Review Article

Consumption and sources of added sugar in Indonesia: a review

Atmarita MPH, DrPH[1], Nelis Imanningsih PhD[2], Abas B Jahari PhD[3], Ir Dewi Permaesih PhD[3], Pauline Chan MSc[4], Maria Sofia Amarra PhD[4]

[1]*Member of Ethic Commission of Health Research, National Institute of Health Research and Development/NIHRD-MOH, Indonesia*
[2]*Center for Research and Development of Biomedical and Health Technology, NIHRD-MOH, Indonesia*
[3]*Center for Research and Development of Public Health, NIHRD-MOH, Indonesia*
[4]*International Life Sciences Institute (ILSI) Southeast Asia Region, Singapore*

Background and Objectives: The present report summarized the best available evidence regarding consumption level and sources of free or added sugars in Indonesia. **Methods and Study Design:** Information was extracted from food balance sheets, household expenditure surveys, nutrition surveys, published studies, unpublished theses/dissertations, and government reports. **Results:** A total of 18 references were obtained, showing varying results. Indonesia's national surveys suggested intakes of sugar below 50 grams per day or below 10% of energy intake. Published studies suggested higher levels of intake. Studies used expenditure surveys or a single day of recall to determine dietary intake. None made use of biomarkers to determine the level of sugar intake. The 2014 Total Diet Study estimated that 11.8% of the population consumed >50 grams sugar per day. Common food sources were table sugar, wheat products, milk products, sweetened drinks, condiments, candies and chocolate products. **Conclusions:** Insufficient evidence exists regarding the levels and sources of added sugar intake of different population groups in Indonesia. A nationwide survey using multiple (at least two) 24-hour recalls to allow estimation of usual intake and to identify food sources, and the use of biomarkers to validate intake will provide more accurate information on which to base policy decisions

Key Words: added sugar, diet, Indonesia, consumption, food sources

INTRODUCTION

There is a continuing increase in levels of overweight and obesity in both developed and developing countries. Global estimates by Ng et al[1] showed that from 1980 to 2013, overweight and obesity combined rose by 27.5% among adults and 47.1% among children, resulting in an increased number of overweight and obese individuals from 857 million in 1980 to 2.1 billion in 2013. More than 50% of the 671 million obese individuals in the world lived in ten countries, among them Indonesia.

Data from Indonesia National Basic Health Research (RISKESDAS) 2007 and 2013 showed that the prevalence of overweight (BMI ≥25) and obesity (BMI >27) among adults aged 18+ years increased from 14.0% and 2.8%, respectively, in 2007, to 25.8% and 5.6%, respectively, in 2012.[2] Both conditions were higher among females than males. During this period, overweight among females increased from 17.5 to 32.3%, while obesity increased from 4.0 to 8.2%. Among males, overweight increased from 10.3 to 19.4%, and obesity increased from 1.6 to 3.0%. Nationwide statistics for 2013 showed that overweight among children under five was 12%. Among children aged 5-12 years, obesity and overweight was 18.8% (10.8% overweight, 8.8% obese). Among teenagers aged 13-15 years, 8.3% were overweight and 2.5% were obese.[3]

Foods with added sugar are thought to contribute to obesity through their caloric load. Sugar added to food increases its caloric content without adding nutrients. The American Heart Association (AHA)[4] and WHO[5] distinguish between two types of dietary sugars: *naturally occurring sugars* such as those naturally found in fruit (fructose) and milk (lactose), and *added* or *free sugars* that are added to foods during processing or preparation including sugars and syrups added at the table. Intake of sweetened foods may not produce a corresponding reduction in intake of other foods[6] resulting in increased energy intake with subsequent increase in body weight and fat mass. This may be due to a stimulation of reward-related pathways within the brain,[7,8] enhanced by reduced levels of the stress hormone corticosterone,[9] and leading to increased consumption of sweet foods even in the absence of hunger.[7,8] An increasing amount of evidence has shown

Corresponding Author: Dr Maria Sofia Amarra, ILSI Southeast Asia Region, International Life Sciences Institute, 9 Mohamed Sultan Road #02-01, Singapore 238959.
Tel: +65 6352 5220/+65 8210 0637; Fax: +65 6352 5536
Email: sofiaamarra@ilsisea.org.sg
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that added sugar, particularly high fructose corn syrup, is a major risk factor for diabetes independent of its effect on weight.[10]

Recommendations for sugar intake vary. WHO strongly recommends a daily intake of free sugars to less than 10% of total energy intake for adults and children.[11] A conditional recommendation for further reduction to below 5% or roughly 25 grams (6 teaspoons) per day would provide additional benefits,[11,12] among which includes reducing the risk of type 2 diabetes.[13] The American Heart Association (AHA)[4] recommends that intake of added sugars should not exceed 100 calories per day for women and 150 calories per day for men. Based on data showing that high sugar intake compromises micronutrient density, both the AHA and Institute of Medicine (IOM) recommend that added sugars consumption should not exceed 25% of total energy intake.[14,15] The 2010 Dietary Guidelines for Americans recommend limiting the combined intake of added sugars and solid fats to no more than 5-15% of total calories.[16] The Indonesian Dietary Guidelines include the statement "consume complex carbohydrate for energy."[17] The Ministry of Health stated that sugar intake >50 grams per day is excessive for the Indonesian population, and currently recommends a daily intake of 300 g total carbohydrates and added sugar not exceeding 25 g.[18]

Data on sugar intakes in developing countries in Southeast Asia, including Indonesia, is very limited. There is a need to understand the contribution of sweetened foods and beverages to total energy intakes in Asian diets, to allow more focused dietary intervention approaches in these countries. The purpose of this review is to summarize the best available evidence regarding consumption of 'free' or 'added' sugars in Indonesia. The objectives are to 1) examine intakes of sugar and foods with added sugar among different age and sex groups, expressed in terms of grams per day, kcal/day, percentage contribution to total energy intake, and percentage contribution to total carbohydrate intake; 2) identify the most common or frequently consumed sources of added sugars in the Indonesian population; 3) identify gaps and provide recommendations for future research.

MATERIALS AND METHODS

Search strategy

Information on consumption of sugars and foods with added sugar was extracted from food balance sheets, household expenditure surveys, nutrition surveys, and reports available in websites of the government of Indonesia and international organizations (e.g., WHO, FAO). A search for published papers that included dietary intake as a study variable was conducted on PubMed and Google scholar. Local journals, unpublished theses and dissertations, and hard copies of government reports were hand-searched. Additional unpublished information from the latest Indonesian Individual Food Consumption Survey (SKMI or Survei Konsumsi Makanan Individu) which formed part of the 2014 Total Diet Study was obtained from the Ministry of Health.

Search terms used in Pubmed were "indonesia" and the following terms: ("fast foods"[MeSH Terms] OR ("fast"[All Fields] AND "foods"[All Fields]) OR "fast foods"[All Fields] OR ("processed"[All Fields] AND "food"[All Fields]) OR "processed food"[All Fields]); ("carbohydrates"[MeSH Terms] OR "carbohydrates"[All Fields] OR "sugar"[All Fields])) OR ("diet"[MeSHTerms] OR "diet"[All Fields]); ("dental caries"[MeSH Terms] OR ("dental"[All Fields] AND "caries"[All Fields]) OR "dental caries"[All Fields])); ("diabetes mellitus"[MeSH Terms] OR ("diabetes"[All Fields] AND "mellitus"[All Fields]) OR "diabetes mellitus"[All Fields] OR "diabetes"[All Fields] OR "diabetes insipidus"[MeSH Terms] OR ("diabetes"[All Fields] AND "insipidus"[All Fields]) OR "diabetes insipidus"[All Fields])); ("obesity"[MeSH Terms] OR "obesity"[All Fields])); AND "humans"[MeSH Terms]. Search terms used in Google were: sugar, added sugar, free sugar, diet, eating habits, dental caries, obesity, diabetes, food security, food consumption, processed foods, Indonesia. Since the study used data from published and available literature and completed surveys, ethics approval was not required.

Selection criteria

Studies were included if they 1) examined eating habits, food consumption, and/or dietary patterns among different age and population groups; 2) examined subjects' intake of sugar and/or sweetened foods in terms of quantities and/or frequencies of consumption; 3) covered the period January 2000 to July 2015. Since there were very few studies, all studies and survey results that conformed to the above criteria were included.

Figure 1 shows the flow chart for selection of included studies.

Data synthesis

Data on the consumption level of sugar and sweetened food sources were extracted from published studies, unpublished theses/dissertations, databases and survey reports, including unpublished results from the 2014 Total Diet Study.

For National Socio-Economic Survey (SUSENAS or Survei Sosial Ekonomi Nasional) data, foods with added sugar were extracted from the list provided in the report and their percentage contribution to total calories estimated. This was done by first identifying the energy content of each food item using the SUSENAS tables on caloric content of food items.[19] Total calories ingested from each sweetened food item were then calculated based on the amount consumed and expressed as a percentage of total mean energy intake (also available in the report). The total amount of calories obtained from the sweetened food (rather than from its sugar content alone) was computed since food composition data on the sugar content of each food was not available, either from SUSENAS tables or from the Indonesia food composition table. Hence the figure for estimated percentage contribution of the sweetened food to total energy intake included the caloric contribution of other ingredients present in the food (i.e., fat, protein, and starch), in addition to that of sugar.

For FAO food balance sheet data, the total amount of available sugar and sweeteners per capita per day (expressed as total kcal and total grams) was extracted. The percentage contribution of sugar and sweeteners to total available energy (kcal/day) was computed by dividing the

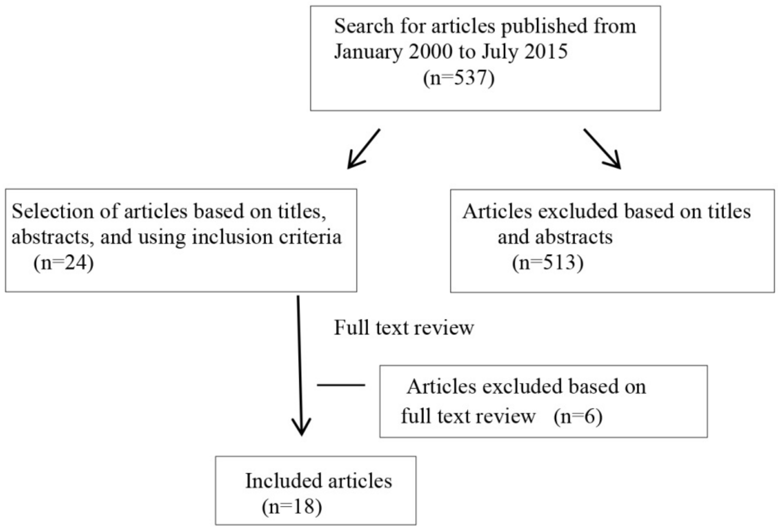

Figure 1. Flow chart for selection of studies.

amount of calories from sugar and sweeteners by the total available calories per capita per day. Similarly, the percentage contribution of sugar and sweeteners to total available carbohydrates was computed by dividing the amount of sugar and sweeteners (in grams) by the total available carbohydrates (also in grams).

For published studies with information on total energy intake and the amount of sugar consumed by subjects, an assigned energy value of 4 kcal/g sugar was used to estimate the percentage contribution of sugar to total energy.

Description of information sources

These information sources have been described in an earlier paper.[20] Food balance sheets describe the amount of food available in a country for consumption (per capita basis), calculated by estimating the quantity of foodstuffs produced, added to the quantity imported and adjusted for any changes in stocks that have occurred.[21] The limitation is that per capita consumption of foods or nutrients does not represent food actually consumed as waste or losses are not taken into account. The advantage of food balance sheets is that they are available on-line and regularly updated.[21]

National household expenditure surveys (HES) measure households' total monetary expenditures as a proxy for income.[22] Food data collected in HESs reflect the quantity of food "acquired" by a household, including food purchases, foods consumed from own farms or gardens, and foods received in kind. Estimated quantities serve as the basis for calculating indicators of food security such as diet quantity and diet quality.[21]

Nutrition surveys represent the best way to assess food actually consumed. However, they are not available for all countries due to the large costs required to mount nationwide surveys.[21] In such cases, small studies done on specific groups serve as the main sources of information on individual intakes.[21]

Dietary assessment methods used in nationwide food consumption surveys have limitations due to measurement errors. However they are lesser in magnitude and easier to interpret than errors in food balance sheets and household surveys.[21] In summary, food consumption surveys provide the most precise dietary intake information followed by household expenditure surveys, and food balance sheets are the least precise.[23]

RESULTS

A total of 18 references, comprising 5 government reports, 1 international organization dataset, and 12 published studies (including those which analysed nationwide survey data) were found. Table 1 shows the characteristics of the included studies.

Level of sugar intake and contribution to total energy

Table 2 summarizes the results obtained from nationally representative surveys, food balance sheet data, and individual studies regarding levels of sugar intake and their estimated contribution to total energy. While the national surveys (i..e, SUSENAS and SKMI) indicate low levels of per capita sugar consumption that fall within WHO recommendations, individual studies indicate higher levels of intake exceeding the Indonesian cut-off of <25 g sugar/day but within the WHO cut-off of <50 g sugar/day.

Nationally representative surveys and food balance sheet data

1. SUSENAS 2014[19]

The National Socio-Economic Survey (SUSENAS) is an annual survey conducted by BPS – Statistics Indonesia. SUSENAS is a series of large-scale multi-purpose socio-economic surveys that cover a nationally representative sample of 300,000 households. It comprises a core questionnaire which consists of a household roster listing the sex, age, marital status, and educational attainment of all household members, supplemented by modules to collect information on health care and nutrition, household income and expenditure, and labor force experience. The questionnaires consumption module includes data on the quantity and value of food and beverages consumed (purchased and own production or delivery), covering 215 commodities categorized into 14 groups.[19] SUSENAS 2014 showed that per capita consumption of cane sugar/brown sugar was 19.92 g/day, contributing approximately 3.9% to per capita total energy intake.[19]

Table 1. Characteristics of included studies

Type of data	Author (yr)	Sampling method	Age (sample size)	Method of measurement	Level of added sugar identified	Sources of added sugar identified
National level data	SUSENAS (2014)[19]	Multi-stage cluster sampling	All ages (300,000 households/year; 75,000 households/quarter)	Per capita consumption (grams/day, kcal/day)	Yes	Yes
	Total Diet Study (2014)[24]	Taken from Basic Health Research (Riskesdas 2013) sampling unit (nationwide sample)	All ages (45,802 households including all household members)	One 24-hour food recall	Yes	Yes
	FAO Food Balance Sheet (2013)[25]	NA	NA	Per capita supply of sugar and sweeteners available for consumption	Yes	No
	Riskesdas (2013)[2]	Four-stage stratified sampling	≥10 yrs (---)	---	No	Yes
	Food Security Agency, Ministry of Agriculture (2013)[26]	Multi-stage cluster sampling of Susenas	All ages (Susenas sample for 1993-2012)	Per capita consumption (kcal/day)	Yes	No
	Hardinsyah (2011)[27]	Multi-stage cluster sampling of Susenas	All ages (Susenas sample for 2002, 2007, 2009)	Per capita consumption (grams/day, kcal/day)	Yes	No
	Perdana (2014)[28]	Taken from Riskesdas 2010 nationwide sample	Adult females 19-55 yrs (n=61,759)	One 24-hour food recall	Yes	No
	Riskesdas (2008)[35]	Two-stage cluster sampling	>10 yrs (---)	Questionnaire on consumption frequency of sweet meals/drinks	No	No
	Molyneaux & Rosner (2004)[36]	Taken from Susenas	All ages (Susenas sample for 1999 to 2002)	Real household expenditure for sugar and drink mixes	No	Yes
Children	Prawirohartono et al (2015)[37]	Multiple cluster random sampling	3-5 yrs (n=249)	24-hour recall for 3 days including weekend days	No	Yes (sweetened condensed milk)
	Sekiyama et al (2012)[38]	Purposive sampling (selection of underweight children in selected communities)	1-12 yrs (n=159)	3-hour-interval food recall survey for 7 consecutive days for each child and child's mother	No	Yes
	Amalia et al (2012)[39]	Convenience sample of children in public and private schools with school-based dental programs in Yogyakarta	12 yrs (n=1906)	Structured questionnaire to assess frequency of consumption of sugary foods & drinks	No	Yes
	Mulyani D, McIntyre J (2002)[30]	Purposive sampling (all children living in 2 orphanages and a boarding facility for rural children from poor families in Medan, Indonesia)	7-19 yrs (n=176)	Estimated from recipes of foods served from the kitchen	Yes	Yes

--- No information.

Table 1. Characteristics of included studies (cont.)

Type of data	Author (yr)	Sampling method	Age (sample size)	Method of measurement	Level of added sugar identified	Sources of added sugar identified
Adults	Guelinckx et al (2015)[31]	Random selection from a database of participants in population surveys	18 yrs and above (n=1366)	24-hr-fluid-specific record for 7 consecutive days	No	Yes (fluids)
	Antono et al (2013)[18]	Purposive selection of subjects with diabetes family history in first degree relatives (mother, father, siblings) and grandparents	20-40 yrs (n=79)	Weekly food frequency questionnaire	Yes	Yes
	Lipoeto et al (2004)[32]	Purposive sampling; matching of subjects with and without cardiovascular disease by age and gender	Not specified (n=282)	Semi-quantitative food frequency questionnaire on foods eaten in the past 12 months	Yes	No
	Hartini (2004)[33]	Purposive sampling of pregnant women registered in a nutritional surveillance system	14-49 yrs (n=450)	Six 24-hour recalls in each trimester of pregnancy	Yes	No
Elderly	Setiati et al (2013)[34]	Purposive sampling (patients who visited 13 hospitals in 15 cities in Indonesia)	60 yrs and above (n=387)	One 24-hour food recall	Yes	No

--- No information.

Table 2. Results of studies on levels of added sugar intake in Indonesia

Author (yr)	Age group	Males	Females	Both sexes	Contribution to carbohydrate intake (%)	Contribution to energy intake (%)
Nationally representative studies						
SUSENAS (2014)[19]	---	---	---	Per capita consumption of cane sugar/ brown sugar=19.92 g/capita/day	---	3.91
Total Diet Study (2014)[†24]	Mean sugar intake±SD by age groups and sex (g/day)					
	0-59 months	17.77±17.29	19.41±21.27	18.60±19.43	10.08±9.50	---
	5-12 yrs	16.82±15.76	16.88±15.86	16.85±15.81	7.16±6.51	---
	13-18 yrs	18.61±17.65	17.13±16.57	17.90±17.15	7.55±7.20	---
	19-55 yrs	32.78±26.43	21.51±19.46	27.54±24.11	10.17±8.19	---
	>55 yrs	32.31±25.49	23.29±20.59	28.15±23.79	12.27±9.52	---
	All ages	29.74±25.38	20.93±19.29	25.61±23.15	10.02±8.38	---
	Proportion of the population who consumed sugar >50 grams/day by age group and sex[†]					
	0-59 months	4.9 %	7.5 %	6.2 %	---	---
	5-12 yrs	4.5	4.3	4.4	---	---
	13-18 yrs	5.5	4.0	4.8	---	---
	19-55 yrs	18.7	7.5	13.5	---	---
	>55 yrs	18.0	8.8	13.7	---	---
	All ages	15.9	7.1	11.8	---	---
FAO food balance sheet (2013)[25]	NA	NA	NA	Total available sugar and sweeteners (2013)=46.5 g/capita/day equivalent to 164 kcal/capita/day;	≈ 7.4% of available carbohydrates/capita/day[††]	≈ 5.9% of available total kcal/capita/day[‡]
Food Security Agency, Ministry of Agriculture (2013)[26]	NA	NA	NA	Consumption of sugar 1993-2012 Year Kcal/capita/day 1993 110 1996 124 1999 92 2002 96 2005 99 2008 94 2011 81 2012 70	---	---
Hardinsyah (2011)[27]	All ages	---	---	Mean intake of visible sugar from Susenas data 2002-2009 (g/capita/day) 2002 28.3 2007 26.2 2009 23.8	---	≈4.8% of total energy in 2009

Table 2. Results of studies on levels of added sugar intake in Indonesia (cont.)

Author (yr)	Age group	Males	Females	Both sexes	Contribution to carbohydrate intake (%)	Contribution to energy intake (%)
Nationally representative studies						
Perdana (2014)[28]	Mean added sugar intake±SD (g/day)			---	---	---
	19-55 y		2.4±12			
	19-29 y		1.5±9.5	---	---	---
	30-49 y		2.7±13.6	---	---	---
	50-55 y		3.5±14	---	---	---
Individual studies						
Children						
Mulyani D, McIntyre J (2002)[30]	7-19 yrs	---	---	Mean intake of 60 g sugar/child/day	---	---
Adults						
Guelinckx et al (2015)[31]	≥18 yrs	---	---	10.9% of Indonesian subjects exceeded the WHO recommendation for energy intake from free sugars, based on fluid intake alone	---	---
Antono et al (2013)[18]	20-40 yrs	---	---	Respondents with diabetes ingested 73.2 g added sugar/day Healthy respondents ingested 33.8 g added sugar/day	Respondent with diabetes=17.1%‡ Healthy respondents= 13.1%‡	---
Lipoeto et al (2004)[32]		---	---	Cases with CVD ingested 34.6±28.8 g sugar/day Controls without CVD ingested 31.6±21 g sugar/day	Cases ≈ 17.0%‡ Controls ≈ 15.4%‡	Cases ≈ 7.8%‡ Controls ≈ 7.6%‡
Hartini (2004)[33]	14-49 yrs	---	Sugar intake of pregnant women (g/day) - Before economic crisis=44±25 - Transition period= 41±23 - During the crisis= 46±23	---	---	---
Elderly						
Setiati et al (2013)[34]	Mean±SD (g sugar products/day)					
	≥60 yrs	40.1±57.3 Median=20 25th-75th percentile=0-50.5	43.9±60.1 Median=20 25th-75th percentile= 0-63.5		Contribution of sugar products to carbohydrate intake‡ Men ≈ 21.8% Women ≈ 26.8%	Contribution of sugar products to energy intake‡ Men ≈ 12.2% Women ≈ 14.2%

†Analysed from 2014 Total Diet Study (unpublished results).
‡Computed from study information.
--- No published data.

2. 2014 Total Diet Study 2014[24]

The National Basic Health Research (RISKESDAS) collects data on health and nutrition variables, using the same primary sampling unit provided by Central Bureau of Statistics (CBS). The 2014 Total Diet Study collected food consumption data for all members of households participating in RISKESDAS 2013, representing national and provincial levels. A total of 45,802 households comprising 145,358 individuals were included. A single 24-hour food recall was used to determine foods consumed by each household member.

Mean sugar intake by all age groups was 25.6±23.15 g sugar/day (Table 2). Those aged >55 years had the highest consumption level (28.15±23.79 g/day). The study showed that 11.8% of the total population consumed >50 g sugar/day, and the highest proportion of individuals consuming this amount was adults aged 19 years and older (Table 2).

Figure 2 shows the demographic characteristics of the population consuming >50 g sugar/day. A greater proportion of males than females consumed this amount. Proportions were similar in urban and rural areas, and among different income levels.

3. FAO food balance sheet[25]

FAO food balance sheet data showed that from 2010 to 2013, the amount of sugar and sweeteners available for consumption in Indonesia increased from 14.33 to 16.98 kg/capita/year, equivalent to 39.3 and 46.5 grams/capita/day, respectively (Figure 3). This amount comprised approximately 5.2% and 5.9% of available calories in 2010 and 2013, respectively (Figure 3).

4. SUSENAS 1993-2012 data analysed by Food Security Agency, Ministry of Agriculture[26]

The Food Security Agency examined trends in per capita consumption of sugar using SUSENAS data. Results showed that sugar consumption decreased from 110 kcal/capita/day (~27.5 g sugar/d) in 1993 to 70 kcal/capita/day (~17.5 g sugar/d) in 2012.

5. SUSENAS 2002-2009[27]

Hardinsyah's[27] analysis of sugar intake using SUSENAS data showed that mean daily per capita intake of visible

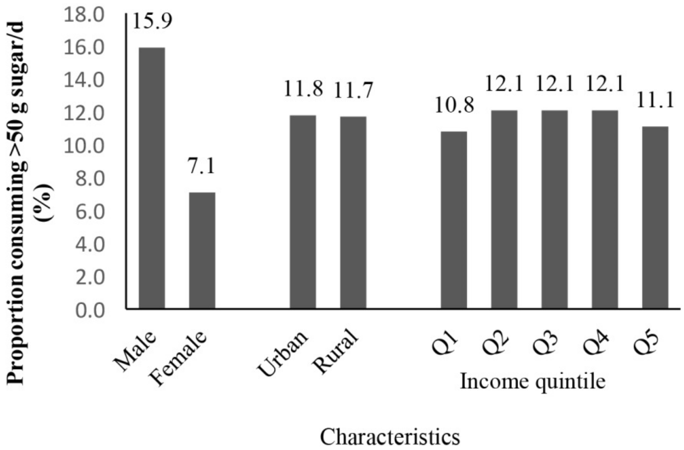

Figure 2. Proportion of population who consumed sugar >50 grams/day by demographic characteristics, Total Diet Study, Indonesia 2014. Source: Analysed from 2014 Total Diet Study (unpublished results).

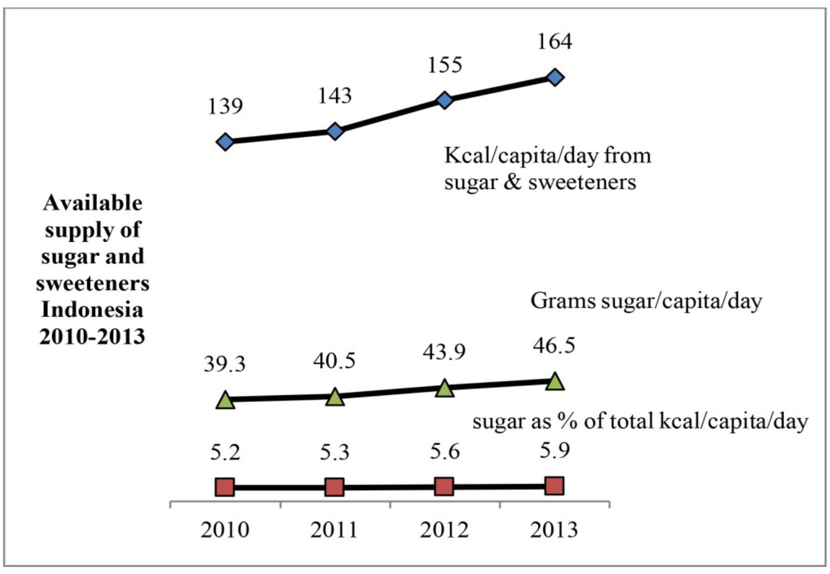

Figure 3. Trends in available per capita sugar and sweeteners supply, Indonesia 2010-2013. Source: Computed from FAOSTAT food balance sheet data.[25]

sugar was 28.3 g, 26.2 g, and 23.8 g in 2002, 2007, and 2009, respectively. In 2009, the proportion of energy from visible sugar was 4.8%, well within the recommendation in the Indonesian dietary guidelines, with some individuals exceeding dietary recommendations.

6. RISKESDAS 2010[28]

The National Basic Health Research (RISKESDAS) provides evidence for policy makers on key health areas such as health status, nutrition status, food consumption, health environment, health attitude, and health service utilization. In 2007, data including biomedical data were collected on a nationally representative sample of 258,284 households comprising 972,989 individuals.[29] Perdana[28] analysed food consumption patterns of adult females aged 19-55 years using data from the 2010 RISKESDAS. Added sugar was among the least consumed food groups with average consumption of 2.4±12.5 g/day.

Individual studies

Only one published study among younger age groups was found. Compared with national surveys, results of published studies suggested higher levels of sugar consumption in all age groups and that younger individuals consumed more sugar than older ones. This is in contrast to data from the latest 2014 Total Diet Study showing that adults particularly those age >55 years consume more sugar than younger ones.

Studies among children

Mulyani and McIntyre's[30] study among children aged 7 to 19 years living in orphanages in Medan found that mean daily sugar consumption was 60 grams per child per day, with consumption rate increasing slightly during the fasting month of Ramadhan.

Studies among adults

Guelinckx et al[31] found that based on free sugar intake from fluid consumption alone, 10.9 % of Indonesian subjects exceeded the WHO recommendation of sugar consumption <10% of total energy.

Antono et al[18] found that individuals with and without diabetes consumed 73.2 and 33.8 g added sugar/day, respectively. In contrast, Lipoeto et al's[32] study among individuals with and without cardiovascular disease showed that those with CVD consumed approximately 34.6 g sugar/day (i.e., ~7.8% of energy intake), while healthy controls consumed approximately 31.6 g/day (i.e., ~7.6% of energy intake).

Hartini[33] examined the effect of the economic crisis (i.e., before, early transition, and during the crisis) on food habits and dietary intakes of pregnant women in Central Java. Results showed that mean levels of sugar intake displayed a stable pattern (no significant differences) across these three time periods – i.e., 44, 41, and 46 g/day respectively.

Studies among elderly

Setiati et al[34] conducted a multicenter cross-sectional study in 13 hospitals in 15 cities across Indonesia, covering 387 elderly outpatients aged 60 years and over, using a single 24-hour recall. The average amount of ingested sugar products was 40.1 g/day among men and 43.9 g/day among women, contributing about 12.2% and 14.2% of energy intakes, respectively.

Contribution of sugar and sweeteners to carbohydrate intake

1. FAO food balance sheet[25]

Calories ingested from carbohydrate sources (cereals, starchy roots, pulses, vegetables and fruits) were extracted from FAO food balance data. In 2013, total per capita caloric intake from these foods was 2202 kcal/day. Sugar and sugar crops contributed approximately 7.4% (164 kcal/day) of calories from carbohydrate foods (Figure 4).

2. 2014 Total Diet Study

Figure 5 shows the contribution of sugar and confectionery to carbohydrate intake of different age groups. Results showed a U-shaped distribution wherein sugar contributed higher percentages of the carbohydrate intakes of the youngest and oldest age groups (21.2% and 23.3% of carbohydrate intake, respectively). Males, urban residents, and individuals from higher socio-economic classes consumed greater amounts of sugar as a proportion of total carbohydrates.

3. Individual studies

No studies were found that examined the contribution of added sugar to children's carbohydrate intake. Studies suggested that among adults and the elderly, sugar comprised more than 10% of carbohydrate intake.

Studies among adults

Antono et al's[18] study among respondents with and without diabetes indicated that added sugar contributed approximately 17.1 and 13.1% of their carbohydrate intake, respectively. Similarly, Lipoeto et al's[32] study indicated that sugar comprised approximately17.0% and 15.4% of carbohydrate intake of individuals with and without CVD, respectively (Table 2).

Studies among elderly

Data from Setiati et al's[34] study indicated that sugar products comprised approximately 21.8% and 26.8% of the carbohydrate intake of men and women, respectively.

Sources of added sugar

Results of studies that examined sources of added sugar are summarized in Table 3. Nationwide surveys suggested that table sugar (cane and brown sugar), sweetened condensed milk, and syrup are common sources of added sugar. Published studies did not mention table sugar but showed other similar food sources (i.e., sweetened beverages, condensed milk, desserts and confectionery).

Nationally representative studies

1. SUSENAS 2014[19]

Sugar and foods with added sugar were selected from the list of consumed food items provided in SUSENAS 2014. Results suggested that per capita mean intakes of sugar and sweetened foods were within recommended amounts (i.e., below 10% of energy intake) (Table 3). Sweetened foods that contributed most to caloric intake (approxi-

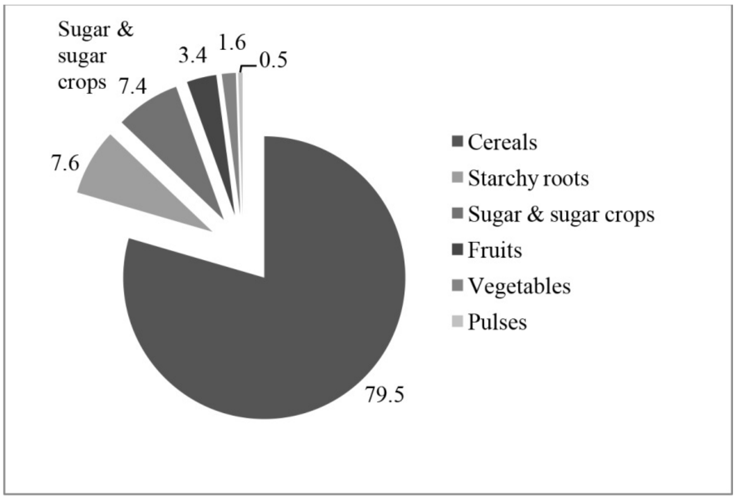

Figure 4. Sugar and sugar crops as percentage of per capita calories available from carbohydrate source foods, Indonesia 2013. Source: Computed from FAOSTAT food balance sheet data.[25]

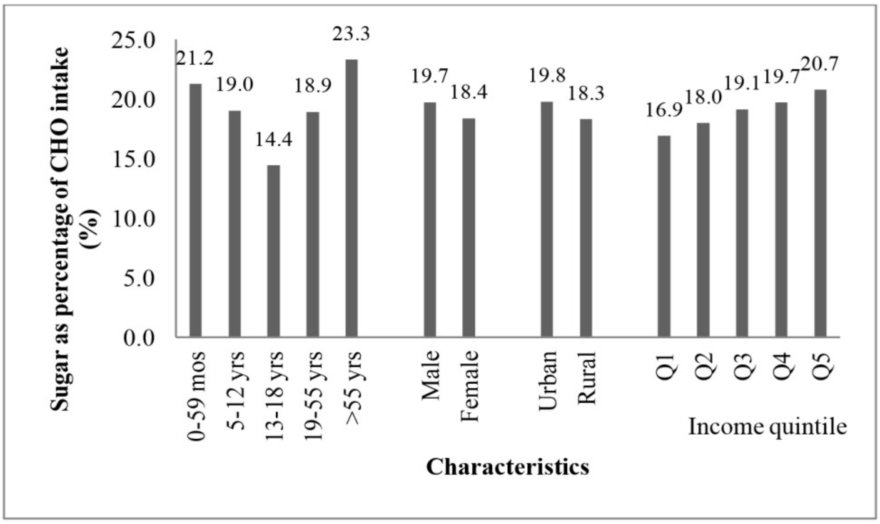

Figure 5. Percentage contribution of sugar and confectionery intake to carbohydrate intake per day by demographic characteristics Indonesia 2014. Source: Analysed from 2014 Total Diet Study (unpublished results).

mately 4%) were table sugar (cane and brown sugar) while *kue basah* or steam cake, *roti manis* or sweet breads, and cookies together contributed approximately 2%. Beverages such as packed tea, packed juices, and soda/CO_2 drinks appeared to contribute very little (<1%) to per capita caloric intake.

2. 2014 Total Diet Study

Unpublished data for the 2014 Total Diet Study obtained from the Health Ministry showed that, in the population consuming >50 g sugar per day, table sugar contributed the greatest proportion (58%) of total sugar intake. This was followed by wheat products (8.5%), milk products (8.3%), tea drinks (5.1%), fruit juice (3.9%), condiments (2.5%), candies and chocolates (2.4%), other drinks and carbonated drinks (2.7%).

Per capita consumption of sugar and foods with added sugar (beverages and sweet liquid milk) by different age groups are also shown in Table 3. Approximately 16 grams of sugar and confectionery consisting of raw sugar (*gulapasir, gulamerah, gulaaren, gulakelapa*), syrup, candy, honey, etc. were consumed daily by all age groups. Other sources of sugar –i.e., beverages and sweet liquid milk– were consumed at approximately 25 and 3.6 mL/day, respectively. Older adults aged >55 years were the highest consumers of sugar and confectionery, while younger ages (0-18 years) were the highest consumers of beverages. Infants and children below 12 years were the highest consumers of sweet liquid milk. Sweet foods commonly consumed in all age groups were jelly/gelatin and syrup. Younger age groups consumed more jelly or gelatin, while older age groups consumed more syrup.

3. RISKESDAS 2013[35] and RISKESDAS 2008[36]

RISKESDAS data showed that in 2013, 53.1% of the population aged 10 years and above consumed sweet foods/drinks once or more daily, representing a decrease from 65.2% in 2008. In 2013, 13.4% of the population aged 10 years and above ingested sweet biscuits once or more daily.

4. *SUSENAS 1999-2002[36]*

A report by Molyneaux and Rosner[36] on the changing patterns of Indonesian food consumption showed that,

Table 3. Results of studies on sources of added sugar in Indonesia

Author (yr)	Age group	Sweet food items	Estimated daily per capita intake (kcal)†		Percentage contribution to daily per capita calorie intake‡ (%)			Estimated quantity of intake/capita/day†
Nationally representative studies								
SUSENAS (2014)†19	N/A	Cane sugar & brown sugar	72.99		3.91			19.92 gm
		Kue basah/boil or steam cake	14.32		0.77			0.1 *buah* (unit)
		Sweet canned liquid milk	11.81		0.63			3.52 gm
		Roti manis/other bread	11.01		0.59			0.07 *potong* (piece)
		Kue kering/biskuit/cookies	10.41		0.56			2.44 gm
		Coffee/other drinks	6.20		0.33			0.1 *gelas* (glass)
		Other ice	3.46		0.19			12.34 mL
		Ice cream	2.01		0.11			0.01 *mangkukkecil*
		Packed tea	1.38		0.07			4.93 mL
		Packed juice	0.89		0.05			3.09 mL
		Syrup	0.91		0.05			0.53 mL
		Bubur kacang hijau/porridge of mung bean	0.76		0.04			0.01 *porsi* (portion)
		Health drink	0.35		0.02			0.44 mL
		Soda/ CO2 drink	0.18		0.01			0.75 mL
Total Diet Study (2014)§	All ages	Type of food contributing to sugar intake of the population consuming >50 g sugar/day	Contribution to sugar intake (%)					
		Sugar	58.0					
		Wheat products	8.5					
		Milk Products	8.3					
		Tea Drinks	5.1					
		Fruit Juice	3.9					
		Condiments	2.5					
		Candies and Chocolate products	2.4					
		Other Drinks	1.8					
		Carbonated Drinks	0.9					
		Starchy tuber products	0.4					
		Alcoholic Drink	0.4					
		Meat Products	0.2					
		Isotonic / Supplement Water	0.2					
		Rice products	0.1					
		Nuts, legumes and Seed Products	0.1					
		Poultry Products	0.1					
		Salt Water Fish products	0.1					
		Jam	0.1					
		Energy Drinks	0.1					
Total Diet Study (2014)§			Mean per capita intake of sweetened foods by age group					
		Type of food	0-59 mo	5-12 y	13-18 y	19-55 y	>55 y	All ages
		Beverage excluding tea, coffee (ml/day)	32.3±95	54.5±118	45.5±119	19.6±96	6.0±56	25.0±98.6
		Sugar & confectionery (g/day)	11.9±28.6	14.7±32.7	11.6±24.0	16.4±22.6	18.1±22.8	15.7±24.4
		Sweet liquid milk (cc/day)	22.6±88	10.2±52.3	3.6±30.1	1.8±22.8	0.7±12.1	3.6±32.7

†Computed from Executive Summary of Consumption and Expenditure of Indonesia.[19] ‡Based on mean energy intake= 1868.69 kcal/capita/day. §Analysedfrom 2014 Total Diet Study (unpublished results).
--- No published data.

Table 3. Results of studies on sources of added sugar in Indonesia (cont.)

Author (yr)	Age group	Sweet food items							
Total Diet Study (2014)[§]				Mean intake of sweetened foods (g/day) by individuals who consume these foods					
				0-59 mo	5-12 y	13-18 y	19-55 y	>55 y	All ages
		Sugar		7.5±7.5	8.4±8.2	8.7±8.6	10.2±9.0	10.1±8.6	9.9±8.9
		Brown & palm sugar		9.7±11.0	8.1±10.0	7.4±9.4	7.8±9.6	8.1±10.1	7.9±9.7
		Jam		8.4±8.5	10.6±7.4	12.1±7.2	11.5±7.5	10.3±7.7	11.2±7.5
		Candy		10.1±10.3	9.4±8.7	8.4±6.7	6.2±6.2	5.7±4.3	8.6±8.3
		Syrup		18.1±13.4	16.0±10.5	17.9±10.8	19.7±12.3	16.1±10.5	18.5±11.8
		Chocolate		10.5±11.9	12.0±11.9	12.2±10.6	10.8±11.9	7.6±5.7	11.0±11.5
		Jelly, gelatin		25.2±25.2	23.9±24.1	20.2±21.5	15.1±20.9	15.6±25.3	19.0±23.0
		Honey		11.4±8.6	11.4±4.5	14.4±6.6	14.5±8.8	13.7±8.3	14.1±8.6
		Sweeteners		6.4±7.4	2.7±4.3	2.9±4.9	5.1±6.8	3.7±5.5	4.5±6.3
		Male	Female	Both sexes					
Riskesdas (2013)[2]	≥10 yrs	---	---	- Proportion of the population aged ≥10 yrs consuming sweet foods/drinks once or more daily=53.1% - Proportion of the population aged ≥10 yrs consuming biscuits once or more daily=13.4%					
Riskesdas (2008)[35]	>10 yrs	67.2% consume sweet foods once or more daily	63.4% consume sweet foods once or more daily	Proportion of the population consuming sweet food/drinks once or more daily=65.2%					
Molyneaux&Rosner (2004)[36]	----	---	---	Sugar and drink mixes – real expenditure on this category increased by 25% from 1999 to 2002					
Individual studies									
Children									
Prawirohartono et al (2015)[37]	3-5 yrs	---	---	29.3% of children ingested sweetened condensed milk habitually					
Sekiyama et al (2012)[38]	1 to 12 years	---	---	Candies and desserts, soft drinks and juice drinks, sweets made from coconuts, sweet beans, flour or rice, together with other types of snacks (i.e., salty & savory), contributed up to 40% of energy intake					
Amalia et al (2012)[39]	12 yrs	---	---	59.1% of children consumed sugary foods & drinks ≥5 times a day					
Mulyani D, McIntyre J (2002)[30]	7-19 yrs	---	---	Sweet cakes, sugar incorporated in tea and breakfast porridge					
Adults									
Guelinckx et al (2015)[31]	≥18 yrs	---	---	Type of beverage consumed		Liters/day (95% CI)		Equivalent Kcal/day (95% CI)	
				Hot beverages		0.26 (0.24, 0.27)		52 (48, 55)	
				Juices		0.02 (0.01, 0.02)		8 (6, 9)	
				Regular sweetened beverages		0.17 (0.15, 0.20)		74 (64, 84)	
Antono et al (2013)[18]	20-40 yrs	---	---	Soda, flavoured syrup drinks, sweet beverages, sweet desserts, candies, sweet snacks, chocolate, ice cream, juice, coffee, tea					

†Computed from Executive Summary of Consumption and Expenditure of Indonesia.[19] ‡Based on mean energy intake= 1868.69 kcal/capita/day. §Analysed from 2014 Total Diet Study (unpublished results).
--- No published data

based on SUSENAS estimates, real expenditure for sugar and drink mixes increased by 25% during the period 1999-2002.

Individual studies

Studies among children

Prawirohartono et al's[37] study among 249 pre-schoolers aged 3 to 5 years showed that 29.3% were fed sweetened condensed milk (containing 44% sugar) regularly. Sekiyama et al's[38] study on snack food consumption among 154 children aged 1 to 12 years in a rural village found that snack foods contributed approximately 40% of children's total energy intake. These included candies and desserts, sweetened carbonated beverages and fruit drinks, sweets made from coconuts, sweet beans, flour or rice, salty and savoury foods. In a study among children aged 7 to 19 years living in orphanages, Mulyani and McIntyre[30] found that sugar intake came from sweet cakes and sugar incorporated in tea and breakfast porridge. Amalia et al's[39] assessment of the frequency of sugary foods and drinks consumption among 12-year old schoolchildren found that 59.1% consumed these foods ≥5 times a day or more.

Studies among adults

Guelinckx et al's[31] study among 1366 Indonesian subjects found that regular sweetened beverages and hot beverages were sources of added sugar. Mean daily intake of regular sweetened beverages was 0.17 L/day while that of hot beverages was 0.26 L/day, providing 74 and 52 kcal/person/day respectively. Antono et al[18] identified soda and flavoured syrup drinks as significant sources of sugar (i.e., consumed >2 times and >5 times/week, respectively) among both diabetic individuals and non-diabetics. Other food sources for both healthy and diabetic respondents were sweet desserts, candies, sweet snacks, chocolate, ice cream, and beverages (juice, tea, coffee).

DISCUSSION

Levels and sources of added sugar intake

Nationwide surveys and studies that examined consumption levels of added sugar showed varying results. Indonesia's nationwide surveys[19,24] revealed low levels of sugar intake that fell within WHO recommendations (i.e., below 50 grams per day or below 10% of energy intake) and Indonesian guidelines (below 25 grams per day). Published studies suggested higher intake levels. One published study among children[30] showed intake levels above 50 grams per day. Among adults and the elderly, studies showed sugar intake levels above the Indonesian recommendation of 25 grams per day, but below the WHO recommendation of 50 grams per day. Common sources of added sugar shown in nationwide surveys were table sugar (cane or brown sugar), sweetened condensed milk and syrup, while those shown in published studies were sweetened beverages, condensed milk, sweet desserts and confectionery.

FAO food balance data showed that Indonesia's per capita supply of sugar and sweeteners in 2013 was approximately 46 g/day.[25] The FAO food balance sheet handbook[40] states that this amount reflects only the quantities reaching the consumer. The amount of sugar and sweeteners actually consumed may be lower than the quantity shown in the food balance sheet, depending on the degree of losses in the household (e.g., during storage, in preparation and cooking, as plate waste, quantities fed to domestic animals and pets or thrown away). However waste occurring in the household is excluded from food balance sheet data,[40] and no information for waste on sugar and sweeteners is found in the 2013 FAOSTAT website.

Although Indonesia's national surveys indicate low levels of sugar intake that fall within dietary recommendations, other types of studies suggest that there has been a shift in the local diet towards inclusion of more processed foods containing added sugars and fat, contributing to increased energy intake. In their study on food consumption patterns in Indonesia, Philippines, and Malaysia, Lipoeto et al[41] found that Western fast-foods were considered as snacks to be consumed occasionally, and that while many aspects of traditional diets were retained, more sugar was consumed and added to traditional recipes. Usfar and Fahmida[42] noted that the habit of consuming sweet foods daily was practiced by 65% of the population. The authors recommended that the following messages be included in the Indonesian Dietary Guidelines: 1) Limit the intake of soft drinks and fruit drinks sweetened with sugars; 2) Choose fresh fruits for snacks instead of sweet foods.

Increasing availability (and therefore consumption) of Western fastfoods containing high fat and sugar may also contribute to the increased level of obesity in Indonesia. Rahmawati and Handayani[43] compared the energy density per serving of Indonesian, Oriental, and Western recipe-based fastfoods currently available in Indonesia. Energy densities of Indonesian and Oriental fastfoods (1.47±0.09 kcal/g and 1.66±0.34 kcal/g, respectively) were significantly lower than that of Western fast-foods (2.46±0.21 kcal/g) ($p<0.05$).

Market reports indicate an increasing demand for sugar by the Indonesian population. Information from Euromonitor International in 2010[44] showed that consumer expenditure on sugar and confectionery increased from US$ 3.2 billion in 2007 to US$ 3.6 billion in 2009, and was projected to increase further to US$ 7.3 billion in 2014. This is consistent with recent reports that Indonesia's sugar imports were expected to increase by 29% in 2015, from 2.8 million metric tons in 2014 to 3.6 million metric tons in 2015, driven by increasing domestic demand for sweetened foods and beverages.[45] Deloitte[46] conducted a consumer insights survey in 2015 covering 2000 households in five major cities, to provide perspectives on Indonesian consumer spending habits by food product category and to identify shifts in consumer behaviour. Results showed increased spending in the Beverage and Packaged Food categories across all income levels. For Beverages, expenditures increased from 4-8% of total spending in the previous 2013 survey to 5-11% in 2015. For Packaged Food, expenditure increased from 12-27% in 2013 to 18-32% in 2015. The report also noted the potential for further growth in the Confectionery and Packaged Foods categories, as many low income consumers expressed their intention to increase future spending in these products. A 2014 EU-Indonesia Business

Network (EIBN) report[47] showed the following breakdown of retail sales for packaged foods in 2010-2012: dried processed food (33%), bakery products (15%), dairy products (11%), confectionery (9%), sweet and savoury snacks (6%), oils and fats (6%). The report also noted that the non-alcoholic drinks industry of Indonesia was worth approximately US$8.5 billion in 2013, with a growth rate of 10%. Compounded annual growth rates of various ready-to-drink (RTD) beverage products in Indonesia from 2006 to 2011 were: juice/juice drinks (16.3%), isotonic drinks (16.3%), dairy/soy (8.1%), coffee (7.5%), energy drinks (6.9%), tea (3.6%), carbonated drinks (2.1%).

It is likely that this increase in demand for sweetened processed and packaged foods (and their subsequent consumption) was not captured in the country's food consumption surveys. Hardinsyah[27] examined SUSENAS data on intakes of visible sugar for the period 2002-2009 and concluded that the resulting intake levels are an underestimation of actual intakes. Underestimation can be due to underreporting. In the 2003 Malaysian Adult Nutrition Survey, Mirnalini et al[48] found that under-reporting occurred in half of the study population. Under-reporting can be due to the survey method used, in this case a single 24-hour recall. Limitations of the 24-hour recall method include reliance on subjects' memory for identification of foods eaten and quantification of portion sizes, and the need for highly trained interviewers. Some individuals also tend to underestimate portion sizes particularly the less healthy foods, termed optimistic bias.[49] Such phenomena may be common among Southeast Asian populations, and should be further investigated so that steps can be taken to mitigate these errors when planning future surveys.

These changing food consumption patterns together with reduced physical activity likely contribute to a rapid increase in the prevalence of overweight and obesity,[50] which in turn increases risk of chronic disease. Comorbidities associated with obesity (including central obesity) that have been observed in Indonesian subjects include hypertension,[51-53] impaired glucose tolerance, insulin resistance, diabetes mellitus,[52,54-56] osteoarthritis,[57] metabolic syndrome,[58] obstructive sleep apnea syndrome,[59] and gout.[60] Sugar consumption has also been associated with undernutrition in Indonesia. Using data from two nationwide surveys conducted in 2007, Mauludyani et al[61] showed that a lower proportion of household expenditure on sugar was associated with reduced odds of wasting and undernutrition among children less than 2 years old.

Methodological limitations of studies in the review

There are different ways of measuring dietary intake. Dietary assessment methods aim to capture "usual" or long-term average intake because dietary recommendations are intended to be met over time and diet-health hypotheses are based on dietary intakes over the long term.[62] Twenty-four hour recalls are preferred, being less invasive than weighed records, and more accurate than food frequency questionnaires.[62]

All self-report dietary assessment instruments are prone to measurement error, defined as the difference between the true value of a parameter (e.g., actual intake) and the value obtained from a measure (e.g., reported intake).[63] Measurement error consists of random and systematic errors, and occurs both within and between individuals. Random error is an unpredictable source of error that contributes variability; it is addressed by repeating the number of measures. Systematic error, or bias, arises from the use of inaccurate instruments resulting in measurements that consistently depart from the true value in the same direction. It is addressed by using a reference instrument (gold standard) such as a biomarker against which the truth can be estimated and bias is corrected, and also through the use of statistical modeling methods to estimate usual intake distributions.[62-64]

The use of biomarkers overcomes the limitations of traditional dietary assessment methods. Biomarker concentrations in body fluids take into account bioavailability, metabolism, nutrient-nutrient interaction and excretion, and therefore provide better information on the bioavailable nutrient than dietary data.[65] Prior to developing overt clinical symptoms, body nutrient pools such as serum levels manifest initial changes, while tissue levels remain stable and exhibit change over a longer period. Continuing nutrient imbalance (deficiency or excess) over the long term then results in clinical manifestations of the disease.[65,66] The disadvantage is that biochemical methods are invasive and expensive to undertake.

Metabolomics has allowed the development of biomarkers that measure intake of specific foods rather than nutrients.[67] Correlating dietary biomarkers with disease biomarkers provides a more valid and precise approach to studying diet-disease relationships[67,68] and enables the development of more specific and practical dietary guidelines. Dietary biomarkers that have been examined for their ability to measure added sugar intake and found to be suitable include urinary sucrose, fructose, and combined sucrose/fructose,[69] and the abundance of a carbon stable isotope $\delta^{13}C$ in serum, fingerstick blood, and red blood cell alanine.[70,71] Joosen et al[69] showed that sucrose and fructose in 24-hour urine collections are sensitive indicators of dietary sugar intake and not influenced by BMI, allowing precise classification of individuals as either low or high sugar consumers. Nash et al[68] showed that the isotope ratios of $\delta^{13}C$ and $\delta^{15}N$ in red blood cells and hair predicted sugar intake in a Native American population, explaining approximately 52%, 47%, and 34% of the variance in intake of total sugars, added sugars, and sugar-sweetened beverages, respectively.

In the present review, all studies used interview methods to assess dietary intake and none made use of biomarkers.SUSENAS[19] used a household food consumption and expenditure questionnaire while the 2014 Total Diet Study[24] used a single 24-hour recall. Due to the discrepancy between a low level of reported food intake and high level of overweight and obesity as shown in these surveys, it is likely that the methods used in Indonesia's nationwide food consumption surveys failed to capture precisely the levels of intake of different groups. A single day of recall can estimate group mean intakes, but at least two or more days of recall are needed to estimate the distribution of usual intakes in a population and to determine individual adherence to dietary recommendations.[49,64]

New knowledge and implications for research

Present knowledge on metabolic effects of fructose

The most common dietary sugars are fructose, glucose, and sucrose. Fructose and glucose are naturally occurring monosaccharides present in fruits and honey. Sucrose is a disaccharide extracted from sugar cane and beets, comprising 50% glucose, 50% fructose. High fructose corn syrup is produced by hydrolysing cornstarch to glucose and converting glucose into fructose through enzymatic isomerization, resulting in a product containing 55% fructose and 45% glucose.[72] The primary types of sugar added to foods are sucrose, high fructose corn syrup, honey and other edible syrups.[72]

Studies indicate that excessive fructose intake under hypercaloric conditions has detrimental metabolic effects including dyslipidemia, elevated blood pressure, high plasma glucose, prothrombotic disorder, pro-inflammatory state, and associated cardiac and renal disease.[73] These effects are mediated by the intracellular production of uric acid. Dietary fructose is readily absorbed via glucose transporters and metabolized by the liver. When fructose enters hepatocytes and other cells (tubular cells, adipocytes, intestinal epithelial cells), it is completely metabolized by the enzyme fructokinase with consumption of ATP (adenosine triphosphate), resulting in decrease in intracellular phosphate and ATP depletion.[73] Its metabolism is unlike that of glucose, whose phosphorylation is tightly regulated so that ATP levels are never depleted. Uric acid is a product of fructose metabolism. Increased uric acid concentrationis a key mechanism to explain how fructose causes metabolic syndrome and cardiovascular disease.[73,74] Injurious effects of hyperuricemia include reduction in concentration of nitric oxide, induction of platelet aggregation, and pro-inflammatory activity. Impaired production of nitric oxide results in systemic and intrarenal vasoconstriction, renal microvascular disease, systemic hypertension, higher blood insulin concentration and peripheral insulin resistance, and increased secretion of hepatic triacylglycerol.[74,75] In humans, studies showed that uric acid is an independent predictor of hypertension, obesity, hyperinsulinemia, renal disease.[74] Studies have also demonstrated that increased dietary fructose stimulates salt absorption in the small intestine and kidney tubules, resulting in a state of salt overload and thus causing hypertension.[76]

In terms of effects on body composition, human experiments showed that dietary fructose contributes to increased visceral fat storage compared with glucose, and it is considered one of the nutrients to have potential impact on body fat distribution independent of its impact on overall adipose tissue accretion.[77] Visceral adiposity (intra-abdominal adipose tissue) is a better correlate of metabolic abnormalities than the amount of subcutaneous fat.[77] It is part of a phenotype including dysfunctional subcutaneous adipose tissue expansion and ectopic triglyceride storage with related cardiometabolic risk factors including hypertriglyceridemia, increased free fatty acid availability, adipose tissue release of pro-inflammatory cytokines, liver insulin resistance and inflammation, among others.[77] Compared with Caucasians, Asians are especially prone to visceral fat accumulation despite lower total adiposity values.[77] Tuan et al[78] reported that at the same age, sex and BMI, Indonesians have more body fat (and therefore more visceral fat and higher cardiovascular disease risk) than Chinese adults. Using data from the 2000 Indonesian Family Life Survey, the authors found that the optimal BMI cut-off for predicting hypertension among adults aged 18-65 years was 21-22.5 kg/m^2. Studies have also shown that even with relatively little weight gain, Asian populations exhibit pancreatic beta-cell dysfunction and increased risk of insulin resistance and diabetes.[79] In fact, a position statement from the American Diabetes Association recommended that testing for diabetes among Asian American adults (particularly those originating from Southeast Asia) be implemented at a BMI of ≥23 kg/m^2.[80]

It has been pointed out that there is no biological need for added sugars in the diet, and that added sugar particularly fructose is implicated in the development of diabetes mellitus and related metabolic derangements that raise cardiovascular risk.[10] While glucose is the main source of fuel for brain cells requiring approximately 130 gm carbohydrate/day, FAO/WHO recommend that this need be met by consuming whole grains, legumes, intact fruits and vegetables, rather than foods with added sugars.[81]

Future research directions

Soewondo et al[29] reported that Indonesia has the world's seventh largest number of diabetic patients in spite of a low prevalence, mainly due to the size of the population. In 2007, the national prevalence of diabetes was 5.7%, of which more than 70% of cases were undiagnosed.[29] In 2015, the International Diabetes Federation (IDF) reported a prevalence of 6.2% among Indonesian adults aged 20-79 years, comprising more than 10 million cases.[82] WHO estimates that in 2030, there will be more than 21 million Indonesians afflicted by the disease.[83] Diabetes risk factors for Indonesians were age, central obesity, hypertension, dyslipidemia, and smoking.[29] Soewondo et al[29] emphasized the need for prevention by way of food policy and information campaigns. Hence, accurate estimates of sugar intake levels in different population groups are needed and food sources that contribute significantly to sugar intake should be identified in order to guide intervention and policy, together with promoting healthier diet and lifestyle among Indonesians.

CONCLUSION

Due to methodological limitations in national surveys and few published studies with small sample sizes and varying methods, insufficient evidence exists regarding the levels and sources of added sugar intake in Indonesia. Limitations in the data obtained from Indonesia's nationally representative surveys arise from the use of household food consumption and expenditure information in SUSENAS and use of a single 24-hour recall in the Total Diet Study. Household consumption and expenditure surveys provide less accurate estimates compared with nationwide individual food consumption surveys. In terms of dietary assessment methods, a single

24-hour recall can estimate group mean intakes but cannot be used to estimate usual or long-term intake.

In order to definitively establish the levels and sources of sugar intake in Indonesia, there is a need for a nationally representative survey using valid and precise methods of data collection and analysis. Levels of sugar intake can be estimated more accurately by using biomarkers to validate dietary data, e.g., urinary fructose and glucose or isotope ratios of $\delta^{13}C$ and $\delta^{15}N$ in red blood cells and hair. Sources of added sugar can be identified using multiple 24-hour recalls or validated food frequency questionnaires. In contrast to using a single 24-hour recall, multiple recalls (at least two days) corrected for measurement error can estimate usual or long-term intake of total sugar from different food sources. Implementing improved methods to assess sugar consumption will provide reliable information on which to base policy decisions and to design more effective interventions.

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DISCLAIMER

The views expressed in this paper are those of the authors and do not reflect the views of their respective institutions. All authors read and approved the final report.

REFERENCES

1. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384:766-81. doi: 10. 1016/S0140-6736(14)60767-4.
2. Ministry of Health, Indonesia. Penyajian pokok-pokok hasil riset kesehatan dasar 2013. Badan Penelitian dan Pengembangan Kesehatan, Kementerian Kesehatan RI, 2013. [cited 2016/02/16]; Available from: http://www.depkes. go.id/resources/download/general/pokok2%20hasil%20riskesdas% 202013.pdf. (In Indonesian)
3. Fadjar E. Study: 15 Indonesian provinces have high prevalence of obesity. Tempo.Co Jakarta [newspaper online]. 2014/04/20 [cited 2016/02/15]; Available from: http://en.tempo.co/read/news/2014/04/20/055571863/Study-15-Indonesian-Provinces-Have-High-Prevalence-of-Obesity.
4. Johnson RK, Appel LJ, Brands M, Howard BV, LeFevre M, Lustig RH, Sacks F, Steffen LM, Wylie-Rosett J; on behalf of the American Heart Association Nutrition Committee of the Council on Nutrition, Physical Activity, and Metabolism and the Council on Epidemiology and Prevention. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. Circulation. 2009;120:1011-20. doi: 10.1161/CIRCULATIONAHA.109. 192627.
5. WHO. WHO Technical Report Series 916. Diet, nutrition and the prevention of chronic diseases. Geneva: WHO Press; 2003.
6. Bray GA. Energy and fructose from beverages sweetened with sugar or high-fructose corn syrup pose a health risk for some people. Adv Nutr. 2013;4:220-5. doi: 10.3945/an.112. 002816.
7. Tappy L. 'Toxic' effects of sugar: should we be afraid of fructose? BMC Biol. 2012;10:42. doi: 10.1186/1741-7007-10-42.
8. Bellisle F, Drewnowski A, Anderson H, Westerterp-Plantenga M, Martin CK. Sweetness, satiation, and satiety. J Nutr. 2012;142:1149s-54s. doi: 10.3945/jn.111.149583.
9. Ulrich-Lai YM, Ostrander MM, Herman JP. HPA axis dampening by limited sucrose intake: reward frequency vs. caloric consumption. Physiol Behav. 2011;103:104-10. doi: 10.1016/j.physbeh.2010. 12.011.
10. DiNicolantonio JJ, O'Keefe JH, Lucan SC. Added fructose: a principal driver of type 2 diabetes mellitus and its consequences. Mayo Clin Proc. 2015;90:372-81. doi: 10. 1016/j.mayocp.2014.12.019.
11. WHO. Guideline: sugars intake for adults and children. Geneva: WHO Press; 2015.
12. WHO. WHO calls on countries to reduce sugars intake among adults and children. 2015/03/4 [cited 2015/07/15]; Available from: http://www.who.int/mediacentre/news/releases/2015/sugar-guideline/en/.
13. WHO. Global report on diabetes. Geneva: WHO Press; 2016.
14. Van Horn L, Johnson RK, Flickinger BD, Vafiadis DK, Yin-Piazza S; on behalf of the Added Sugars Conference Planning. Translation and implementation of added sugars consumption recommendations: a conference report from the American Heart Association Added Sugars Conference 2010. Circulation. 2010;122:2470-90. doi: 10.1161/CIR. 0b013e3181ffdcb0.
15. Dietary Guidelines Advisory Committee. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010 to the Secretary of Agriculture and the Secretary of Health and Human Services. 2010/05 [cited 2015/07/15]; Available from: https://www.cnpp.usda.gov/sites/default/files/dietary_guidelines_for_americans/2010DGACReport-camera-ready-Jan11-11.pdf
16. US Department of Agriculture and US Department of Health and Human Services. Dietary guidelines for Americans 2010 7th edition. Washington DC: US Government Printing Office; 2010.
17. Soekirman. Taking the Indonesian history leap into betterment of the future generation: development of the Indonesian Nutrition Guidelines. Asia Pac J Clin Nutr. 2011; 20:447-51.
18. Antono L, Kurniati A, Angela A, Pertiwi K, Susana. The incidence of diabetes in Indonesian young adults: the importance of lifestyle compared to family history. 2013 International Conference on Food and Agricultural Sciences. ICPBEE. 2013;55:62-6. doi: 10.7763/ICPBEE.2013.V55. 12.
19. BPS-Statistics Indonesia. Executive summary of consumption and expenditure of Indonesia. Based on Susenas 2014. Jakarta: Sub directorate of Household Statistics, BPS-Statistics Indonesia. 2015 [cited 2015/07/15]; Available from: http://www.bps.go.id/website/pdf_publikasi/Ringkasan-Eksekutif- Pengeluaran-dan-Konsumsi-Penduduk-Indonesia--September-2014.pdf.
20. Amarra MSV, Khor GL, Chan P. Intake of added sugar in Malaysia: a review. Asia Pac J Clin Nutr. 2016;25:227-40. doi: 10.6133/apjcn.2016.25.2.13.
21. FAO. Carbohydrates in human nutrition. Rome: FAO; 1998.
22. Smith LC. The use of household expenditure surveys for the assessment of food insecurity. Rome: FAO; 2003.

23. Smith LC, Subandoro A. Measuring food security using household expenditure surveys. Food Security in Practice technical guide series. Washington DC: International Food Policy Research Institute; 2007.
24. Badan Penelitian dan Pengembangan Kesehatan. Studi diet total: survei konsumsi makanan individu Indonesia 2014. 2015 [cited 2015/07/15]; Available from: http://terbitan.litbang.depkes.go.id/penerbitan/index.php/blp/catalog/book/105.
25. FAO Statistics Division. FAOSTAT Food balance sheet. 2014 [cited 2015/07/21]; Available from: http://faostat3.fao.org/download/FB/FBS/E.
26. Indonesia Food Security Agency, Ministry of Agriculture. National nutrition strategy. Paper of Indonesia. Paper presented at FAO/WHO 2nd International Conference on Nutrition, Jakarta. 2013/12/17 [cited 2015/09/21]; Available from: http://www.fao.org/3/a-at618e.pdf.
27. Hardinsyah. Analisis konsumsi lemak, gula dan garam penduduk Indonesia. Gizi Indon. 2011;34:92-100.
28. Perdana SM. Balanced diet index development of adult females in Indonesia [thesis]. Indonesia: Bogor Agricultural University. 2014 [cited 2016/03/16]; Available from http://repository.ipb.ac.id/handle/123456789/68764.
29. Soewondo P, Ferrario A, Tahapary DL. Challenges in diabetes management in Indonesia: a literature review. Global Health. 2013;9:63.doi:10.1186/1744-8603-9-63.
30. Mulyani D, McIntyre J. Caries inhibitory effect of fluoridated sugar in a trial in Indonesia. Aust Dent J. 2002;47:314-20.
31. Guelinckx I, Ferreira-Pego C, Moreno LA, Kavouras SA, Gandy J, Martinez H et al. Intake of water and different beverages in adults across 13 countries. Eur J Nutr. 2015; 54(Suppl):S45-55. doi: 10.1007/s00394-015-0952-8.
32. Lipoeto NI, Agus Z, Oenzil F, Wahlqvist M, Wattanapenpaiboon N. Dietary intake and the risk of coronary heart disease among the coconut-consuming Minangkabau in West Sumatra, Indonesia. Asia Pac J Clin Nutr. 2004;13:377-84.
33. Hartini TS. Food habits, dietary intake and nutritional status during economic crisis among pregnant women in Central Java, Indonesia. [Dissertation]. Sweden: Umea University; 2004 [cited 2016/03/16]; Available from: https://www.diva-portal.org/smash/get/diva2:142668/FULLTEXT01.pdf
34. Setiati S, Harimurti K, Dewiasty E, Istanti R, Mupangati YM, Ngestiningsih D et al. Profile of food and nutrient intake among Indonesian elderly population and factors associated with energy intake: a multi-centre study. Acta Med Indones– Indones J Intern Med. 2013;45:265-74.
35. Ministry of Health, Indonesia. Report on result of National Basic Health Research (RISKESDAS) 2007. 2008 December [cited 2015/12/12]; Available from: http://labdata.litbang.depkes.go.id/riset-badan-litbangkes/menu-riskesnas/menu-riskesdas/147-rkd-2007.
36. Molyneaux JW, Rosner LP. The changing patterns of Indonesian food consumption and their welfare implications. Indonesian Food Policy Program. Working paper no.15. 2004/05 [cited 2016/03/10]; Available from: http://pdf.usaid.gov/pdf_docs/Pnade890.pdf.
37. Prawirohartono EP, Lestari SK, Nurani N, Sitaresmi MN. Differences in nutrient biomarkers concentration by habitual intake of milk among preschool children in an urban area of Indonesia. J Hum Nutr Food Sci. 2015;3:1055.
38. Sekiyama M, Roosita K, Ohtsuka R. Snack foods consumption contributes to poor nutrition of rural children in West Java, Indonesia. Asia Pac J Clin Nutr. 2012;21:558-67.
39. Amalia R, Schaub RMH, Widyanti N, Stewart R, Groothoff JW. The role of school-based dental programme on dental caries experience in Yogyakarta Province, Indonesia. Int J Paediatr Dent. 2013;22:201-10. doi: 10.1111/j.1365-263X.2011.01177.x.
40. FAO. Food balance sheets: a handbook. Rome: FAO; 2001.
41. Lipoeto NI, Khor GL, Angeles-Agdeppa I. Food consumption patterns and nutrition transition in Southeast Asia. Public Health Nutr. 2013;16:1637-43. doi: 10.1017/S1368980012004569.
42. Usfar AA, Fahmida U. Do Indonesians follow its Dietary Guidelines? – Evidence related to food consumption, healthy lifestyle, and nutritional status within the period 2000-2010. Asia Pac J Clin Nutr. 2011;20:484-94.
43. Rahmawati W, Handayani D. Different recipes and energy density of Indonesia fast food on percentage of Indonesian daily value. Obes Control Ther. 2014;1:1-5.
44. International Markets Bureau. The Indonesian consumer – behaviour, attitudes and perceptions toward food products. Market analysis report. Agriculture and Agri-Food Canada; 2011 [cited 2016/03/16]; Available from: http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-region/southeast-asia/the-indonesian-consumer-behaviour-attitudes-and-perceptions-toward-food-products/?id=1410083148749#f.
45. Rusmana Y, Listiyorini E. Sugar imports rising 29% in Indonesia as drinks demand booms. Bloomberg News. 2014/08/26 [cited 2016/03/16]; Available from: http://www.bloomberg.com/news/articles/ 2014-08-25/raw-sugar-imports-seen-surging-29-by-indonesian-refiners-in-15.
46. Deloitte. Deloitte consumer insights: capturing Indonesia's latent markets. Deloitte Southeast Asia Ltd. 2015 [cited 2016/08/29]; Available from: http://www2.deloitte.com/content/dam/Deloitte/jp/Documents/consumer-business/cp/jp-cp-middle-class-indonesia-en.pdf.
47. EIBN (EU-Indonesia Business Network). EIBN sector reports. Food and beverage. 2014 [cited 2016/08/29]; Available from: http://www.flandersinvestmentandtrade.com/export/sites/trade/files/news/637150602213204/637150602213204_1.pdf.
48. Mirnalini K, Zalilah MS, Safiah MY, Tahir A, Siti Haslinda MD, Siti Rohana D, Khairul Zarina MY, Mohd Hasyami S, Normah H. Energy and nutrient intakes: findings from the Malaysian Adult Nutrition Survey (MANS). Mal J Nutr. 2008;14:1-24.
49. Baranowski T. 24-hour recall and diet record methods. In: Willett W, editor. Nutritional epidemiology. New York: Oxford University Press; 2013. pp. 49-69.
50. Roemling C, Qaim M. Obesity trends and determinants in Indonesia. Appetite. 2012;58:1005-13. doi: 10.1016/j.appet.2012.02.053.
51. Tesfaye F, Nawi NG, Van Minh H, Byass P, Berhane Y, Bonita R, Wall S. Association between body mass index and blood pressure across three populations in Africa and Asia. J Hum Hypertens. 2007;21:28-37. doi: 10.1038/sj.jhh.1002104.
52. Mihardja L, Delima, Manz HS, Ghani GL, Soegondo S. Prevalence and determinants of diabetes mellitus and impaired glucose tolerance in Indonesia (a part of basic health research/Riskesdas). Acta Med Indones – Indones J Intern Med. 2009;41:169-74.
53. Rizkiriani A, Khomsan A, Riyadi H. Obesity and hypertension among adolescents in Jakarta, Indonesia. Pak J Nutr. 2014;13:17-21.
54. Mihardja L, Soetrisno U. Prevalence and determinant factors for overweight and obesity and degenerative diseases among

young adults in Indonesia. JAFES. 2012;27:77-81. doi: 10. 15605/jafes.027.01.12.
55. Purnamasari D, Soegondo S, Oemardi M, Gumiwang I. Insulin resistance profile among siblings of type 2 diabetes mellitus (preliminary study). Acta Med Indones – Indones J Intern Med. 2010;42:204-8.
56. Pramono LA, Setiati S, Soewondo P, Subekti I, Adisasmita A, Kodim N, Sutrisna B. Prevalence and predictors of undiagnosed diabetes mellitus in Indonesia. Acta Med Indones – Indones J Intern Med. 2010;42:216-23.
57. Tamin TZ, Witjaksono F, Winokan MAC, Soewito F. The management for grade 1 obesity as the underlying disease of osteoarthritis. Maj KedoktIndon. 2009;59:129-33.
58. Soewondo P, Purnamasari D, Oemardi M, Waspadji S, Soegondo S. Prevalence of metabolic syndrome using NCEP/ATP III criteria in Jakarta, Indonesia: the Jakarta primary non-communicable disease risk factors surveillance 2006. Acta Med Indones – Indones J Intern Med. 2010;42: 199-203.
59. Supriyatno B, Said M, Hermani B, Sjarir DR, Sastroasmoro S. Risk factors of obstructive sleep apnea syndrome in obese early adolescents; a prediction model using scoring system. Acta Med Indones – Indones J Intern Med. 2010;42:152-7.
60. Padang C, Muirden KD, Schumacher HR, Darmawan J, Nasution AR. Characteristics of chronic gout in Northern Sulawesi, Indonesia. J Rheumatol. 2006;33:1813-7.
61. Mauludyani AV, Fahmida U, Santika O. Relationship between household expenditures on strategic foods and prevalence of undernutrition among children 0 to 23 months of age in Indonesia. Food Nutr Bull. 2014;35:440-8.
62. National Cancer Institute. Measurement error webinar series. U.S. Department of Health and Human Services. No date [cited 2015/07/30]; Available from: http://epi.grants. cancer.gov/events/measurement-error/.
63. Kirkpatrick S. Introduction to measurement error in dietary intake. National Cancer Institute, U.S. Department of Health and Human Services. [cited 2015/07/30]; Available from: http://appliedresearch.cancer.gov/measurementerror/ mews_webinar1.pdf.
64. National Cancer Institute. Dietary assessment primer. U.S. Department of Health and Human Services, National Institutes of Health. [cited 2016/02/02]; Available from: http://dietassessmentprimer.cancer.gov/.
65. Jacob RA, Milne DB. Biochemical assessment of vitamins and trace minerals. Clin Lab Med. 1993 [cited 2015/07/24]; Available from: http://pubag.nal.usda.gov/pubag/download PDF.xhtml?id= 44788&content=PDF.
66. WHO. Expert committee on medical assessment of nutritional status. WHO Technical Report Series No. 258. Geneva: WHO Press; 1963.
67. Scalbert A, Brennan L, Manach C, Andres-Lacueva C, Dragsted LO, Draper J, Rappaport SM, van der Hooft JJJ, Wishart DS. The food metabolome: a window over dietary exposure. Am J Clin Nutr. 2014; 99:1286-308. doi: 10.3945/ ajcn.113.076133.
68. Nash SH, Kristal AR, Hopkins SE, Boyer BB, O'Brien DM. Stable isotope models of sugar intake using hair, red blood cells, and plasma, but not fasting plasma glucose, predict sugar intake in a Yup'ik study population. J Nutr. 2014; 144:75-80. doi: 10.3945/jn.113.182113.
69. Joosen AMCP, Kuhnle GGC, Runswick SA, Bingham SA. Urinary sucrose and fructose as biomarkers of sugar consumption: comparison of normal weight and obese volunteers. Int J Obesity. 2008;32:1736-40. doi: 10.1038/ijo. 2008.145.
70. Jahren AH, Bostic JN, Davy BM. The potential for a carbon stable isotope biomarker. J Anal At Spectrom. 2014;29:75. doi: 10.1039/c3ja50339a.
71. Choy K, Nash SH, Kristal AR, Hopkins S, Boyer BB, O'Brien DM. The carbon isotope ratio of alanine in red blood cells is a new candidate biomarker of sugar-sweetened beverage intake. J Nutr. 2013;143:878-84. doi: 10.3945/jn. 112.172999.
72. Sigman-Grant M, Morita J. Defining and interpreting intakes of sugars. Am J Clin Nutr. 2003;78(Suppl):815s-26s.
73. Johnson RJ, Nakagawa T, Sanchez-Lozada LG, Shafiu M, Sundaram S, Le M, Ishimoto T, Sautin YY, Lanaspa MA. Sugar, uric acid, and the etiology of diabetes and obesity. Diabetes. 2013;62:3307-15. doi: 10.2337/db12-1814.
74. Johnson RJ, Segal MS, Sautin Y, Nakagawa T, Feig DI, Kang D-H, Gersch MS, Benner S, Sanchez-Lozada LG. Potential role of sugar (fructose) in the epidemic of hypertension, obesity and the metabolic syndrome, diabetes, kidney disease, and cardiovascular disease. Am J Clin Nutr. 2007;4:899-906.
75. Jia G, Aroor AR, Whaley-Connell AT, Sowers JR. Fructose and uric acid: is there a role in endothelial dysfunction? Curr Hypertens Rep. 2014;16:434. doi: 10.1007/s11906-014-0434-z.
76. Soleimani M. Dietary fructose, salt absorption and hypertension in metabolic syndrome: towards a new paradigm. Acta Physiol (Oxf.). 2011;201:55-62. doi: 10. 1111/j.1748-1716.2010.02167.x.
77. Tchernof A, Despres J-P. Pathophysiology of human visceral obesity: an update. Physiol Rev. 2013;93:359-404. doi: 10.1152/physrev.00033.2011.
78. Tuan NT, Adair LS, Suchindran CM, He K, Popkin BM. The association between body mass index and hypertension is different between East and Southeast Asians. Am J Clin Nutr. 2009;89:1905-12. doi: 10.3945/ajcn.2008.26809.
79. Chan JCN, Malik V, Jia W, Kadowaki T, Yajnik CS, Yoon K-H, Hu FB. Diabetes in Asia: epidemiology, risk factors, and pathophysiology. JAMA. 2009;301:2129-40. doi: 10. 1001/jama.2009.726.
80. Hsu WC, Araneta MRG, Kanaya AM, Chiang JL, Fujimoto W. BMI cut points to identify at-risk Asian Americans for type 2 diabetes screening. Diabetes Care. 2015;38:150-8. doi: 10.2337/dc14-2391.
81. Mann J, Cummings JH, Englyst HN, Key T, Liu S, Riccardi G et al. FAO/WHO scientific update on carbohydrates in human nutrition: conclusions. Eur J Clin Nutr. 2007; 61(suppl):S132-7.
82. International Diabetes Federation. IDF Diabetes Atlas 7th edition. International Diabetes Federation. 2015 [cited 2016/03/22]; Available from: http://www.idf.org/ membership/ wp/indonesia.
83. WHO. Country and regional data on diabetes. World Health Organization; 2016 [cited 2016/03/22]; Available from: http://www.who.int/diabetes/facts/world_figures/en/index5.h tml.