funding support from Thailand Science Research and Innovation. We gratefully acknowledge assistance from the participants in this study.

Authors' contributions

Meesuptong J, principal investigator, conceptualised and designed the study, conducted the study, data analysis and interpretation, prepared the draft of the manuscript and reviewed the manuscript; Meesubthong C, led the data collection in northeastern Thailand, data analysis and interpretation; Udomsamuthirun P, advised on the data analysis and interpretation, and reviewed the manuscript.

Conflict of interest

All authors declare no conflicts of interest.

References

Bagozzi RP & Yi Y (1988). On the evaluation of structural equation models. *J Acad Mark Sci* 16(1):74-94.

Belletti G, Casabianca F & Marescotti A (2012). Local food quality and local resources. Local agri-food systems in a global world. Market, Social and Environmental challenges, Cambridge Scholars Publishing, 278.

Choe JYJ & Kim SS (2018). Effects of tourists' local food consumption value on attitude, food destination image, and behavioral intention. *Int J Hosp Manag* 71:1-10.

Czup A (2020). *The Impact of Cooking Knowledge, Attitude, Behavior, and Food Security Status on Diet Quality of College Students at the University of Maine.* Master of Science in Food Science and Human Nutritional.

Davis FD (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *Manag Inf Syst Q* 13(3): 319-340.

Ferrer MCR, Fonsah EG, Ramirez OA & Escalante CL (2011). *Local Food Impacts on Health and Nutrition (No. 321-2016-11102)* Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011.

Festinger L (1957). *A Theory of Cognitive Dissonance.* Stanford. Stanford University Press, CA.

Finney SJ & DiStefano C (2006). *Non-normal and Categorical Data in Structural Equation Modeling.* In Hancock Gr & Mueller RO (Hrsg.). *Structural Equation Modeling: A second course* (S.269-314). Information Age Publishing, Greenwich, Connecticut.

Fornell C & Larcker DF (1981). Evaluating structural equation models with unobservable variables and measurement error. *J Mark Res* 18(1):39-50.

Hair JF, Celsi M, Ortinau DJ & Bush RP (2010). *Essentials of Marketing Research* (2nd ed.). McGraw-Hill/Irwin, New York.

Hasan AAT (2022). Perceived value and behavioral intentions toward dining at Chinese restaurants in Bangladesh: the role of self-direction value and price fairness. *Sount Asian J Bus Manag* (ahead-of-print).

Jackson DL (2001). Sample size and number of parameters estimates in maximum likelihood confirmatory factor analysis: A Monte Carlo investigation. *Structural Equation Modeling* 8(2):205-223.

Jun K, Yoon B, Lee S & Lee DS (2021). Factors influencing customer decisions to use online food delivery service during the COVID-19 pandemic. *Foods* 11(1): 64.

Khor GL, Cobiac L & Skrzypiec G (2002). Gender differences in eating behavior and social self concept among Malaysian university students. *Malays J Nut* 8(1), 75-98.

Kivela J, Inbakaran R & Reece J (1999). Consumer research in the restaurant environment, Part 1: A conceptual model of dining satisfaction and return patronage. *Int J Contemp Hosp* 11(5):205-222.

Kumar A & Smith S (2018). Understanding local food consumers: Theory of planned behavior and segmentation approach. *J Food Prod Mark* 24(2):196-215.

Liu R, Pieniak Z & Verbeke W (2013). Consumers' attitudes and behaviour towards safe food in China: A review. *Food Control* 33(1):933-104.

Nystrand BT & Olsen SO (2020). Consumers' attitudes and intentions toward consuming functional foods in Norway *Food Qual Prefer* 80:103827.

Petrescu DC, Vemeir I & Petrescu-Mag RM (2020). Consumer Understanding of food quality, healthiness, and environmental impact: Across-National Perspective. *Int J Environ Res Public Health* 17(169):1-20.

Phengphol N (2011). The application of local wisdom for production of condiment Isan' Food ingredient into commercial. *Am J Appl Sci* 8(12):1258-1262.

Pongsawatmanit R (2020). Textural characteristics of Thai foods. In K Nishinari (ed). *Textural characteristics of world foods* (pp. 151-166). John Wiley & Sons Ltd, Hoboken, NJ, USA.

Rahmat N, Ramlan MN, Ghazali, PNA & Ngali N (2021). Intention to Eat Traditional Food among University Students. *Int J Acad Res Bus Soc Sci* 11(13):127-138.

Raji MNA & Zainal A (2016). The effect of customer perceived value on customer satisfaction: A case study of Malay upscale restaurants. *Geografia Malays J Soc Space* 12(3):58- 68.

Rakinaung NE, Jerayingmongkol P & Sanguanprasit B (2015). Factors related to eating behaviour of men and women in Tomohon, Indonesia. *J Health Sci* 29(1):S103-S108.

Somnasang P & Moreno-Black G (2000). Knowing, gathering and eating: knowledge and attitudes about wild food in an Isan village in Northeastern Thailand. *J Ethnobiol* 20(2):197-216.

Srisongka N & Yanasugondha V (2019). Intelligibility of English in Thai Street Food Menus Perceived by East Asian Tourists. *LEARN Journal* 12(2):107-121.

Suntikul W, Pratt S & Chong YWJ (2020). Factors that influence Chinese outbound tourists' intention to consume local food. *J China Tour Res* 16(2):230-247.

Wah CS (2016). Gender differences in eating behavior. *Int J Bus Econ Man* 4:116-121.

Westfall P H & Henning KS (2013). *Understanding advanced statistical methods* (p. 543), CRC Press, Boca Raton.

Mal J Nutr 29(2): 333-342, 2023

Effect of zinc and probiotics supplementation on IL-6 and tissue neutrophil levels in rats exposed to cigarette smoke

Putu Gita Andryani[1*], Endang Mahati[2], Kusmiyati Tjahjono[3], Yan Wisnu Prajoko[4], Neni Susilaningsih[5] & Hermawan Istiadi[6]

[1]*Biomedical Science, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia;* [2]*Department of Pharmacology and Therapeutics, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia;* [3]*Department of Biochemistry, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia;* [4]*Department of Surgery, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia;* [5]*Department of Histology, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia;* [6]*Department of Anatomical Pathology, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia*

ABSTRACT

Introduction: Cigarette smoke exposure can cause inflammation, inducing the release of acute phase cytokines, such as IL-6, that will then trigger the recruitment of neutrophils, which are mostly phagocytic cells. Zinc and probiotics are known to have beneficial effects against inflammation. This study was conducted to investigate the effect of zinc and probiotics supplementation on IL-6 and tissue neutrophil levels in rats exposed to cigarette smoke. **Methods:** In a randomised, experimental study with post-test control group design, thirty 2 to 3-month-old male Wistar rats, each weighing 180-220 g, were divided into five groups: control group without treatment (C); exposed to cigarette smoke [C (-)]; exposed to cigarette smoke and received zinc (Z); exposed to cigarette smoke and received probiotics (P); and exposed to cigarette smoke and received a combination of zinc and probiotics (ZP). **Results:** Mean tissue neutrophil levels in Z, P, and ZP groups were 43.43±2.01, 34.67±1.32, and 29.77±5.05 cells, respectively. There were significant differences between supplementation intake and tissue neutrophil levels in each group compared to C (-) group ($p<0.05$). Meanwhile, only IL-6 level in the ZP group (6.02 pg/mL) decreased significantly compared to C (-) group (10.61 pg/mL). **Conclusion:** These results suggest that a combination of zinc and probiotics have an anti-inflammatory effect as measured by IL-6 and neutrophil levels.

Keywords: cigarette smoke, IL-6, neutrophils, probiotics, zinc

INTRODUCTION

Cigarette smoke emitted from burning cigarettes contains thousands of chemicals such as nicotine, hydrogen cyanide, formaldehyde, arsenic, benzene, carbon monoxide, tobacco-specific nitrosamines (TSNAs), and polycyclic aromatic hydrocarbons (PAHs)

*Corresponding author: Putu Gita Andryani
Biomedical Science, Faculty of Medicine, Diponegoro University, Semarang, Central Java, Indonesia
Tel: (+62) (24) 76928010; Fax: (+62) (24) 76928011; E-mail: andryanigita@gmail.com
doi: https://doi.org/10.31246/mjn-2022-0116

(Oberg *et al.,* 2010). These particulates may cause inflammation and oxidative stress (American Cancer Society, 2021; Padmavathi *et al.,* 2018). There are three types of cigarette smoke inhaled through passive smoking: mainstream smoke, sidestream smoke, or a combination of both (second-hand smoke). Mainstream smoke is smoke exhaled by active smoking, meanwhile sidestream smoke is smoke from the end of the cigarette. Mainstream smoke contains 3-11% carbon monoxide, 15-43% particulates, and 1-9% nicotine. In a previous study, sidestream smoke was reported to be more dangerous than mainstream smoke because it contained two times more nicotine and carbon monoxide, fifteen times more formaldehyde, and was more toxic (Oberg *et al.,* 2010).

Health effects of cigarette smoke includes chronic obstructive pulmonary disease (COPD), hypertension, cardiovascular disease, cancer, low birth weight, and death (Oberg *et al.,* 2010; CDC, 2018). More than 80% of the 1.3 billion people worldwide use tobacco in low- and middle-income countries. Tobacco causes 8 million deaths annually, with over 7 million mortalities due to direct tobacco, whereas 1.2 million is the result of passive smoking being exposed to second-hand smoke (WHO, 2021). According to Riskesdas (2018), the prevalence of cigarette smoking in Indonesia was 28.8%, while the prevalence of cigarette smoking among 10-18 years old was 9.1%, which meant that there was an increase compared to the data in 2013 (7.2%). Generally, smoking behaviour is found to be higher among males (62.9%) aged 15 years or older (Kementerian Kesehatan RI, 2018). More than 57.8% of students in Indonesia are exposed to cigarette smoke at home, 66.2% in closed public areas, and 67.2% in the open public areas (WHO, 2020).

Cigarette smoke may cause oxidative stress, an imbalanced condition between the number of free radicals and antioxidants in our body. Oxidative stress may cause tissue damage and induce an inflammatory response that releases pro-inflammatory cytokines such as tumour necrosis factor (TNF), Interleukin-1 (IL-1), Interleukin-6 (IL-6), granulocyte macrophage-colony stimulating factor (GM-CSF), and monocyte-colony stimulating factor (M-CSF). IL-6 is an acute pro-inflammatory cytokine produced by macrophages and monocytes. The production of IL-6 during acute inflammation triggers a subset of chemokines and adhesion molecules to be activated by the endothelial cells, smooth muscle cells, and fibroblasts, which in turn triggers the recruitment of neutrophils. Neutrophils are predominant phagocyte cells during acute inflammation. They are the first cells to reach the site of infection and the first line of defence. Additionally, it has been demonstrated that IL-6 inhibits neutrophil death, extending the neutrophil's lifespan (Padmavathi *et al.,* 2018; Choy & Rose-John, 2017).

Zinc is a micronutrient that plays a role in cell replication, growth, immune responses, antioxidant, and anti-inflammation. Zinc functions as an anti-inflammatory agent by inhibiting the activation of nuclear factor kappa B (NF-κB) (Prasad & Ananda, 2014). Previous studies have shown that zinc has an anti-inflammatory effect by decreasing leukocyte, IL-6, and TNF-α levels (Anggraeni, Adji & Murwanti., 2015; Utomo *et al.,* 2020). Probiotics, such as *Lactobacillus sp.*, *Bifidobacterium sp.*, *Lactococcus sp.*, *Bacillus sp.*, and yeasts, are live microorganisms that in adequate amounts confer a benefit to human health (Azad *et al.,* 2018). Probiotics act as anti-inflammatory agents by suppressing cytokines production in the intestinal or the extra-intestinal region. Basically, probiotics work in the intestine, but can also affect other systems, such as the respiratory system through the gut-lung axis, and the nervous system via the gut-brain axis. In the respiratory system, when there is an imbalance of microbiota in the gut, known as dysbiosis, it will affect the immunity of the lungs. Contrarily, the respiratory system has its own microbiota, and intestine dysbiosis can result from lung inflammation and vice versa (Luminturahardjo, 2021). This study aimed to investigate the effect of zinc and probiotics supplementation on IL-6 and tissue neutrophil levels in rats exposed to cigarette smoke.

MATERIALS AND METHODS

Figure 1 shows the flow of the experimental study. The study had a randomised design with post-test control groups. Thirty 2 to 3-month-old male Wistar rats, each weighing approximately 180-220 g, were purchased from FMIPA UNNES and divided into five groups (six rats in each group) and were group-housed in cages with a three-day acclimation period. They were maintained under controlled temperature (28-32°C) and light (12/12-hour light/dark cycle). (C) was the control group without treatment; [C (-)] was exposed to cigarette smoke from two cigarettes per day for seven days; (Z) was exposed to cigarette smoke from two cigarettes per day and received 5mg/kg body weight/day zinc for seven days; (P) was exposed to cigarette smoke from two cigarettes per day and received one sachet of probiotics per day for seven days; and (ZP) was exposed to cigarette smoke from two cigarettes per day and received a combination of zinc and probiotics for seven days.

The animals were placed in the chamber with holes on the top and side, and given two cigarettes per day. The full procedure was conducted twice a day (in the morning and afternoon). A cigarette

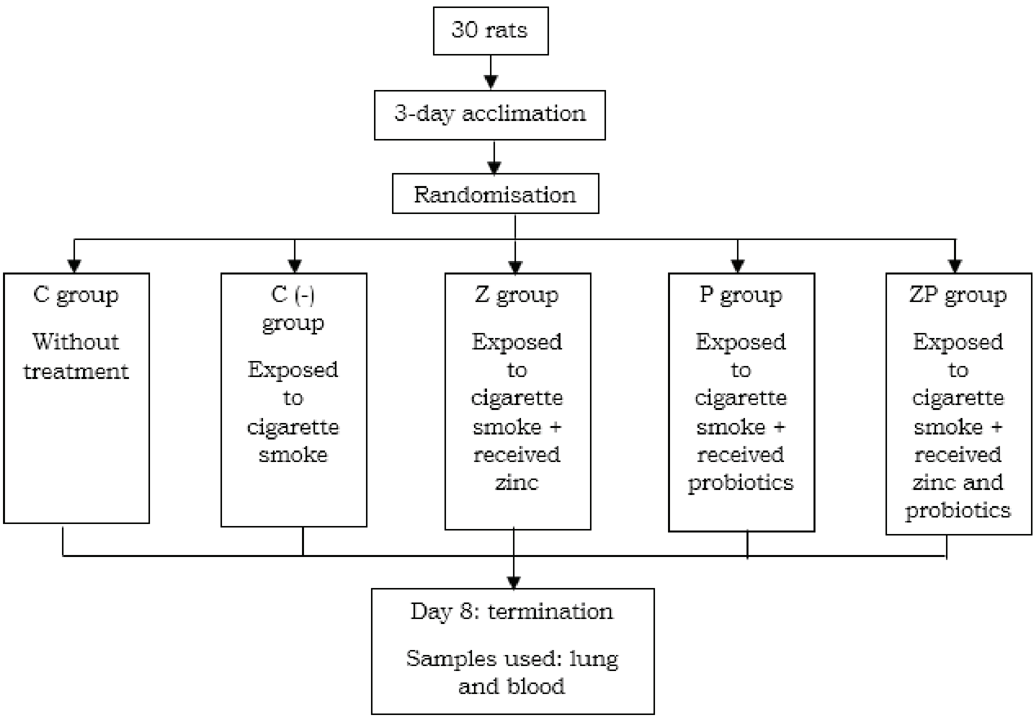


Figure 1. Flow diagram

was aspirated with a syringe and puffs of smoke were expelled into the chamber. Each cigarette took six minutes to burn completely. Our study used zinc sulphate and L-bio probiotics®, which contained *Lactobacillus casei*, *Lactobacillus salivarius*, *Lactobacillus acidophilus*, *Bifidobacterium longum*, *Bifidobacterium lactis*, *Bifidobacterium infantis*, and *Lactococcus lactis* in every sachet ~ ±2.5x10^9 CFU. Zinc sulphate (5mg/kg body weight/day) and probiotics (1 sachet ~ ±2.5x10^9 CFU) were given by oral gavage once daily, 30 minutes before being fed.

On day 8, blood samples were collected by medial canthus sinus orbitalis puncture and put in an ethylenediamine tetraacetic acid (EDTA) tube. The blood samples were centrifuged at 1000 xg for 15 minutes. Plasma IL-6 was measured by the Enzyme-linked immunosorbent assay (ELISA) method using Rat IL-6 ELISA Kit Elabscience®. Absorbance at 450 nm was measured using an ELISA microplate reader (ELx800, BioTek Instruments, USA). Next, the rats were terminated by cervical dislocation and their right lungs collected from all groups. Lung tissue sections (4-μm thick) were fixed and embedded in phosphate-buffered formalin (pH 7.0). Lung sections were stained with haematoxylin and eosin (H&E). Histological examination was done under a microscope to identify neutrophils (magnifications: 400x). All procedures were carried out as approved by the Health Research Ethics Commission (KEPK) of Diponegoro University (Permit number:15/EC/H/FK-UNDIP/III/2022).

Normality testing was completed using Shapiro-Wilk test. One-way analysis of variance (ANOVA), followed by Games-Howell post-hoc test were used for analysis. All statistical analyses were performed using the IBM SPSS Statistics for Windows version 26.0 (IBM corp, Armonk, New York). Results were expressed as mean±standard deviation (*SD*).

RESULTS

IL-6 levels in C, C (-), Z, P, and ZP groups were 5.04, 10.61, 8.69, 9.21, and 6.02 pg/mL, respectively. Statistical analysis showed significant differences in IL-6 levels between the groups (p=0.002). Mean IL-6 level in C (-) group (10.61 pg/mL) was higher than C group (5.04 pg/mL), and it was significantly different (p=0.011). Mean IL-6 levels in Z and P groups were lower than in C (-) group, but no significant differences were detected. Meanwhile, IL-6 level in ZP group was lower and had a significant difference than C (-) group (p=0.022), but almost the same as (C) group (Figure 2).

Mean tissue neutrophil levels in groups C, C (-), Z, P, and ZP were 10,77, 63,97, 43,43, 34,67, and 29,77 cells, respectively. Statistical analysis showed significantly different tissue neutrophil levels between the groups (p<0.001). Tissue neutrophil level in C (-) group was higher and significantly different than in C group. Mean tissue neutrophil levels in Z, P, and ZP groups were lower and significantly different than in C (-) group (Figures 3 & 4).

DISCUSSION

Cigarette smoke releases danger signals, which act as ligands for toll-like receptors (TLR). The binding of ligand to its receptor induces cytokines and chemokines release like IL-6, IL-8, IL-1β, TNF-α, GM-CSF, monocyte chemoattractant protein-1 (MCP-1), and intercellular adhesion molecule 1 (ICAM-1), which cause innate immune response (Yudhawati & Prasetiyo, 2018). Cigarette smoke also activates transcription factor NF-κB through degradation of IκB so that NF-κB translocates into the nucleus. This process causes an increase in the amount of lung

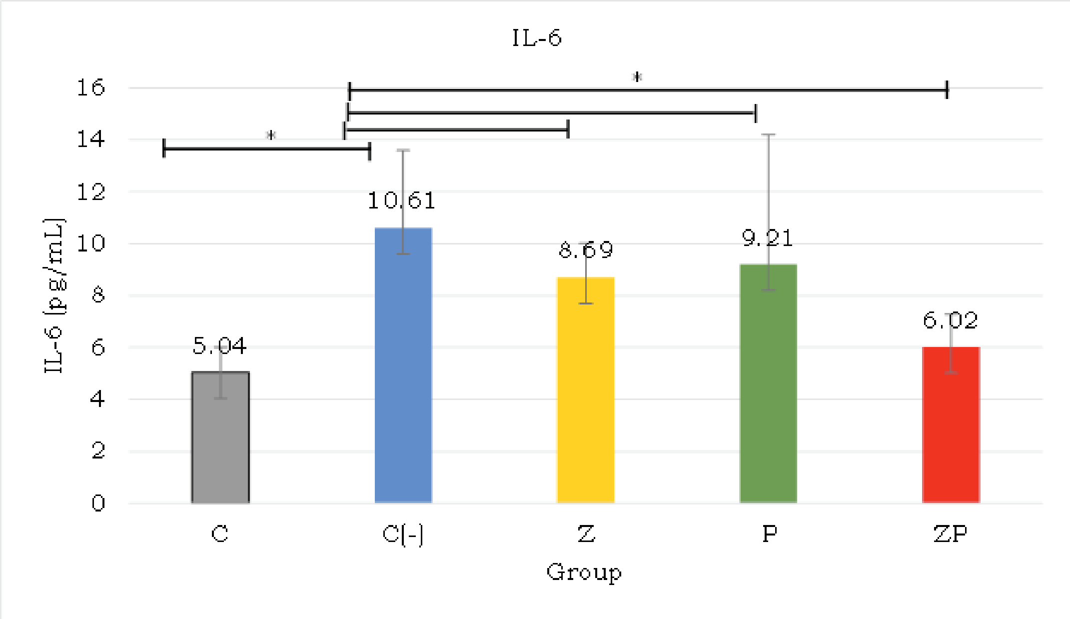


Figure 2. IL-6 levels in different treatment groups; *p<0.05: statistically significant difference

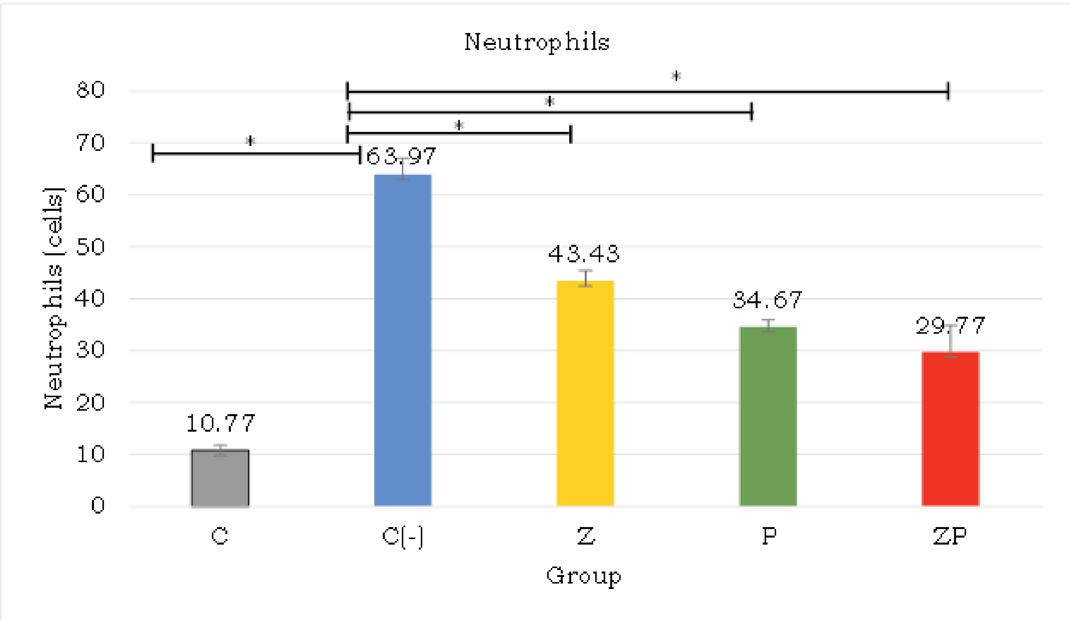


Figure 3. Tissue neutrophil levels in different treatment groups; *p<0.05: statistically significant difference

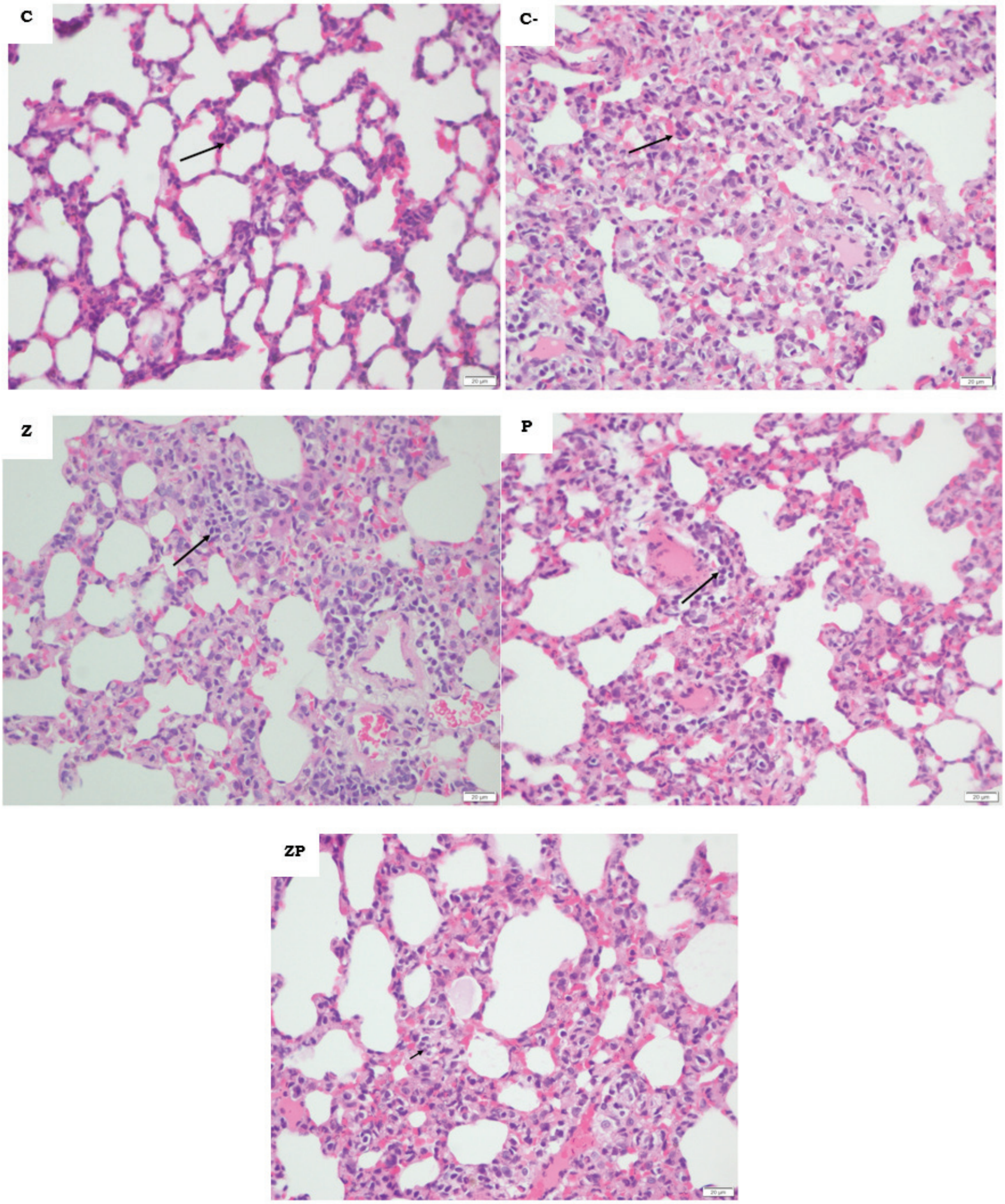


Figure 4. Tissue neutrophils histology. C = control group without treatment; C (-) = exposed to cigarette smoke from two cigarettes per day for seven days; Z = exposed to cigarette smoke from two cigarettes per day and received 5mg/kgbw/day zinc for seven days; P = exposed to cigarette smoke from two cigarettes per day and received one sachet probiotics per day for seven days; ZP = exposed to cigarette smoke from two cigarettes per day and received a combination of zinc and probiotics for seven days. H&E staining was performed on 4 μm sections. Representative images were obtained by a 400x magnification. Black arrow: neutrophils.

and airway macrophages, leading to inflammation (Lu, Gottlieb & Rounds, 2018). Increased tissue neutrophil levels also occur because of released GM-CSF on inflammation. Studies showed that accumulation of neutrophils on cigarette smoke exposure was caused by increase of neutrophil recruitment and suppression of neutrophil apoptosis. Moreover, nicotine and acrolein delay neutrophil spontaneous death by suppressing Akt deactivation (Xu *et al.,* 2013; Heijink *et al.,* 2015). In this study, rats exposed to cigarette smoke [C (-)] showed an increase in the level of IL-6 (10.61 pg/mL) compared to the C group (5.04 pg/mL) (p=0.011). In the lung histology, rat lung sections from C (-) group were presented with an elevation of neutrophils.

Rats exposed to cigarette smoke and receiving zinc (Z group) presented a decrease in IL-6 level (8.69 pg/mL) compared to the C (-) group (10.61 pg/mL) without a significant difference; while tissue neutrophil level in the Z group (43.43 cells) was lower and significantly different than in the C (-) group (63.97 cells). Utomo *et al.* (2020) reported that zinc supplementation is a cytokine regulator, showing that zinc can decrease pro-inflammatory cytokines like IL-6 and TNF-α. The mechanism of zinc decreasing IL-6 levels is by increasing the expression of A20, an anti-inflammatory protein and peroxisome proliferator-activated receptor α (PPAR-α), a mediator involved in lipid metabolism, inflammation, and glucose homeostasis. Furthermore, zinc inhibits IKKβ kinase activity, keeps sequestering NF-κB in the cytoplasm, and inhibits inflammation (Gammoh & Rink, 2017). Anggraeni *et al.* (2015) reported that topical zinc can decrease leukocyte levels in incision wounds. It showed that zinc plays a role in wound healing as a zinc-dependent matrix metalloproteinases cofactor, which may reduce the risk of infection (Anggraeni *et al.,* 2015). Cahiadewi, Santosa & Suprihati (2016) also reported that zinc supplementation can decrease lung eosinophil numbers in ovalbumin-sensitised mice via intraperitoneal injection and inhalation. Zinc deficiency impairs neutrophil's ability to phagocyte, increases NETs release, and increases neutrophil degranulation. A previous study showed that zinc decreased NETs release through inhibiting citrullination of histone H3 (Kuzmicka *et al.,* 2021). Zinc may also contribute to maintaining the integrity of the membrane and acts as a cytoprotective and anti-apoptotic agent (Liu *et al.,* 2022).

The group exposed to cigarette smoke and received probiotics (P) showed a decrease in IL-6 level (7.31 pg/mL) compared to C (-) group (5.04 pg/mL) with no significant difference. This may be because the 7th day was still the peak time of IL-6 in inflammation (Wang *et al.,* 2010). However, tissue neutrophils level in the P group (34.67 cells) was lower and significantly different than in the C (-) group (63.97 cells). Several studies reported that probiotics strains could modulate immune response through metabolite compounds that produce antimicrobial agents or short-chain fatty acids (SCFAs), such as butyrate, acetate, and propionate, which play a role as immunomodulators in the intestines. Butyrate stimulates anti-inflammatory signalling through GPR109A on colonic macrophages and dendritic cells to induce IL-10 production. Butyrate also stimulates T cells differentiation to T effectors. This mechanism not only affects the intestinal system, but also the respiratory system via the gut-lung axis (Dang & Marsland, 2019). Target sites of probiotics affect NF-κB. *Lactobacillus casei* could inhibit degradation of IκB; while *Bifidobacterium* *lactis* could inhibit degradation of IκB and activation of NF-κB (Bhardwaj *et al.,* 2020). *Bifidobacterium longum* was reported to decrease pro-inflammatory response by decreasing neutrophils recruitment and accumulation in rat lungs induced by *Klebsiella pneumonia* (Lajqi *et al.,* 2020). Another study showed that probiotics contained in Prato cheese – *Lactococcus lactis* and *Lactobacillus casei 01* decreased total leukocytes in the bronchoalveolar lavage (BAL) of rats exposed to cigarette smoke from 12 cigarettes per day compared to the control group and the group which received conventional cheese containing *Lactococcus lactis* only (Vasconcelos *et al.,* 2019).

Rats exposed to cigarette smoke and receiving zinc and probiotics (ZP group) presented a decrease in IL-6 level (6.02 pg/mL) compared to C (-) group (10.61 pg/mL), with a significant difference (p=0.022), though its level was almost the same as in (C) group (5.04 pg/mL). Tissue neutrophils level in the ZP group (29.77 cells) was lower and significantly different than in the C (-) group (63.97 cells). Park *et al.* (2018) reported that a combination of probiotics complex, rosavin, zinc, and prebiotics could decrease TNF-α, IL-6, IL-1β, and IL-17 levels. Therefore, a combination of zinc and probiotics could decrease pro-inflammatory cytokines like IL-6. *Lactobacillus* and *Bifidobacterium* are the most common strains of probiotics. *Lactobacillus acidophilus* has been known to reduce STAT3 and phosphorylated STAT3 in mice induced with colitis. Furthermore, *Lactobacillus casei* and *Bifidobacterium lactis* could repair mucosal and liver injuries on colitis in rats (Park *et al.,* 2018). Previous studies showed that probiotics could decrease inflammatory response in Crohn's disease and food allergy by increasing anti-inflammatory cytokines and decreasing pro-inflammatory cytokines; while zinc supplementation in tuberculosis patients could increase their nutritional status, haemoglobin level, and plasma zinc, and also increase immunity in human immunodeficiency virus (HIV) patients. A combination between zinc and probiotics increases the immune system by increasing lymphocyte levels and decreasing levels of monocytes and neutrophil-to-lymphocyte ratio (NLR) (Widiastuti, Darmono & Sofro, 2019; Setiyaningrum, Darmono & Sofro, 2016). Another study showed that the combination of zinc and probiotics was more effective in resolving diarrhoea in children under five years old than in children who received zinc supplementation only (Surono *et al.,* 2014). Therefore, the combination of zinc and probiotics has a synergistic effect (Park *et al.,* 2018).

CONCLUSION

The repeated consumption of a combination between zinc and probiotics in rats exposed to cigarette smoke was able to reduce inflammatory responses, as indicated by decreased IL-6 and tissue neutrophil levels.

Authors' contributions

Putu GA, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and led the data collection; Endang M, advised on the data analysis and interpretation, and reviewed the manuscript; Kusmiyati T, reviewed the manuscript; Yan WP, reviewed the manuscript; Neni S, reviewed the manuscript; Hermawan I, conducted data analysis and interpretation.

Acknowledgement

We thank the animal laboratory, GAKY laboratory, and pathology anatomy laboratory for providing animals, reagents, and histopathological analysis in this study.

Conflict of interest

Authors declare no conflict of interest.

References

Anggraeni D, Adji D & Murwanti R (2015). Kesembuhan luka setelah pemberian topikal zink pada tikus dengan pakan lemak tinggi. *Jurnal Kedokteran Hewan* 9(2):105–108.

Azad M, Kalam A, Sarker M & Wan D (2018). Immunomodulatory effects of probiotics on cytokine profiles. *Biomed Res Int* 2018(8063647:1–10.

Bhardwaj R, Singh BP, Sandhu N, Singh N, Kaur R, Rokana N, Singh KS, Chaudhary V & Panwar H (2020). Probiotic mediated nf κb regulation for prospective management of type 2 diabetes. *Mol Biol Rep* 47(March):2301–2313.

Cahiadewi A, Santosa YI & Suprihati S (2016). Pengaruh suplementasi zink terhadap jumlah eosinofil pada jaringan paru penderita alergi: studi eksperimental pada mencit balb/c dengan sensitisasi ovalbumin. *JKD* 5(4):265–274.

CDC (2018). Health effects of secondhand smoke. *Centers for Disease Control.* From https://www.cdc.gov/tobacco/secondhand-smoke/health.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Ftobacco%2Fdata_statistics%2Ffact_sheets%2Fsecondhand_smoke%2Fhealth_effects%2Findex.htm. [Retrieved May 12 2021].

Choy E & Rose-John S (2017). Interleukin-6 as a multifunctional regulator: Inflamation, immune response, and fibrosis. *J Scleroderma Relat Disord* 2(Suppl 2):S1–S5.

Dang AT & Marsland BJ (2019). Microbes, metabolites, and the gut–lung axis. *Mucosal Immunol* 12(4):843–850.

Gammoh NZ & Rink L (2017). Zinc in infection and inflammation. *Nutrients* 9(624):1–25.

Heijink IH, Pouwels SD, Leijendekker C, Bruin HG, Zijlstra GJ, Vaart H, Hacken NHT, Oosterhout AJM, Nawijn MC & Toorn M (2015). Cigarette smoke–induced damage-associated molecular pattern release from necrotic neutrophils triggers proinflammatory mediator release. *Am J Respir Cell Mol Biol* 52(5):554–562.

Kuzmicka W, Manda-Handzlik A, Cieloch A, Mroczek A, Demkow U, Wachowska M & Ciepiela O (2021). Zinc supplementation modulates nets release and neutrophils' degranulation. *Nutrients* 13(51):1–13.

Lajqi T, Poschl J, Frommhold D & Hudalla H (2020). The role of microbiota in neutrophil regulation and adaptation in newborns. *Front Immunol 11(Article 568865):*1–10.

Liu X, Ali MK, Dua K & Xu R (2022). The role of zinc in the pathogenesis of lung disease. *Nutrients* 14(2115):1–14.

Lu Q, Gottlieb E & Rounds S (2018). Effects of cigarette smoke on pulmonary endothelial cells. *Am J Physiol Lung Cell Mol Physiol* 314:L743-756.

Luminturahardjo W (2021). Peranan probiotik dalam penanganan infeksi COVID-19. *Cermin Dunia Kedokteran* 48(5):273–278.

Oberg M, Jaakkola MS, Pruss-Ustun A, Schweizer C & Woodward A (2010). Second hand smoke: Assessing the enviromental burden of disease at national and local levels. World Health Organization.

Padmavathi P, Raghu PS, Reddy VD, Bulle S, Marthadu SB, Maturu P & Varadacharyulu NC (2018). Chronic cigarette smoking-induced oxidative/nitrosative stress in human erythrocytes and platelets. *Mol Cell Toxicol* 14(1):27–34.

Park JS, Choi J, Kwon JY, Jung KA, Yang CW, Park SH & Cho ML (2018). A probiotic complex, rosavin, zinc, and prebiotics ameliorate intestinal inflammation in an acute colitis mouse model. *J Transl Med* 16(1):1–10.

Prasad & Ananda S (2014). Zinc is an antioxidant and anti-inflammatory agent: its role in human health. *Frontiers in Nutrition* 1(Article 14):1–10.

Kementerian Kesehatan RI (2018). *Hasil utama riskesdas 2018*. Kementerian Kesehatan RI, Jakarta.

Setiyaningrum Z, Darmono SS & Sofro MAU (2016). Effect of combined probiotics and zinc supplementation on immune status of pulmonary tuberculosis patients. *Pak J Nutr* 15(7):680–685.

Surono IS, Martono PD, Kameo S, Suradji EW & Koyama H (2014). Effect of probiotic L. plantarum IS-10506 and zinc supplementation on humoral immune response and zinc status of Indonesian pre-school children. *J Trace Elem Med Biol* 28(4):465-9.

American Cancer Society (2021). *Harmful chemicals in tobacco products. American Cancer Society.* From https://www.cancer.org/content/dam/CRC/PDF/Public/8344.00.pdf. [Retrieved May 12 2021].

WHO (2020). *In: Global Youth Tobacco Survey*: *Lembar informasi indonesia 2019*. From https://www.who.int/docs/default-source/searo/indonesia/indonesia-gyts-2019-factsheet-(ages-13-15)-(final)-indonesian-final.pdf?sfvrsn=b99e597b_2. [Retrieved June 15 2021].

Utomo MT, Sudarmo SM & Sudiana K (2020). Zinc supplementation in cytokine regulation during lps-induced sepsis in rodent. *J Int Dent Medical Res* 13(1):46–50.

Vasconcelos FM, Silva HLA, Poso SMV, Barroso MV, Lanzetti M, Rocha RS, Graca JS, Esmerino EA, Freitas MQ, Silva MC, Raices RSL, Granato D, Pimentel TC, Sant'ana AS, Cruz AG & Valenca SS (2019). Probiotic prato cheese attenuates cigarette smoke-induced injuries in mice. *Food Res Int* 123(2019):697–703.

Wang K, Yuan CP, Wang W, Yang ZQ, Cui W, Mu LZ, Yue ZP, Yin XL, Hu ZM & Liu JX (2010). Expression of interleukin 6 in brain and colon of rats with TNBS-induced colitis. *World J Gastroenterol* 16(18):2252–9.

WHO (2021). *In: Tobacco.* Word Health Organization. From https://www.who.int/news-room/fact-sheets/detail/tobacco. [Retrieved May 12 2021].

Widiastuti Y, Darmono SS & Sofro MA (2019). Pengaruh supplementasi probiotik dan selenium terhadap respon imun NLR (Neutrophil Lymphocyte Count Ratio), haemoglobin dan albumin pada tikus wistar yang diinduksi Mycobacterium tuberculosis. *J Nutr College* 8(1):38–48.

Xu Y, Li H, Bajrami B, Kwak H, Cao S, Liu P, Zhou J, Zhou Y, Zhu H, Ye K & Luo HR (2013). Cigarette smoke (cs) and nicotine delay neutrophil spontaneous death via suppressing production of diphosphoinositol pentakisphosphate. proceedings of the national academy of sciences. *Proc Natl Acad Sci* 110(19):7726–7731.

Yudhawati R & Prasetiyo YD (2018). Imunopatogenesis penyakit paru obstruktif kronik. *Jurnal Respirasi* 360(23):19–25.

Mal J Nutr 29(2): 343-354, 2023

Assessment of skipping breakfast at home among adolescent school students in Badia Region, Jordan

Amani Masalha[1], **Mohammad S ALBashtawy**[2], **Mohammad N Alshloul**[3], **Nisren Abu Baker**[4], **Shereen Hamadneh**[2], **Abdullah Alkhawaldeh**[2], **Mohammed S Alyahya**[5], **Ma'en Aljezawi**[2], **Asem Abdalrahim**[2], **Mohammad Suliman**[2] **& Doha M Alshloul**[5]

[1]*Mafraq Health Directorate, Ministry of Health, Jordan;* [2]*Department of Community and Mental Health, Princess Salma, Faculty of Nursing, Al al-Bayt University, Jordan;* [3]*Irbid National University, Faculty of Nursing, Irbid-Jordan;* [4]*Department of Community and Mental Health, Faculty of Nursing, Jordan University of Science & Technology, Irbid, Jordan;* [5]*Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan*

ABSTRACT

Introduction: Healthy meals play an essential role in the healthy physical and mental development of adolescents. Breakfast at home is associated with improved nutritional choices, and skipping breakfast is detrimental. This study assessed prevalence of skipping breakfast at home among adolescent students in the Badia Region of Jordan, identifying the reasons and characteristics associated with such behavioural choice. **Methods:** A cross-sectional survey among adolescent students (aged 13-16 years, in 8^{th}-9^{th} grades) from six public schools in Badia Region, Mafraq Governorate, Jordan, was conducted through self-administered questionnaire from February to March 2022. **Results:** Results showed that 68.1% of 552 student participants regularly skipped breakfast at home (72.4% boys vs. 61.3% girls; p=0.007). Among those who regularly skipped breakfast, three main rationales for this choice were not feeling hungry (5.3%), lack of time (2.7%), and lack of appetite (3.5%). **Conclusion:** The prevalence of skipping breakfast at home among adolescents in Badia Region was high for various reasons, including lack of time, not feeling hungry, seeking to manage weight, and insufficient knowledge on the importance of healthy breakfast. Therefore, understanding the reasons and factors that contribute towards breakfast skipping may help in solving the problem, underscoring that positive beliefs should be reinforced in schools, with parents encouraging adolescents to eat healthy breakfast.

Keywords: adolescence, Badia region, breakfast consumption, Jordan, skipping breakfast

INTRODUCTION

Healthy food, including the behaviour related to eating, as well as nutritional content, is essential for the human body to perform its biological and physical operations with optimal efficiency. It is essential for growth and development, and for meeting the requirements of daily life (Gómez-Pinilla, 2008). Healthy eating encompasses many nutritional, personal, and socio-cultural considerations pertaining to the type of

*Corresponding author: Dr Mohammad N Alshloul, RN, Ph.D.
Associate Professor, Irbid National University, Faculty of Nursing, Irbid-Jordan
Tel:+962-781874521; E-mail: alshloulm@gmail.com
ORCID: https://orcid.org/0000-0001-9448-9369
doi: https://doi.org/10.31246/mjn-2022-0121

food per se (e.g., its nutritional content and methods of preparation), amount, timing, and quality. The global norm is that people should typically eat three meals a day – breakfast, lunch, and dinner (Paoli *et al.*, 2019). Breakfast is considered particularly essential because it provides the body with the necessary energy to perform the physical and mental activities undertaken throughout the remainder of the day, until repose during the night when the body can repair and recover. Breakfast is also particularly instrumental in regulating appetite and reducing the risk of type 2 diabetes (Alhilabi & Payne, 2018).

Breakfast at home (B@H) typically provides the best nutritional, physiological and social contexts for morning eating, and it should not be skipped, particularly among adolescents, who in addition to basic physiological benefits can attain improved mental performance from an appropriate and healthy breakfast (O'Sullivan *et al.*, 2009). Studies have documented that skipping breakfast is a common nutritional problem among adolescents (Ali *et al.*, 2019). Most studies related to skipping breakfast showed an increase in its prevalence among children (aged under 18 years) and an association with increased rates of obesity and weight gain (up to 30.0%). Physiological impacts of breakfast-skipping can be profound, including increased risk of heart disease, as well as broader negative psychological associations (Bonnet *et al.*, 2020). Ardeshirlarijani *et al.* (2019) reviewed related literature and found that breakfast-skipping is particularly notable among adolescents, especially among girls, in which context is related to body image issues. Furthermore, they reported that five studies identified poor quality food intake and increased metabolic syndrome for those who skipped breakfast.

This study focused on assessing the prevalence of skipping B@H among adolescent school students in the Badia Region of Mafraq Governorate in Jordan, drawing attention to the nutritional health issues of these students and their behavioural choices. A healthy breakfast for school children in adolescence provides the essential nutrients needed for their activities and is associated with improving the general nutritional status of the individual (ALBashtawy, 2017). A large percentage of adolescents who live in Jordan have poor eating habits and continuing these habits may increase their risk of chronic diseases during adolescence and later in life. Students' breakfast-skipping is associated with several health problems and can interfere with daily life through impaired psychosocial and cognitive functions, reduced academic achievement, and poorer school attendance (ALBashtawy, 2015; Moller *et al.*, 2021).

The results of this study have important implications on health promotion and disease prevention programmes for this target group. Discovery of the reasons for skipping B@H in an adolescent group can reveal new evidence or provide additional support to existing evidence, which can be used to promote healthy nutritional status of adolescent students and improve their breakfast intake (Abu-Mweis *et al.*, 2014). Those who have regular healthy, balanced breakfasts tend to get more fibre and dairy in their diets, which leads to less overeating and fewer unhealthy snacks throughout the day. Furthermore, those who eat breakfast at home are more likely to achieve such benefits, including in terms of improving cognitive performance, getting essential nutrients, keeping cravings under control, avoiding overweight and obesity, improving muscle gain and development, healthier skin, stabilising blood glucose, and cardiac protection (Bonnet *et al.*, 2020). Accordingly, pressure is increasing on the Jordanian government and the Ministry of Health to pay attention to the nutritional health issues of students at this stage. In the Badia Region, few studies have focused on the consumption of B@H. Therefore, this study aimed to identify the prevalence and reasons for skipping B@H, and to examine its associations with socio-demographic characteristics of adolescent school students in the Badia Region, Jordan.

MATERIALS AND METHODS

Study design

A cross-sectional descriptive design was used. The study was conducted among adolescent students aged 13-16 years from six public schools in Jordan's Northeastern Badia Region (which constitutes 25,930 km^2 or 35.7% of the total area of the region).

Setting and sample

The schools in the Directorate of Education for Northeastern Badia are distributed through four sub-regions: Umm Al-Jamal, Subha, Umm Al-Qattin, and Deir Al-Kahf. A sub-region, Umm Al-Jamal, was randomly selected. This sub-region had 42 schools and 7,025 male and female students, according to the official statistics of the Governorate of Mafraq (2021). Eighth and ninth graders (aged 13-16 years) were selected as the sample, numbering 1,258 pupils (Governorate of Mafraq, 2021). Six public schools (three females and three males) in three different areas of Umm Al-Jamal were randomly selected, targeting 590 students overall.

To determine the minimum sample size, the following formula was used:

$$n = N * X / (X + N - 1)$$

where $X = Z\alpha/22 * p * (1-p)/\text{MOE}^2$, $Z\alpha/2$ is the critical value of the normal distribution at $\alpha/2$, MOE is the margin of error at 5%, p is the expected prevalence of breakfast consumption among students aged 13-16 years (0.5%), and N is the population size (Daniel, 1999).

According to the formula, the minimum size sample was 233. However, to overcome the problems of attrition and incomplete questionnaires, a larger sample of students (*n*=590) was taken as a precaution. The final sample size in the study (after dropout and loss to follow-up etc.) was 552. Thus, the number added to the minimum sample was 319.

Inclusion and exclusion criteria

All male and female adolescent students in the 8^{th}-9^{th} grades (aged 13–16 years) from the selected schools were included, while students in other grades and students or their families who preferred not to participate in the study were excluded.

Definitions

Conceptually, 'breakfast' is the first meal of the day that breaks the fast after the longest period of sleep, being consumed within three hours of waking, and comprising food or beverages from at least one food group (Deshmukh-Taskar *et al.*, 2010). In itself, it may be consumed at any location (O'Neil, 2014), but it is generally considered to be the 'most important meal of the day', both popularly and among physiologists (Frank, 2009). Skipping B@H intrinsically referred to not consuming a morning meal in the home, and a 'breakfast skipper' was operationally defined as 'a subject who did not eat breakfast at home on four or more days a week' (Frank, 2009).

Measurement and data collection

Data collection took place in the second semester of 2022, from the second to the fourth week of February. After receiving all approvals to conduct the study, we visited the principals of the selected schools to explain the purpose, method, and procedures of data collection. After obtaining the principals' approval, the 8^{th}-9^{th} grade classes were recruited and the purpose of the study and its importance were explained to the students.

The study tool was developed based on a comprehensive review of the literature regarding breakfast consumption among school students of different age groups (ALBashtawy, 2015; ALBashtawy, 2017; Kubik *et al.*, 2009;). It was subjected to linguistic validation, to ensure that the questions were translated reliably. To achieve this, experts in both languages translated the questionnaire into Arabic, and another person back-translated the Arabic version into English; and the secondary English translation was found to be valid in comparison to the original. The final version of the questionnaire was checked for face validity by an expert panel of researchers at the study places. The Cronbach's alpha coefficient for the study instrument was found to be 0.734, indicating high internal consistency and reliability.

After developing the questionnaire and preparing it in its initial version, it was presented to research experts to check its content and to ensure the accuracy of the questionnaire. The questionnaire was then distributed to 19 school students of the same age as the target sample of the study, as a convenient sample, to determine the validity of the questionnaire from their perspective in terms of selected questions, the time required to fill out the questionnaire, and unclear questions or phrases.

The questionnaire consisted of four sections. The first section contained questions about socio-demographic data including school, gender, grade, age, mother's education, residential arrangements (i.e., parents or grandparents living in the home), mother's employment, and household income. The second section contained questions that covered personal characteristics, including 'yes' or 'no' questions about days and places of eating breakfast, and three multiple-choice questions on the components of a meal, who prepares it, and with whom the participant ate it. The last section consisted of questions exploring the reasons for skipping breakfast, comprising nine 'yes' or 'no' questions, and one open-ended question, enabling participants to express any reasons not listed in the available options.

Data analysis

IBM SPSS Statistics for Windows version 26.0 (IBM Corporation, Armonk, New York, USA) was used to analyse the collected data. Shapiro-Wilk test was used, as it is the most powerful testing tool when testing for a normal distribution. Descriptive analysis, including mean and standard deviation values, were used to analyse continuous dependent and independent variables. Frequency distributions were used to analyse categorical variables and chi-square test was used to compare the differences between the variables of skipping B@H. To estimate the relationship between two dependent variables, binary logistic regression was used, with a statistical significance of $p<0.05$.

Ethical considerations

Ethical approval to conduct this study was obtained from the Scientific Research and Ethics Committee of the College of Nursing, Al al-Bayt University (IRB #2/2022). Permission was also obtained from the Directorate of Education of Northeastern Badia to conduct the study in selected schools. Principals of the selected schools also gave their consent and facilitation. As the study included participants aged under 18 years, written informed consent was obtained from the students and their parents/ guardians prior to conducting any data collection. The investigator ensured that the relevant protocols were followed, taking into account informed consent, autonomy, anonymity, and confidentiality issues. The confidentiality and anonymity of the information were guaranteed. Furthermore, the demographic questionnaire was coded with numbers to keep the data confidential and to anonymise all responses.

RESULTS

Socio-demographic characteristics

A total of 552 adolescent students from six public schools in the Jordanian Badia Region participated in the study. The majority were males (61.6%), more than half were from the 9th grade (51.6%), in the age group of 15-16 years (52.0%) (with the remainder aged under 15 years), with a mean age of 14.5±0.53 years. Regarding living status, the vast majority of participants (99.5%) lived with their parents and did not have sufficient monthly income (75.7%). Moreover, most of their mothers did not work outside the home (*n*=473, 85.7%) and 348 (63.0%) were uneducated. The majority of the students reported skipping B@H on four or more days per week (*n*=376, 68.1%), while less than a third (*n*=176, 31.9%) consistently had

Table 1. Socio-demographic distribution of school students by gender (*N*=552)

Variables	*Male*		*Female*		*Total*	
	n	*%*	*n*	*%*	*n*	*%*
Class						
8th grade	162	47.6	105	49.5	267	48.4
9th grade	178	52.4	107	50.5	285	51.6
Age in years						
13-14	162	47.6	103	48.6	265	48.0
15-16	178	52.4	109	51.4	287	52.0
Residential status (living with…)						
Parents	340	100.0	209	98.6	549	99.5
Mother	0	0.0	1	0.5	1	0.2
Grandparents	0	0.0	2	0.9	2	0.4
Work of mother						
Full time	7	2.1	7	3.3	14	2.5
Part-time	43	12.6	22	10.4	65	11.8
Housewife	290	85.3	183	86.3	473	85.7
Income						
Not sufficient	273	80.2	145	68.4	418	75.7
Sufficient	59	17.4	62	29.2	121	21.9
Sufficient and saving	8	2.4	5	2.4	13	2.4
Education of mother						
Not educated	211	62.1	137	64.6	348	63.0
Secondary and lower	98	28.8	56	26.4	154	27.9
More than secondary	31	9.1	19	9.0	50	9.1
Skipping breakfast 4+ days per week						
No	94	27.6	82	38.7	176	31.9
Yes	246	72.4	130	61.3	376	68.1

B@H before school. Table 1 summarises the socio-demographic characteristics of the study sample.

Comparison of socio-demographic characteristics and skipping B@H

As shown in Table 2, gender was significantly associated with breakfast skipping; more boys skipped their breakfast than girls (72.4% vs. 61.3%, p=0.007), indicating increased risk of breakfast skipping among males. However, age, class, residential arrangements, household income, mother's work, and mother's education were not significantly associated with breakfast skipping behaviour.

Associations between students' breakfast food type and gender

Participants were asked about their consumption of typical Jordanian breakfast foods. Table 3 shows that eating hummus and falafel were significantly associated with gender ($\chi^2(1)$=5.995, p=0.014), reflecting that female students were 1.70 times more likely to eat these than male students. Similarly, having tea at breakfast was significantly associated with gender

Table 2. Comparison of socio-demographic characteristics and skipping breakfast B@H

Socio-demographic characteristics	*Breakfast skipping 4+ days per week n (%)*		χ^2	*p*
	Yes	*No*		
Gender				
Male	246 (72.4)	94 (27.6)	7.318	0.007[a]
Female	130 (61.3)	82 (38.7)		
Age in years				
13-14	174 (65.7)	91 (34.3)	1.415	0.234[a]
15-16	202 (70.4)	85 (29.6)		
Class				
8th grade	174 (65.2)	93 (34.8)	2.069	0.150[a]
9th grade	202 (70.9)	83 (29.1)		
Residential status (living with…)				
Parents	375 (68.3)	174 (31.7)	2.645	0.240[b]
Mothers	0 (0.0)	1 (100.0)		
Father	0 (0.0)	0 (0.0)		
Grandparent	1 (50.0)	1 (50.0)		
Mother's work				
Full time	11 (78.6)	3 (21.4)	0.846	0.679[b]
Part-time	46 (70.8)	19 (29.2)		
Housekeeper	319 (67.4)	154 (32.6)		
Household income				
Not sufficient	291 (69.6)	127 (30.4)	1.95	0.364[b]
Sufficient	77 (63.6)	44 (36.4)		
Sufficient and saving	8 (61.5)	5 (38.5)		
Mother's education				
Not educated	232 (66.7)	116 (33.3)	1.572	0.461[b]
Secondary and lower	111 (72.1)	43 (27.9)		
More than secondary	33 (66.0)	17 (34.0)		

[a]Pearson's chi-square test was conducted and considered statistically significant at p<0.05.
[b]Fisher's Exact Test was conducted and considered statistically significant at p<0.05.

Table 3. Associations between students' breakfast food type and gender

Food type	*Gender, n (%)*		χ^2 *p-value*	*Odds ratio*	*95 % CI*	
	Male	*Female*			*Lower*	*Upper*
Bread and cheese						
Yes	264 (77.6)	166 (78.3)	0.033	0.963	0.636	1.457
No	76 (22.4)	46 (21.7)	0.857[a]			
Hummus and falafel						
Yes	250 (73.5)	175 (82.5)	5.995	0.587	0.383	0.902
No	90 (26.5)	37 (17.5)	0.014[a]			
Oil and thyme						
Yes	263 (77.4)	147 (69.3)	4.388	1.51	1.026	2.224
No	77 (22.6)	65 (30.7)	0.036[a]			
Tea						
Yes	235 (69.1)	163 (76.9)	3.918	0.673	0.454	0.997
No	105 (30.9)	49 (23.1)	0.048[a]			
Chips and chocolate						
Yes	227 (66.8)	145 (68.4)	0.158	0.928	0.643	1.34
No	113 (33.2)	67 (31.6)	0.691[a]			

[a]Pearson's chi-square test was conducted and considered statistically significant at $p<0.05$.

($\chi^2(1)=3.918$, $p=0.048$), revealing that girls were more likely to drink the infusion than boys. Conversely, eating oil and thyme were significantly associated with gender ($\chi^2(1)=4.388$, $p=0.036$), but in this case, boys ($OR=1.51$) were more likely to eat these than girls. Eating bread and cheese or chips and chocolate were not significantly associated with gender ($p>0.05$).

Binary logistic regression on predictors for skipping B@H by gender

Binary logistic regression was conducted to predict the contribution of the most frequent reasons for skipping B@H by gender. Table 4 shows that boys who claimed that they were not hungry, had no time, or had no appetite, were 5.3, 2.7, and 3.5 times more likely to skip their breakfast, respectively. In contrast, not having time to prepare breakfast was not a statistically significant predictor of breakfast skipping ($p=0.863$) and managing body weight was not a statistically significant predictor of girls' skipping B@H ($p=0.225$).

Reasons for skipping B@H

Several reasons for skipping B@H were investigated. The results in Figure 1 showed that the top four reasons were,

Table 4. Binary logistic regression results of factors associated with breakfast skipping

Predictors	*B*	*Wald*	*EXP (B)*	*p*
Model 1: Male students				
Not feeling hungry	1.662	22.075	5.268	<0.001
Having no time	0.976	7.024	2.654	0.008
Having no appetite	1.253	8.437	3.50	0.004
No time to prepare	-0.095	0.03	0.909	0.863
Model 2: Female students				
To manage body weight	0.397	1.469	1.487	0.225

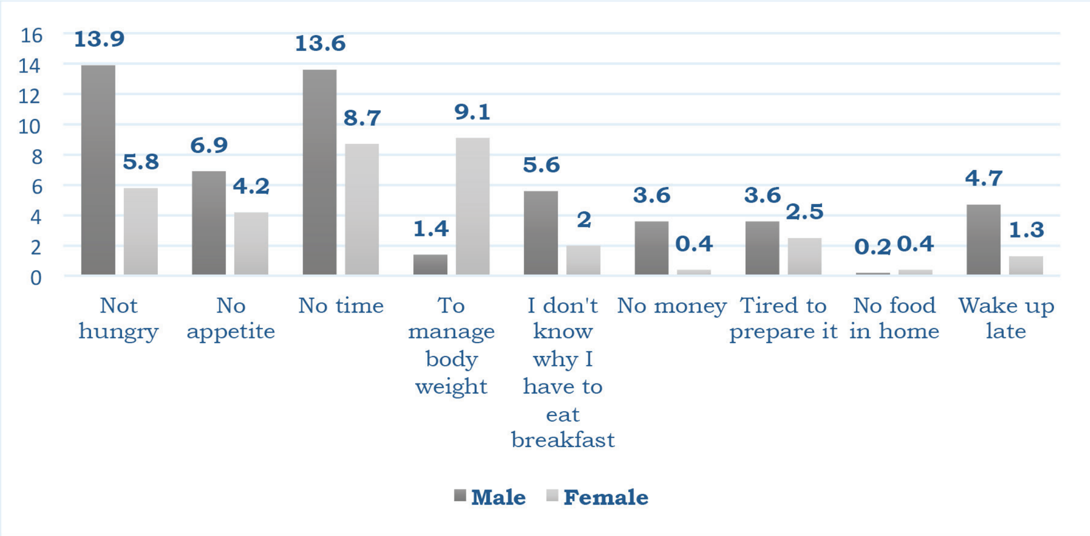


Figure 1. Reasons for skipping breakfast at home

comparing males and females, not feeling hungry (13.9% vs. 5.8%), had no time to eat (13.6% vs. 8.7%), had no appetite (6.9% vs. 4.2%), and no time to prepare it (6.9% vs. 2.5%). On the other hand, the main reason for females skipping breakfast compared to males was to manage body weight (9.1% vs. 1.4%).

DISCUSSION

This study found that 68.1% of participants skipped B@H four or more times per week, which is consistent with the findings of other studies (Abd El-Shaheed *et al.*, 2019; Al-Hazzaa *et al.*, 2020; Badrasawi, Anabtawi & Al-Zain, 2021). This number is considered high compared to other studies conducted among adolescents in Jordan, which reported just over a third (34.5%) regularly skipping breakfast (Abu-Mweis *et al.*, 2014; Ali *et al.*, 2019). The apparent differences between these results may be due to differences in the target study areas and practical definitions of skipping breakfast, the different age groups studied by the researchers, and a variety of research designs.

In the current study, skipping B@H was found to be more common among males than females, consistent with some other studies (Hu *et al.*, 2020; Yahia *et al.*, 2008), but differing from others which found that skipping breakfast was more common among females (ALBashtawy, 2015; Keski-Rahkonen *et al.*, 2003). It should be noted that some studies reported no significant difference by gender (Abu-Mweis *et al.*, 2014; Smith *et al.*, 2017; Yamamoto *et al.*, 2021). In the context of this study, higher breakfast skipping behaviour among males may be attributable to more autonomous behaviour among adolescent males and distorted views on nutritional status and requirements, shaped by peer group pressure, tradition, and living environments (ALBashtawy, 2017). This study found no relationship between income level and skipping breakfast, in contrast with other studies (Badrasawi *et al.*, 2021; Lobstein *et al.*, 2004), which found an association between high income and skipping breakfast.

The study found that those who ate B@H commonly ate various forms of traditional mezze (including flatbread with cheese, falafel, hummus, and oil and thyme), and most preferred to drink tea with the meal (72.1%). However, the majority also reported regularly eating unhealthy breakfast, including chips and chocolate (67.4%). Most of the students' breakfast were prepared by their mothers. A study conducted in Jeddah (Saudi Arabia) reported that 41.0% of school children ate mezze with hard cheese, and 4.0-7.0% consumed bread with "labneh" (a soft cheese) or thyme, and 80.0% of breakfast were prepared by parents (Al-Hazzaa *et al.*, 2020). In an online survey conducted in Palestine with a sample of 193 students aged 12 to 14 years, it was found that 53.0% commonly consumed mezze (bread with cheese, labneh, thyme, and sausage), which was prepared by mothers in 74.8% of cases (Badrasawi *et al.*, 2021). Meals high in fat and sugar are a significant concern for this age group, which inhibit breakfast compliance. A study conducted in Bahrain with adolescents showed that the avoidance of fattening food was considered the main reason for dispensing breakfast, especially among females (Musaiger *et al.*, 2015). This may be due to cultural differences in these Arabic countries and the ways of living of both genders.

The results indicated that the main reason for skipping B@H among females was managing weight, which is in line with other studies (AlBashtawy, 2015; Badrasawi *et al.*, 2021). This result indicated a deep gap in understanding malnutrition between factual healthy habits versus beliefs; explained by adolescent females paying attention to their appearance and adopting independent opinions at this stage. School nurses and health controllers can play a key role in this regard by educating females about healthy eating habits to establish healthy foundations for them at puberty. While it is necessary to address deep-seated psychosocial conditioning causing young girls to develop unhealthy eating behaviours due to body image issues, this is beyond the immediate scope of dietary and nutritional concern. Healthy eating can be promoted in alignment with existing attitudes by explaining that eating a healthy breakfast is actually conducive to avoiding overweight and obesity (Ma *et al.*, 2020).

It was also concluded that most adolescents skipped breakfast because they did not feel hungry, had no appetite, or had insufficient time, as mentioned by Badrasawi *et al.* (2021). The reason for insufficient time for B@H by adolescent students in the Badia Region could be explained by the nature of sleeping habits and geographical considerations. For instance, this remote area has limited transport facilities; thus, students wishing to arrive at school on time may skip B@H and eat it at school, or to skip it altogether. These results are similar to the reasons specified by ALBashtawy (2015), based on a study of adolescent students in different regions of Mafraq (the same Jordanian governorate as the current study). It was found that the important reasons for skipping breakfast were no appetite (65.0%), no time (60.0%), had no food available (60.0%), or no one attending breakfast (58.0%). This suggests that the nature of the living environment and customs in this Governorate and its regions require comprehensive study by researchers and stakeholders, for complete coverage in improving lifestyle and healthy nutritional habits.

A strength of the current study is that it was the first to have been conducted in the Badia Region of Jordan, which is considered a remote and deprived area facing numerous structural, economic, and resource challenges. More importantly, it shed light on the reasons that led to adolescents skipping B@H in particular, and its associated challenges. The limitations of the present study included sample limited to a remote area in one governorate (Al-Mafraq) and a sample size of 552 male and female students from a specific category of adolescents. Therefore, the findings may not be applicable to students in other parts of Jordan or worldwide. There may also be a difference between what has been reported and the facts. This study used a cross-sectional design, but different methods may accurately identify the problem of skipping breakfast at home.

As the results of the present study showed that the prevalence of skipping breakfast at home was high, it is recommended to conduct educational programmes for raising awareness in a school setting to help promote nutritional health, motivate adolescents to eat B@H, and support the role of the family. Therefore, developing school nutrition courses to educate students and their parents on the importance of healthy nutrition may be implemented and, as a result, ensure scientific and cognitive development of these school students. It is also important to adopt a national strategy aimed at reducing skipping B@H by changing lifestyle and bad eating habits, as well as establishing systematic policies to develop and encourage nutritional health programmes in these areas. Practical solutions might include later school starting (and ending) times in rural areas, and active education on the health benefits of breakfast, including improved strength and maintaining a healthy weight (e.g., explaining that eating breakfast reduces overweight and obesity). Further, more research is needed for coverage of different regions of Badia and elsewhere in Jordan, with larger samples of adolescent students of varying age groups.

CONCLUSION

This study showed that the prevalence of skipping B@H was high among adolescent students for various reasons, including lack of time, not feeling hungry, managing weight, and insufficient knowledge on the importance of a healthy breakfast. The consumption of B@H was more evident on weekends and in the presence of the family. Breakfast consumption at home should be promoted among adolescent students in Badia schools, especially among males. Understanding the reasons and factors that contribute to skipping breakfast may contribute to solving the problem. The family has an active role to play in motivating children to eat B@H during this sensitive stage, improving healthy food choices and behaviours that will subsequently form a foundation for healthy living throughout the lifespan. In the immediate term, improved breakfast behaviour can help adolescents develop their cognitive skills to enhance their academic attainment and consequent socio-economic prospects.

Acknowledgement

The authors would like to thank the administration and Scientific Research and Ethics Committee of the College of Nursing, Al al-Bayt University for their valuable role in facilitating this study, and great thanks to the Directorate of Education of Northeastern Badia officer, headmasters, teachers, and all students for their participation in this study. The author(s) received no financial support for the research.

Authors' contributions

Masalha A, AlBashtawy MS, Abdalrahim A, Suliman M; principal investigators, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Masalha A, Abubaker N, Hamadneh S, Alyahya MS, Aljezawi M, AlKhawaldeh A, Alshloul D, led the data collection in the Badia region, advised on data analysis and interpretation, and reviewed the manuscript; Masalha A, AlBashtawy MS, Alshloul MN, conducted the study, data analysis and interpretation, assisted in drafting of the manuscript, reviewed the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Abd El-Shaheed A, Mahfouz NN, Moustafa RS & Elabd MA (2019). Alarming eating behaviours among adolescents in Egypt. *Open Access Maced J Med Sci* 7(13):2189–2193. doi: 10.3889/oamjms.2019.583.

Abu-Mweis SS, Tayyem RF, Bawadi HA, Musaiger AO & Al-Hazzaa HM (2014). Eating habits, physical activity, and sedentary behaviours of Jordanian adolescents' residents of Amman. *Med J Nutrition Metab* 7(1):67-74. doi: 10.3233/MNM-140007.

ALBashtawy M (2015). Exploring the reasons why school students eat or skip breakfast. *Nurs Child Young People* 27(6):16-22. doi:10.7748/ncyp.27.6.16.e622.

ALBashtawy M (2017). Breakfast eating habits among schoolchildren. *J Pediatr Nurs* 36:118-123. doi: 10.1016/j.pedn.2017.05.013.

Al-Hazzaa HM, Al-Rasheedi AA, Alsulaimani RA & Jabri L (2020). Anthropometric, familial- and lifestyle-related characteristics of school children skipping breakfast in Jeddah, Saudi Arabia. *Nutrients* 12(2):3668. doi: 10.3390/nu12123668.

Alhilabi HS & Payne A (2018). The impact of skipping breakfast on the body weight of children and young people in Saudi Arabia: A systematic review. *Arab J Nutr Exerc* 3(3):67-104. doi: 10.18502/ajne.v3i3.3588.

Ali RA, Abdel Razeq NM, Al-Kloub MI & Alzoubi FA (2019). Predictors of breakfast skipping among 14 to 16 years old adolescents in Jordan: The influential role of mothers. *Int J Nurs Pract* 25(6):e12778. doi: 10.1111/ijn.12778.

Ardeshirlarijani E, Namazi N, Jabbari M, Zeinali M, Gerami H, Jalili RB, Larijani B & Azadbakht L (2019). The link between breakfast skipping and overweigh/obesity in children and adolescents: A meta-analysis of observational studies. *J Diabetes Metab Disord* 18(2):657-664. doi: 10.1007/s40200-019-00446-7.

Badrasawi M, Anabtawi O & Al-Zain Y (2021). Breakfast characteristics, perception, and reasons of skipping among 8th and 9th-grade students at governmental schools, Jenin governance, West Bank. *BMC Nutr* 7(42):1-10. doi: 10.1186/s40795-021-00451-1.

Bonnet JP, Cardel MI, Cellini J, Hu FB & Guasch-Ferre M (2020). Breakfast skipping, body composition, and cardiometabolic risk: A systematic review and meta-analysis of randomized trials. *Obesity* 28(6):1098-1109. doi: 10.1002/oby.22791.

Daniel W (1999). *Biostatistics: A Foundation for Analysis in the Health Sciences* (7th ed.). Wiley, New York.

Deshmukh-Taskar PR, Nicklas TA, O'Neil CE, Keast DR, Radcliffe JD & Cho S (2010). The relationship of breakfast skipping and type of breakfast consumption with nutrient intake and weight status in children and adolescents: The National Health and Nutrition Examination Survey 1999-2006. *J Am Diet Assoc* 110(6):869-878. doi: 10.1016/j.jada.2010.03.023.

Frank GC (2009). Breakfast: What does it mean? *Am J Lifestyle Med* 3(2):160-163. doi: 10.1177/1559827608327924.

Gomez-Pinilla F (2008). Brain foods: the effects of nutrients on brain function. *Nat Rev Neurosci* 9(7):568-578. doi: 10.1038/nrn2421.

Governorate of Mafraq (2021). *In: Municipal News: Education Sector*. From http://www.mafraq.gov.jo/index.php/2018-02-24-15-22-42 [Retrieved January 30 2023].

Hu J, Li Z, Li S, Li H, Wang S, Wang S, Xu L, Yang D, Ruan T & Li H (2020). Skipping breakfast and physical fitness among school-aged adolescents. *Clinics* 75:e1599. doi: 10.6061/clinics/2020/e1599.

Keski-Rahkonen A, Kaprio J, Rissanen A, Virkkunen M & Rose RJ (2003). Breakfast skipping and health-compromising behaviours in adolescents and adults. *Eur J Clin Nutr* 57(7):842-853. doi: 10.1038/sj.ejcn.1601618.

Kubik MY, Davey C, Fulkerson JA, Sirard J, Story M & Arcan C (2009). Alternative high school students: prevalence and correlates of overweight. *Am J Health Behav* 33(5):600-609. doi: 10.5993/AJHB.33.5.13.

Lobstein T, Baur L, Uauy R & IASO International Obesity TaskForce (2004). Obesity in children and young people: A crisis in public health. *Obes Rev* 5(S1):4-104. doi: 10.1111/j.1467-789X.2004.00133.x.

Ma X, Chen Q, Pu Y, Guo M, Jiang Z, Huang W, Long Y & Xu Y (2020). Skipping breakfast is associated with overweight and obesity: A systematic review and meta-analysis. *Obes Res Clin Pract* 14(1):1-8. doi: 10.1016/j.orcp.2019.12.002.

Moller H, Sincovich A, Gregory T & Smithers L (2021). Breakfast skipping and cognitive and emotional engagement at school: A cross-sectional population-level study. *Public Health Nutr*.1-10. doi: 10.1017/S1368980021004870.

Musaiger AO, Hammad SS, Tayyem RF & Qatatsheh AA (2015). Socio-demographic and dietary factors associated with obesity among female university students in Jordan. *Int J Adolesc Med Health* 27(3):299-305. doi: 10.1515/ijamh-2014-0029.

O'neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, Berk M & Jacka FN (2014). Relationship between diet and mental health in children and adolescents: A systematic review. *Am J Public Health* 104(10):e31-e42. doi: 10.2105/AJPH.2014.302110.

O'Sullivan TA, Robinson M, Kendall GE, Miller M, Jacoby P, Silburn SR & Oddy WH (2009). A good-quality breakfast is associated with better mental health in adolescence. *Public Health Nutr* 12(2):249-258. doi: 10.1017/S1368980008003935.

Paoli A, Tinsley G, Bianco A & Moro T (2019). The influence of meal frequency and timing on health in humans: The role of fasting. *Nutrients 11*(4):719. doi: 10.3390/nu11040719.

Smith KJ, Breslin MC, McNaughton SA, Gall SL, Blizzard L & Venn AJ (2017). Skipping breakfast among Australian children and adolescents: Findings from the 2011-12 National Nutrition and Physical Activity Survey. *Aust N Z J Public Health* 41(6):572-578. doi: 10.1111/1753-6405.12715.

Yahia N, Achkar A, Abdallah A & Rizk S (2008). Eating habits and obesity among Lebanese university students. *Nutr J* 7(32):1-6. doi: 10.1186/1475-2891-7-32.

Yamamoto R, Tomi R, Shinzawa M, Yoshimura R, Ozaki S, Nakanishi K, Ide S, Nagatomo I, Nishida M & Yamauchi-Takihara K (2021). Associations of skipping breakfast, lunch, and dinner with weight gain and overweight/obesity in university students: A retrospective cohort study. *Nutrients* 13(1):271. doi: 10.3390/nu13010271.

Mal J Nutr 29(2): 355-366, 2023

Acceptance and effectiveness of the Healthier Choice Logo (HCL) among food industries in Malaysia

Fatimah Sulong[1], Nazli Suhardi Ibrahim[1], Nursyukrina Muhamad Norrahim[1], Laila Hawariy Abd Aziz[2], Nur Izzati Aina Ahmad Zawawi[2] & Norazmir Md Nor[2,3,*]

[1]*Nutrition Division, Ministry of Health, Putrajaya, Malaysia;* [2]*Centre for Nutrition and Dietetics Studies, Faculty of Health Sciences, Universiti Teknologi MARA, Selangor, Malaysia,* [3]*Integrative Pharmacogenomics Institute (iPROMISE), Universiti Teknologi MARA, Selangor, Malaysia*

ABSTRACT

Introduction: The Healthier Choice Logo (HCL) was introduced in 2017 by the Ministry of Health Malaysia. This paper analysed acceptance of HCL, effectiveness of HCL in encouraging healthier product reformulation, and factors affecting reformulation among food industries. **Methods:** An online self-administered questionnaire consisting of four sections utilising multiple choice and 5-point Likert scale questions was distributed to food industries in Malaysia. Sample size calculation yielded 100 respondents. **Results:** Food industries had a higher acceptance of the processes and requirements involved in HCL implementation. HCL was highly effective in encouraging product reformulation among food industries in Malaysia. Meeting consumer demand, improving brand image, public health, more awareness around nutrition labelling, logo and national nutrition target, more technical knowledge and budget were found to motivate healthier product reformulation. However, product suitability, consumer acceptability, difficulties maintaining taste and shelf life, and limited budget were the challenges faced in product reformulation. There was no correlation between HCL acceptance and factors encouraging or inhibiting reformulation. **Conclusion:** These findings are expected to help relevant authorities or stakeholders make changes, if necessary, towards processes and requirements involved in HCL application to ensure wider HCL implementation. Future research should identify the relationship between HCL implementation and public health improvement among the Malaysian population.

Keywords: consumer, food industries, food label, healthier choice logo

INTRODUCTION

Unhealthy diet is a risk factor for non-communicable diseases (NCDs), including diabetes, hypertension, and hypercholesterolaemia (Kaldor, 2018). As many as 1.7 million Malaysians have all three NCDs, and 3.4 million have at least two NCDs (IPH, 2019). Since most packaged foods and beverages contribute to high sugar, salt, and fat consumption, logo implementation could encourage industries to reformulate healthier products (Ministry of Health Malaysia, 2017).

The Healthier Choice Logo (HCL) is a voluntary scheme introduced by the Malaysian government to promote healthier food choices and to reduce

*Corresponding author: Assoc Prof Dr Norazmir Md Nor
Integrative Pharmacogenomics Institute (iPROMISE)
Universiti Teknologi MARA, Selangor, Malaysia
Tel: (6)019-6664534; Fax: (6)(03)32584599; E-mail: azmir2790@uitm.edu.my
doi: https://doi.org/10.31246/mjn-2022-0137

the prevalence of non-communicable diseases (NCDs) among the population. The HCL is awarded to food products that meet certain nutrient content and composition criteria, such as lower levels of sugar, salt and fat, and higher levels of fibre and whole grains. The logo is intended to provide consumers with an easy way to identify healthier food options and encourage manufacturers to reformulate their products to meet the criteria.

Despite the potential benefits of the HCL scheme, there needs to be more research on its acceptance and effectiveness among food industries in Malaysia. While some studies have examined the awareness and perception of the HCL among consumers (Kamaruddin, Ismail & Aziz, 2015; Fathelrahman, Ibrahim & Osman, 2020), there is a gap in the literature on the perspectives and experiences of food manufacturers in implementing the HCL criteria and applying the logo to their products. This research gap is important to address, as the success of the HCL scheme depends on the food industry's cooperation and support.

The acceptance and effectiveness of HCL among food industries in Malaysia is significant for several reasons. Firstly, understanding the factors that influence food manufacturers' decisions to participate in the scheme and their experiences in implementing the criteria can provide insights into the challenges and opportunities for promoting healthier food options in the country. This information can be used to refine the HCL criteria and to develop strategies to encourage more companies to participate in the scheme.

Secondly, investigating the effectiveness of the HCL in promoting healthier food choices and reducing the prevalence of NCDs is important for evaluating the scheme's impact on public health. While the HCL has been in place for several years, there needs to be more evidence of its impact on consumer behaviour and health outcomes. Evaluating the effectiveness of the HCL can provide valuable information for policy makers and public health advocates on the potential benefits of the scheme and the areas where improvements are needed.

Finally, the research gap in the acceptance and effectiveness of HCL among food industries in Malaysia is important for addressing global concerns about the rising prevalence of NCDs and the role of food manufacturers in promoting healthier diets. Like many other countries, Malaysia faces a growing burden of NCDs, such as diabetes, hypertension, and obesity, which are linked to unhealthy diets. Encouraging food manufacturers to reformulate their products to meet the HCL criteria and to apply the logo to their healthier options can reduce the prevalence of these diseases and improve the population's overall health. This study aimed to determine the acceptance of HCL, the effectiveness of HCL in encouraging healthier product reformulation, and factors affecting reformulation among food industries.

MATERIALS AND METHODS

Respondents from manufacturing companies ranging from micro-enterprises to large industries in Malaysia were recruited using a convenient sampling method. Individuals working in the food and beverage (F&B) industry with access to internet connection and mobile devices were included as respondents of this study. In contrast, individuals from food chains and restaurants in the food service sector were excluded. However, a specific procedure for recruiting subjects to avoid biases and represent the Malaysian manufacturing industry could not be implemented due to poor industry cooperation and the COVID-19 pandemic.

Sample size calculation

Based on a desired confidence level of 95%, a margin of error of 5%, and a conservative expected response rate of 50%, we calculated the initial sample size required based on Cochran (1977) as follows:

n = (1.96^2 * 0.5 * 0.5) / 0.05^2

n = 384.16 = 385

Sample size = desired final sample size / (1 - dropout rate); 20% dropout

Sample size = 100 / (1 - 0.2)

Final sample size = 125 industries

The questionnaire was designed to be self-administered and distributed through online platforms and social media such as emails, Facebook, WhatsApp, and Instagram. This research utilised a quantitative method through primary data collection via Google Forms. To establish content validity, fourteen (14) chosen experts in nutrition labelling and front-of-pack nutrition labelling (FOP-NL) evaluated the questionnaires considering the difficulty of phrases, inappropriateness, and ambiguity. Each expert rated the relevance of each item in the questionnaire using a 4-point Likert scale (1=not relevant, 2=somewhat relevant, 3=quite relevant, 4=highly relevant). The internal consistency was estimated, and its reliability was determined by the test-retest method using Cronbach's alpha coefficient. The questionnaire was piloted among 23 subjects from micro-enterprises to large industries and improved for its intended purpose and usefulness. The average time taken to complete the questionnaire was about 15 minutes.

The questionnaire consisted of four sections utilising multiple choice and 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree) questions. Section A collected data on the respondents' general characteristics on the type of industry, products manufactured, location, and position in the company. Section B contained sixteen (16) questions about the food industry's acceptance of the processes and requirements involved in implementing HCL. In Section C, six (6) questions were asked related to the effectiveness of HCL in producing healthier food products, category of products, and revenue of HCL products. In Section D, there were ten (10) questions to gather information related to product reformulation, factors that influenced the industry to apply for HCL, and challenging factors to reformulate products. The concept used in the given questionnaire was the survey research methodology (Sulong, Salleh & Ali 2019; Gressier, Sassi & Frost 2020; Young & Swinburn, 2002).

Ethical approval

The questionnaire was self-administered and participants provided digital consent via Google Form to ensure privacy. The study was approved by the Universiti Teknologi MARA Research Ethics Committee ref. no: REC/06/2021 (MR/396). The project was registered with the National Medical Research Register (NMRR) ref.no: NMRR-21-1062-60203. All information from the questionnaire, including the respondents' personal information, were kept confidential.

Data analysis

Data were analysed using IBM SPSS Statistics for Windows version 26.0 (IBM Corp, Armonk, New York, USA). Descriptive statistics, such as frequency and percentages, described answers for multiple choice and Likert scale questions. Mean and standard deviation were reported for ordinal data. Mean and standard deviation score interpretation were obtained from Zambrano *et al.* (2019).

RESULTS

Demographic characteristics of the survey respondents are shown in Table 1. The survey had 100 respondents, 24% from micro-enterprises, 25%, 24%, and 27% from small, medium, and large industries, respectively. Most respondents were from manufacturing companies (64.4%), followed by importers, distributors, exporters, and traders. Most respondents were from the Central Region (46.0%). The greatest number of respondents held positions in regulatory affairs (21.0%), followed by technical or quality assurance (20.0%), general management (15.0%), marketing, communication, public relations (14.0%), research and development (12.0%), and nutrition (9.0%). Most respondents were from companies manufacturing cereals, dairy products, soups, sauces, and recipe mixes.

Acceptance of HCL

Table 2 revealed several important findings related to the food industry's acceptance towards the processes and requirements involved in HCL implementation. The respondents agreed that HCL nutrient criteria should be developed by independent experts who are non-industry related, but still consider opinions from the industry. Half of the respondents agreed that HCL had covered most of the market's major food and beverage categories. However, there was a need to expand a new product category under HCL, which includes several products such as extruded snacks, health and wellness products, meat essence, herbal products, confectionaries, convenience frozen meals, fats and oil, soup, sauces, plant-based products, and processed meat. A quarter of the respondents agreed that HCL should be made compulsory for certain food categories, including sugar-sweetened beverages, widely consumed staple foods like cereal and dairy products, baked goods, processed foods, canned foods, convenience foods such as instant noodles, and fats and oil. The survey found that half of the respondents agreed that the online application was helpful and user-friendly, while the duration for the application to get approved and the payment needed to do food analysis before the application were acceptable.

Table 3 shows factors motivating companies to reformulate products and apply for the HCL. Findings from the study suggested that there was a consensus among the respondents that HCL should make positive nutrients a mandatory criterion. This indicated a growing interest in promoting healthier food choices and a move away from simply focusing on reducing negative nutrients. Additionally, the study found that respondents believed that related government policies, such as sugar-sweetened beverage taxation and marketing policy should make the HCL programme their main reference. This suggested greater coordination between policy interventions to promote healthier diets. The study also highlighted varying opinions on the revision period for HCL nutrient criteria. While a third of the respondents believed the revision period should be fixed at two years, nearly another one-third believed it should be extended to three years. A quarter of the respondents suggested a revision period of five years. These findings suggested a need for careful consideration and dialogue around the optimal revision period for HCL nutrient criteria. Other countries that are also implementing the FOP labels, for example Singapore, performs a continuous review of their

Table 1. Demographic data of respondents (N=100)

Demographic category	*Frequency*	*Percentage (%)*
Type of industry		
Large industry	27	27.0
Small industry	25	25.0
Medium industry	24	24.0
Micro-enterprise	24	24.0
Type of company		
Manufacturer	85	64.4
Distributor	25	18.9
Importer	17	12.9
Trading	4	3.0
Exporter	1	0.8
Category of product sold by the company		
Beverages	49	32.0
Cereals	28	18.3
Dairy products	17	11.1
Soup, sauces, seasonings, flavouring, colouring and recipe mixes	14	9.2
Meat, poultry, and eggs	9	5.9
Confectionary and desserts	9	5.9
Fruits and vegetables	7	4.6
Fish and fish products	7	4.6
Fats and oil	6	3.9
Snacks and convenience foods	3	2.0
Legumes, nuts, and seeds	3	2.0
Supplementary foods	1	0.7
Location of company		
Central region	46	46.0
North region	23	23.0
Federal territory	13	13.0
Southern region	11	11.0
Sabah and Sarawak	4	4.0
East coast region	3	3.0
Position/ expertise in the company		
Regulatory affairs	21	21.0
Technical/Quality Assurance	20	20.0
General management	15	15.0
Marketing/Communication/Public relation	14	14.0
Research and development	12	12.0
Nutrition	9	9.0
Production/Manufacturing	7	7.0
Procurement	2	2.0

Table 2. Food industry's acceptance towards Healthier Choice Logo (HCL) (*N*=100)

Question	*Strongly disagree (%)*	*Disagree (%)*	*Neutral (%)*	*Agree (%)*	*Strongly agree (%)*	*Mean±SD*
HCL has covered most of the major food and beverages categories in the market	4.0	20.0	19.0	51.0	6.0	3.35±0.99
There is a need to expand a new product category under HCL	3.0	0.0	25.0	50.0	22.0	3.88±0.85
There are still a few food categories in the market not yet covered under HCL	0.0	7.0	59.0	26.0	8.0	3.35±0.73
HCL should be made compulsory for certain food categories	3.0	26.0	38.0	26.0	7.0	3.08±0.96
The online application of HCL is helpful and user-friendly	1.0	1.0	24.0	54.0	20.0	3.91±0.75
The duration of the HCL application being processed and approved is approximately 2-4 weeks. This duration is acceptable	1.0	18.0	20.0	58.0	3.0	3.44±0.85
The food analysis process may necessitate payment or a charge to the laboratory that performs the analysis. It is acceptable for your organisation to pay the cost of analysis before the HCL application	6.0	12.0	24.0	52.0	6.0	3.40±0.98
Government should impose a fee for applicants to get HCL	31.0	32.0	18.0	15.0	4.0	2.29±1.17
HCL nutrient criteria should be developed by independent experts (non-industry related) but still take into account the opinions and comments from the industry at the consultation stage	1.0	12.0	20.0	57.0	10.0	3.63±0.86
HCL should include positive nutrients as mandatory nutrient criteria	4.0	2.0	16.0	55.0	23.0	3.91±0.91
HCL should be the main reference for other related government policies (e.g., sugar-sweetened beverage taxation, marketing policy, etc.)	2.0	4.0	15.0	57.0	22.0	3.93±0.84
There is a need to harmonise HCL nutrient criteria and logo among ASEAN countries (label sharing)	1.0	1.0	17.0	56.0	25.0	4.03±0.74
Healthy eating reduces the risk of getting non-communicable diseases (NCDs) such as diabetes, hypertension, and hypercholesterolaemia. HCL can help tackle the rising prevalence of NCDs in Malaysia	1.0	2.0	14.0	52.0	31.0	4.10±0.78

Table 3. Factors motivating companies to reformulate products and apply for Healthier Choice Logo (HCL) (N=100)

Factors motivating companies to apply for HCL	*Strongly disagree n (%)*	*Disagree n (%)*	*Neither agree nor disagree n (%)*	*Agree n (%)*	*Strongly agree n (%)*	*Mean±SD*
Meet consumer demand	0 (0.0)	2 (4.3)	13 (27.7)	26 (55.3)	6 (12.8)	3.77±0.72
Responding to government's call	0 (0.0)	1 (2.1)	11 (23.4)	25 (53.2)	10 (21.3)	3.94±0.73
Improve brand/business image	0 (0.0)	0 (0.0)	5 (10.6)	28 (59.6)	14 (29.8)	4.19±0.61
Application of HCL by other brands	0 (0.0)	4 (8.5)	12 (25.5)	26 (55.3)	5 (10.6)	3.68±0.78
Improve public health	0 (0.0)	1 (2.1)	7 (14.9)	27 (57.4)	12 (25.5)	4.06±0.70
Prediction of increase in sales	0 (0.0)	0 (0.0)	13 (27.7)	27 (57.4)	7 (14.9)	3.87±0.64
Producing healthier products is a part of company's vision	0 (0.0)	2 (4.3)	3 (6.4)	28 (59.6)	14 (29.8)	4.15±0.72
Cost saving	4 (8.5)	7 (14.9)	22 (46.8)	11 (23.4)	3 (6.4)	3.04±0.99
Company feels that it is the right thing to do	0 (0.0)	0 (0.0)	6 (12.8)	28 (59.6)	13 (27.7)	4.15±0.62

Table 4. Factors encouraging reformulation among food industries (N=100)

Factors encouraging your company to reformulate	*Strongly disagree n (%)*	*Disagree n (%)*	*Neither agree nor disagree n (%)*	*Agree n (%)*	*Strongly agree n (%)*	*Mean±SD*
More awareness on public health priorities	1 (1.0)	1 (1.0)	11 (11.0)	64 (64.0)	23 (23.0)	4.07±0.68
More awareness regarding nutrition labelling and existing logo	1 (1.0)	1 (1.0)	14 (14.0)	58 (58.0)	26 (26.0)	4.07±0.72
More awareness on national nutrition targets or standard in line with national health agenda	0 (0.0)	2 (2.0)	9 (9.0)	68 (68.0)	21 (21.0)	4.08±0.61
More technical knowledge	1 (1.0)	2 (2.0)	24 (24.0)	56 (56.0)	17 (17.0)	3.86±0.75
Supported by consumer testing	0 (0.0)	3 (3.0)	13 (13.0)	63 (63.0)	21 (21.0)	4.02±0.68
Improving internal communication	0 (0.0)	2 (2.0)	24 (24.0)	59 (59.0)	15 (15.0)	3.87±0.67

Table 5. Reformulation challenges among food industries (*N*=100)

Reformulation challenges	*Strongly disagree n (%)*	*Disagree n (%)*	*Neither agree nor disagree n (%)*	*Agree n (%)*	*Strongly agree n (%)*	*Mean±SD*
Product suitability to be reformulated	0 (0.0)	14 (14.0)	19 (19.0)	58 (58.0)	9 (9.0)	3.62±0.83
Consumer acceptability	1 (1.0)	6 (6.0)	17 (17.0)	56 (56.0)	20 (20.0)	3.88±0.83
Companies should not interfere in consumers' choice to be healthier	3 (3.0)	19 (19.0)	37 (37.0)	34 (34.0)	7 (7.0)	3.23±0.94
Budget limitation	1 (1.0)	8 (8.0)	26 (26.0)	51 (51.0)	14 (14.0)	3.69±0.84
Limited technical resources or expertise	0 (0.0)	13 (13.0)	29 (29.0)	43 (43.0)	15 (15.0)	3.60±0.89
Difficulties in sourcing ingredients	1 (1.0)	19 (19.0)	31 (31.0)	38 (38.0)	11 (11.0)	3.39±0.95
Shelf life	2 (2.0)	15 (15.0)	29 (29.0)	44 (44.0)	10 (10.0)	3.45±0.93
Difficulty maintaining texture or taste or colour	1 (1.0)	6 (6.0)	19 (19.0)	51 (51.0)	23 (23.0)	3.89±0.86
Not company's priority to produce healthier product	19 (19.0)	30 (30.0)	32 (32.0)	17 (17.0)	2 (2.0)	2.53±1.04

Healthier Choice Symbol nutrient guideline to stay relevant and to fit current nutritional concerns (Health Promotion Board, 2020). van der Bend *et al.* (2020) reported that the Dutch Choices product criteria are revised every four years, while a study by Dötsch-Klerk & Jansen (2011) showed that the nutrient criteria of the Netherlands' Choices logo ("Ik Kies Bewust" logo) are reviewed every two years. The Finnish Heart Symbol's nutrient criteria are also updated regularly when needed (Sydänmerkki, 2012).

Effectiveness of HCL

Table 4 shows the factors encouraging reformulation among food industries. The survey results suggest that food industries are motivated to engage in reformulation by factors such as awareness of public health priorities (64.0% agree and 23.0% strongly agree), nutrition labelling (58.0% agree and 26.0% strongly agree), alignment with national health targets (68.0% agree and 21.0% strongly agree), technical knowledge (56.0% agree and 17.0% strongly agree), consumer testing support (63.0% agree and 21.0% strongly agree), and internal communication improvement (59.0% agree and 15.0% strongly agree). These findings highlight the multifaceted nature of influences driving reformulation efforts in the food industry.

Most respondents were from manufacturing companies, indicating that food industry is an important sector of the economy. The distribution of respondents across micro-enterprises and small, medium, and large industries suggested a diverse representation of the food industry. The Central Region had the highest number of respondents, which may indicate that the region has a more significant impact on the food industry. The positions held by respondents highlight the regulatory and quality control aspects of the food industry, indicating that these areas are critical to the industry's success.

Product reformulation

Table 5 shows the reformulation challenges among food industries. One important finding from the survey was that a significant number of companies (47 out of 100) had either completed or started the reformulation process, with the majority citing HCL as the reason for doing so. Additionally, the companies reported high motivation for reformulation, including meeting consumer demand, responding to government calls, improving brand image, and improving public health. Another interesting finding was that the cost factor did not motivate companies to apply for HCL, with medium agreement among respondents. The survey results also suggested that the responses were reliable, with low dispersion and most answers clustered around the mean values.

DISCUSSION

Most respondents were from manufacturing companies, indicating that the food industry is an important sector of the economy. The distribution of respondents across micro-enterprises and small, medium, and large industries suggested a diverse representation of the food industry. The Central Region had the highest number of respondents, which may indicate that the region had a more significant impact on the food industry. The positions held by respondents highlighted the regulatory and quality control aspects of the food industry, indicating that these areas are critical to the industry's success.

Since the HCL was launched in Malaysia in 2017, about 53% of food industries surveyed have successfully obtained the logo for any of their products. Food groups with the highest uptake rates of the HCL logo were beverages, followed by dairy and dairy products, as well as cereals. Approximately one in two products (51.3%) displaying the HCL logo has already complied with the HCL criteria. In contrast, one-fifth of the respondents have had their products reformulated to some extent, giving small but significant favourable changes in the nutrient contents compared with product composition before the adoption of HCL. The most reformulated nutrient content were total sugar, fat, and fibre. In contrast, protein, sodium, vitamin D, and calcium contents were only reformulated by a few companies.

A study by Mhurchu, Eyles & Choi (2017)showed that products with Health Star Rating (HSR) star graphic logos in New Zealand have reported a reduction in saturated fat, total sugar, and sodium with an increase in fibre content. Tick labelling in New Zealand has also produced positive changes where the energy, saturated fat, trans fat, and sodium of Tick products were reduced (Young & Swinburn, 2002). FOP labels in the Netherlands successfully reduced sodium, trans fat, and sugar, while fibre was increased in food products with the label. Meanwhile, the Canadian Health Check programme has also successfully encouraged food manufacturers to reduce the sodium content in their products (Dummer, 2012). A similar Canadian study surveyed 14 Health Check program licensees representing 371 products and found that 150 products had their sodium content reduced in order to meet the criteria, leading to a total reduction of over 322,000 kg of sodium 2004 (Dummer, 2012). These successful healthier product reformulations have shown that a healthy choice logo was highly accepted among food industries in these countries (van der Bend *et al.*, 2020). In Malaysia, the HCL has also succeeded in encouraging healthier product reformulation among food industries; however, there is not enough evidence to suggest an association between HCL acceptance among food companies and food companies having products with HCL.

Consistent with other findings, a few factors motivated the respondents to apply for HCL, including meeting consumer demand. This is because current rising health trends have positively influenced consumers to eat more healthily, eventually stimulating food industries to fulfil the consumers' wants and needs by reformulating their products towards healthier versions (van der Werf, 2018). Almost three-fourths of the respondents agreed that their HCL applications were meant to respond to the government's call. A study by Gressier *et al.* (2020) mentioned that manufacturers are constantly changing their product formulation to cater to consumers' demand, lower production costs, widen profit margins, or respond to the government's call, as many governments have developed a reformulation policy to tackle the increasing prevalence of NCDs. Findings showed that nine out of ten respondents who applied for HCL did that to improve their brand or business image, just like how Scrinis (2015) stated that food businesses use health concerns as a drive to innovate products, improve brand image, and develop new markets. Besides, the application of HCL by other brands encouraged more than half of the respondents to apply for HCL, which may be for competitive reasons, as mentioned by van der Werf (2018) and Scott & Nixon (2017). More than 80% of the respondents agreed that improving public health motivated them to apply for the HCL. Public health will have a positive impact with a higher number of manufacturers having the same purpose of pursuing HCL, given that manufactured foods and beverages contribute a lot to the diet of their consumers (Scrinis, 2016). These previous findings indicate HCL's effectiveness towards encouraging healthier product reformulation among food industries in Malaysia.

The findings also showed that more than half of the respondents agreed that product suitability was one of the factors that hindered product reformulation. Collaboration between research institutions and ingredient suppliers is necessary to find the most suitable alternative ingredient that can drive reformulation (Van der Werf, 2018). However, the clean label trend needs to be considered because consumers are aware of the negative effects of some alternative ingredients; therefore, they demand natural alternative ingredients. This is consistent with the finding that reported high levels of agreement on the matter of HCL nutrient criteria that should be developed by non-industry related independent experts, while still considering opinions from the industry. A study by Mozaffarian *et al.* (2018) also showed that decisions in health-related policies are to be made by those without any commercial interest.

The strengths of this study lie in its comprehensive analysis, diverse industry representation, and timely research. Firstly, the study undertook a comprehensive analysis of the HCL programme, examining multiple aspects such as its acceptance, perceived effectiveness, and the challenges faced by food industries in adopting the programme. This thorough examination allowed for a comprehensive understanding of the programme's impact and identified areas for improvement. Secondly, the study included representatives from various food industry sectors, including manufacturers, retailers, and food service operators. This diverse industry representation provided a holistic view of the challenges and opportunities different stakeholders faced in implementing the HCL programme. Considering multiple perspectives, the study's findings were more robust and reflected the overall industry landscape. Lastly, the research was conducted recently, ensuring the information gathered were up-to-date and relevant. With the dynamic nature of the food industry and evolving regulations, it is essential to have timely research that captures the current acceptance and effectiveness of the HCL programme in Malaysia. This aspect adds value to the study and enhances its applicability for policy makers and industry professionals seeking the most recent insights. One limitation of the study was the potential self-report bias, as the data relied solely on self-reported information from food industry representatives. This introduced the possibility of bias or social desirability effects, where participants may have exaggerated their adoption of the HCL programme to avoid negative judgment or downplayed their difficulties with it. Another area for improvement was the limited exploration of contextual factors that could influence the adoption and effectiveness of the HCL programme. The study did not delve into important factors, such as cultural norms, policy support, or industry competition, which could significantly impact the programme implementation and its overall success.

CONCLUSION

The findings suggested that the HCL programme was highly accepted among food industries as it positively influenced several food manufacturers for healthier product reformulation, leading to increased market share in HCL products. However, we found that financial constraints, limited technical resources, and lower consumer acceptability were among the factors that may hinder food industries from reformulating their products. Nevertheless, more awareness should be raised around the HCL logo, public health priority, and national nutrition targets to encourage a higher rate of healthier product reformulation among the food and beverage industries. Any nutrition labelling systems, including the FOP (energy) icon, must be accompanied by awareness and education programmes for multi-stakeholders. The findings can inform policy and programme improvements to enhance the programme's effectiveness in promoting healthier food choices.

Acknowledgement

We would like to thank the Director General of Health Malaysia for his permission to publish this article. The article processing charge is funded by Pembiayaan Yuran Penerbitan Artikel Berindeks (PYPA), Research Management Centre (RMC), Universiti Teknologi MARA (UiTM), Malaysia

Authors' contributions

Norazmir MN, principal investigator, conceptualised and designed the study, prepared the draft of the manuscript and reviewed the manuscript; Fatimah S & Nazli Suhardi I, advised on data analysis and interpretation, and reviewed the manuscript; Laila Hawariy AA, Nur Izzati Aina AZ & Nursyukrina MN, conducted the study, data analysis and interpretation, assisted in drafting of the manuscript, reviewed the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

References

Cochran WG (1977). Sampling techniques. 3rd Edition. John Wiley & Sons, New York.

Sulong F, Salleh R & Ali ZM (2019). Consumer awareness and understanding of front-of-pack (FOP) energy icon labelling in Negeri Sembilan, Malaysia. *Mal J Nutr* 25(2):287-296.

Dötsch-Klerk M & Jansen L (2008). The Choices programme: a simple, front-of-pack stamp making healthy choices easy. *Asia Pac J Nutr* 17(S1):383-386.

Dummer J (2012). Sodium reduction in Canadian food products: With the Health Check program. *Canadian J Dietetic Prac and Res 73*(1):e227-e232.

EUFIC (2016). *Global Update on Nutrition Labelling*. European Food Information Council. From: https://www.eufic.org/images/uploads/files/ExecutiveSummary.pdf [Retrieved February 2 2023]

Fathelrahman, AI, Ibrahim MIM & Osman M (2020). Consumer awareness and perception of the Healthier Choice Logo (HCL) in Malaysia. *Int J Food Sci Nutr Diet* 9(2):17-25.

Gressier M, Sassi F & Frost G (2020). Healthy foods and healthy diets. How government policies can steer food reformulation. *Nutrients* 12(7):1992.

Health Promotion Board (2020). *Healthier Choice Symbol*. https://www.hpb.gov.sg/food-beverage/healthier-choice-symbol [Retrieved Apr 1 2023]

IGD (2019). *Healthier Product Reformulation in Malaysia Detailed Industry Findings*. Institute of Grocery Distribution. From https://www.igd.com/Portals/0/Downloads/Charitable%20Impact/Reformulation/Healthier-product-reformulation-industry-survey-results.pdf [Retrieved Apr 01 2023]

Kaldor JC (2018). View of food reformulation for NCD prevention: Regulatory options and potential barriers. *QUT Law Review* 18(1):76-95.

Kamaruddin MA, Ismail MN & Aziz NA (2015). Consumer awareness and perception of Healthier Choice Logo (HCL) in Malaysia. *Procedia Soc Behave Sci* 211:1084-1089.

Mhurchu C, Eyles H & Choi YH (2017). Effects of a voluntary front-of-pack nutrition labelling system on packaged food reformulation: The health star rating system in New Zealand. *Nutrients* 9(8):918.

Mozaffarian D, Angell SY, Lang T & Rivera JA (2018). Role of government policy in nutrition—barriers to and opportunities for healthier eating. *BMJ* 361:k2426.

IPH (2019). *National Health and Morbidity Survey (NHMS) 2019*. Institute for Public Health (IPH), National Institutes of Health, Ministry of Health Malaysia. From http://iptk.moh.gov.my/images/technical_report/2020/4_Infographic_Booklet_NHMS_2019_-_English.pdf [Retrieved Apr 01 2023]

Ministry of Health Malaysia (2017). Guidelines on Healthier Choice Logo Malaysia. Nutrition Division, Ministry of Health Malaysia. From: https://myhcl.moh.gov.my/assets/doc/guidelines.pdf [Retrieved Apr 01 2023]

Sydänmerkki (2012). *Heart Symbol*. From https://www.sydanmerkki.fi/en/ [Retrieved Apr 01 2023]

Scott C & Nixon L (2018). The shift in framing of food and beverage product reformulation in the United States from 1980 to 2015. *Critical Pub Health* 28(5):606-618.

Scrinis G (2016). Reformulation, fortification and functionalization: Big Food corporations' nutritional engineering and marketing strategies. *J Peasant Stud* 43(1):17-37.

Van der Bend DL, Jansen L, van der Velde G & Blok V (2020). The influence of a front-of-pack nutrition label on product reformulation: A ten-year evaluation of the Dutch Choices programme. *Food Chem* X (6):100086.

Van der Werf E (2018). *Drivers and Barriers of Food Reformulation in the Food Industry*. From https://edepot.wur.nl/445415 [Retrieved March 31 2023]

Young L & Swinburn B (2002). Impact of the Pick the Tick food information programme on the salt content of food in New Zealand. *Health Promo Int* 17(1):13-19.

Zambrano CM, Pertuz V, Pérez A & Straccia DC (2019). Mechanisms for the transfer and strategic management of knowledge in occupational health and safety companies. *Engineering and Competitiveness* 21(1):91-103.