REVIEW

A Scoping Review of Epidemiological Studies on Intake of Sugars in Geographically Dispersed Asian Countries: Comparison of Dietary Assessment Methodology

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ABSTRACT

Previous systematic reviews, which focused on sugar intake and its relation with health issues, were mainly conducted in Western countries, not Asian countries characterized by differences in dietary habits and disease prevalence. The scarcity of Asian studies may be attributed to the lack of assessment tools for estimating sugar intake. To provide an overview of the epidemiological studies on sugar intake in Asian countries, with a primary focus on dietary assessment methodology for estimating sugar intake, we conducted a scoping review of the epidemiological studies estimating sugar intake in Asian countries (the United Nations' definition) and Taiwan using PubMed and Web of Science. Study quality was evaluated based on its assessment of sugar intake in the whole diet, dietary assessment methods, and data sources used for estimating sugar content. We identified 143 studies from 136 publications from Eastern ($n = 63$), Southern ($n = 30$), South-Eastern ($n = 26$), and Western ($n = 24$) Asia. Total sugars were investigated in 95 studies, while 23–30 studies investigated sucrose, fructose, added sugars, and free sugars. The main aim of the selected studies was assessment of diet–disease relations ($n = 85$) and estimation of dietary intake ($n = 40$), and 62 studies assessed sugars as the primary exposure/outcome. A total of 120 studies assessed sugar intake in the whole diet, and 62 studies used validated FFQs or multiple-day dietary assessment methods. Only 41 studies used country-specific comprehensive food-composition databases or directly measured sugar content. Only 17 studies reported high-quality data. This review elucidated a sufficient number of epidemiological studies estimating sugar intake across Asian countries; however, most studies reported low-quality data. The results from our review showed that both feasible and validated dietary assessment methods, as well as comprehensive country-specific sugar-composition databases, are essential for producing high-quality studies with accurate sugar intake to examine its association with health outcomes. *Adv Nutr* 2022;13:1947–1973.

Statement of Significance: This scoping review provides a comprehensive overview of the epidemiological studies on intake of sugars in Asian countries and suggests the necessity of feasible and validated dietary assessment methods and comprehensive country-specific sugar-composition databases in individual Asian countries.

Keywords: sugar, FFQ, food-composition database, dietary assessment methodology, epidemiological study, Asia

Introduction

Recently, dietary sugars have attracted much attention due to their influence on human health. Several countries and regional or global bodies have developed guidelines to limit intake of sugars mainly added during manufacturing, cooking, and at the table (i.e., added and free sugars) (1, 2). For instance, the USDA (3) suggests limiting the individual intake of added sugars to less than 10% of the daily total energy intake to maintain an appropriate energy intake (4). Meanwhile, the WHO (5) recommends the overall reduction of intake of free sugars to prevent weight gain (6) and strongly recommends reducing the free sugar intake to less than 10% of the daily total energy intake and conditionally recommends reducing it to less than 5% to prevent dental

caries (7). Several systematic reviews have focused on intake of sugars (8, 9) and their relation with health issues, such as dental caries (7), overweight (6), type 2 diabetes (10), and cardiovascular risk factors (11–13). However, the studies included in these reviews were conducted mainly in Western countries. Such comprehensive reviews are unavailable for Asian countries, where individuals presumably have different dietary habits and disease profiles (14, 15). Some Asian countries have reported on reviews focusing on sugar(s) intake and its food sources; nonetheless, they only evaluated the individual country rather than Asia as a whole region (16–19). Furthermore, the majority of reported sugar(s) intake is in the form of sugary foods, including sweeteners (16–19).

Fewer studies on the intake of sugars in the Asian population are possibly attributed to the lack of assessment tools—namely, food-composition databases (FCDs) and validated dietary assessment tools for its estimation. This necessitates developing feasible assessment tools for the target nutrients before investigating the associations between their intake and health effects in nutritional epidemiological studies (19, 20). Unlike Western countries (21–23), limited Asian countries have country-specific FCDs with information on the content of total sugars (i.e., the sum of monosaccharides and disaccharides), monosaccharides, and disaccharides (24–34). The majority of these countries have introduced the contents of total sugars and saccharides in the last decade. However, information on the content of sugars is still unavailable in FCDs developed in other Asian countries (35–41). Meanwhile, there have been no country-specific FCDs with information on the contents of added and free sugars in Asian countries; by contrast, only limited Western countries have such FCDs (22, 42). In addition, FFQs developed for estimating dietary intake in Asian populations have not been validated to estimate intake of sugars (43–49), partly due to the lack of content of sugars in country-specific FCDs. The use of these FFQs could lead to ambiguous findings, particularly in epidemiological studies with intake of sugars as the primary exposure/outcome. In addition, sugars are nonessential nutrients; thus, the public health priority of assessing their intake and influence on health status may have been lower than the priority of assessing micronutrients in Asian countries. Moreover, the rising prevalence of overweight/obesity in Asian countries (15) increases the need for epidemiological studies on sugars and methodologies to estimate their intake as an energy-providing nutrient.

This scoping review aimed to provide an overview of the epidemiological studies on intake of sugars in Asian countries, mainly focusing on the dietary assessment methodology for estimating intake of sugars. It is essential to evaluate the availability and quality of the dietary assessment tools as they possibly influence the availability and accuracy of the estimated intake of sugars and their relation with health outcomes.

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Abbreviations used: DR, dietary record; FCD, food-composition database; PROSPERO, Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews.

Methods

This scoping review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PROSPERO) (50, 51). The review protocol was not registered in PROSPERO since it does not accept protocols for scoping reviews.

Search strategy

To identify epidemiological studies estimating the intake of sugars in Asian countries, one of the authors (AF) searched the PubMed and Web of Science Core Collection databases on 26 February 2021, without a restriction on the publication date. The search strings used were related to the following terms: *1*) sugar, *2*) dietary intake, and *3*) study field and population (i.e., Asian countries and population) (**Supplemental Table 1**).

Studies that met the following criteria were eligible for this review: *1*) published in English; *2*) full-text articles in peer-reviewed journals; *3*) conducted among the inhabitants of Asian countries (without restrictions on participant characteristics, such as age, health status including pregnancy and lactation, and whether free-living or not); *4*) estimating the self-selected dietary intake of sugars in participants (without restrictions on the type of diet, e.g., vegan diet); and *5*) assessing dietary intake using self-, guardian-, or interviewer-administered dietary assessment methods [e.g., dietary record (DR), 24-h dietary recall, and FFQ], including their electronic versions at the individual level. The study design was not restricted. The Asian countries were defined as 48 countries and 2 regions listed in the United Nations geoscheme for Asia (52) and Taiwan. We considered sugars as nutrients and defined them as total sugars (including simple sugars/carbohydrates); monosaccharides, such as glucose, fructose, and galactose; disaccharides, such as sucrose, maltose, lactose, and trehalose; and added, free, non-milk extrinsic, or naturally occurring sugars.

Publications that met the following criteria were excluded: *1*) reviews, case reports, proceedings, and abstracts; *2*) studies on the content of sugars in food items or dishes; *3*) non-human studies; *4*) studies using food supply data; *5*) studies in Asian-origin populations conducted in non-Asian countries; *6*) studies using only a biomarker (e.g., blood or urinary glucose) for estimating intake of sugars; 7) studies that regulated the dietary intake for an experiment or treatment; and *8*) those estimating only the intake of table sugar or the total weight of sugar-containing food items.

Study selection

Publications retrieved from the 2 databases were exported as CSV files and imported into Microsoft Excel 2019 MSO

(Microsoft Corporation). Duplicate publications were identified and eliminated using the PubMed IDentifier. One author (AF) screened the titles and abstracts of all publications for their eligibility and manually searched their reference lists to identify additional potentially relevant publications. Subsequently, the same author (AF) and a review team comprising 3 authors (YO, FO, and MS) retrieved and independently investigated complete texts of the screened publications. All disagreements were discussed and resolved by consensus or by another author (SS), if necessary.

Data charting

One author (AF) conducted data charting using a standardized form explicitly developed for this review, and the review team (YO, FO, and MS) assessed the extracted data. The following information was extracted: the name of the first author, the year of publication, country, target population, survey name and year, characteristics of the study population (sex, age, and sample size), study design, the main aim of the study, dietary assessment method, if the dietary assessment was conducted for the whole diet or specific foods (e.g., sugary foods) or occasions (e.g., snacking), data sources used for estimating content of sugars, if the same database was shared with other nutrients, the types of sugars estimated, and the definitions and estimation methods for added and free sugars. We extracted the definitions of added and free sugars due to the inconsistent definitions between countries and organizations and between different versions of FCDs in 1 particular country (53). For instance, the Dietary Guidelines for Americans considers total sugars in both fruit and vegetable juice concentrates as added sugars (4). In contrast, the Food Patterns Equivalents Database 2011–2012 considers total sugars only in fruit juice concentrates as added sugars, whereas the earlier versions included neither (42). Similarly, in the United Kingdom, total sugars in both fruit and vegetable juices and their concentrates are considered free sugars (54), whereas the WHO definition of free sugars includes only those in fruit juices and their concentrates (5). Furthermore, we extracted the estimation methods of added and free sugars because their content in food items was unavailable in Asian country–specific FCDs. The content of added and free sugars in food items should be estimated in individual studies based on the saccharide content of the ingredients (55). We did not extract the intake of individual sugars because our objective was to provide an overview of the studies and to investigate the dietary assessment methodology used to assess intake of sugars, rather than estimating the representative intake of sugars in each population.

One author (AF) manually searched the reference lists of publications selected for the review as well as websites of governments, national institutions, and companies to obtain information on dietary assessment questionnaires and FCDs. Each population was considered as a different study when a single publication investigated several populations from different countries. Each publication with a different study purpose was regarded as a different study when several publications reported the results of the same study population.

Assessment of study quality and synthesis of results

We evaluated the quality of each study based on the following components of the methodology: assessing intake of sugars from the whole diet, dietary assessment method, and data sources used for estimating content of sugars. To assess intake of sugars from the whole diet, we classified studies as having "sufficient" quality if they assessed intake of sugars from whole dietary sources and for all occasions of dietary intake. We included this criterion because intake of sugars estimated from limited dietary sources and occasions leads to its underestimation. For the dietary assessment method, we considered studies as having "sufficient" quality if they assessed dietary intake using DRs, dietary recall, diet history over multiple days, or a dietary assessment questionnaire validated for estimating the intake of sugars. This criterion was applied to assess if each study estimated reliable and habitual dietary intake. Regarding the data sources used for estimating content of sugars, we considered studies as having "sufficient" quality if they predominantly used an FCD developed in individual countries and included the content of sugars for the majority of food items within the database. If the latter information was unavailable, we considered the FCD that included the content of sugars in the comprehensive food items. Furthermore, studies that directly measured the content of sugars in food items were considered to be of "sufficient" quality. We assigned a score of 1 point to each of the 3 items upon classifying the studies to be of "sufficient" quality. Studies that scored 3 points were considered to have reported high-quality data; however, this procedure did not necessarily guarantee the quality of the overall study.

We performed a narrative synthesis of the findings from individual studies, in terms of regions and countries, study characteristics and main aims, dietary assessment methodology of intake of sugars, main aims and study quality, and the types of estimated sugars. Microsoft Excel 2019 MSO was used to generate all figures. One author (AF) scored and tabulated the studies, which were thereafter assessed by the review team (YO, FO, and MS).

Results

We identified 15,508 articles through the database search, of which 10,496 were retrieved following the removal of duplicates (**Figure 1**). We reviewed the titles and abstracts of all articles to determine their eligibility; eventually, 179 publications were considered eligible. Furthermore, we reviewed the reference lists from these publications to identify additional articles, of which 12 articles were considered eligible. After excluding 55 publications identified by the full-text search that met the exclusion criteria, we included 143 studies from 136 publications (of which 3 publications each reported different populations from 2 countries, and 1 publication reported different populations from 5 countries).

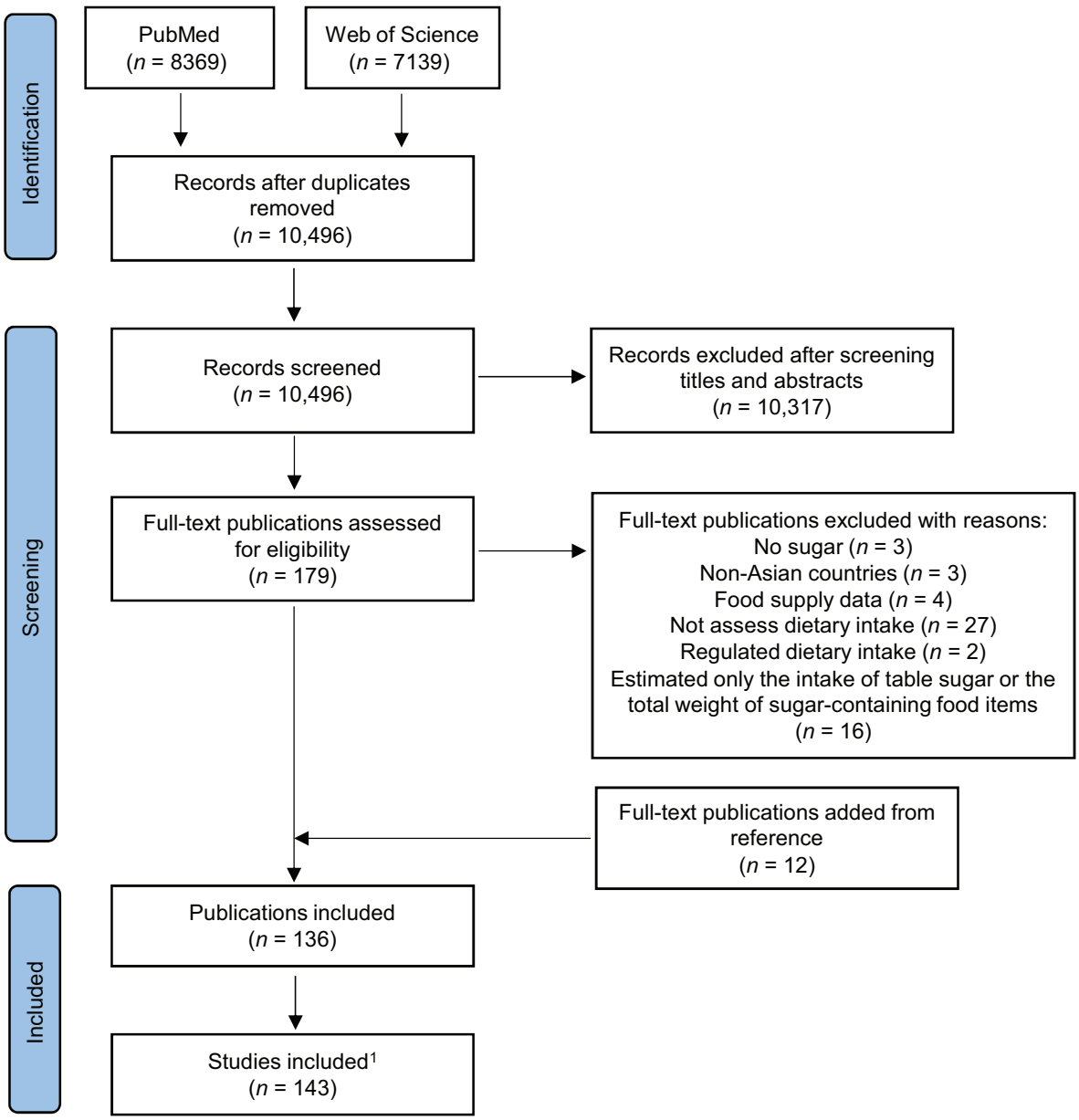

FIGURE 1 Flow diagram of the study selection process of epidemiological studies on intake of sugars in Asian countries. [1]Three publications each reported different populations from 2 countries, and 1 publication reported different populations from 5 countries.

Study characteristics and main aims

The study characteristics and main aims of the 143 studies are shown in **Supplemental Table 2**. Of these studies, 63 were from Eastern Asia (36 from Japan, 13 from Korea, 11 from China, and 3 from Taiwan), 26 from South-Eastern Asia (14 from Malaysia, 4 from Thailand, 3 each from Indonesia and Singapore, and 1 each from Cambodia and the Philippines), 30 from Southern Asia (23 from Iran, 6 from India, and 1 from Pakistan), and 24 from Western Asia (5 from Jordan, 4 from Israel and Saudi Arabia, 3 from Cyprus, 2 each from Kuwait and Turkey, and 1 each from Bahrain, Lebanon, State of Palestine, and United Arab Emirates), with no studies from Central Asia (**Figure 2**).

The first study that met the inclusion criteria was published approximately 50 y ago (i.e., in 1973), whereas more than 80% of the studies ($n = 116$) were published after 2010. Approximately 90% of the studies ($n = 126$) included both men and women. The median sample size was 829 (range: 22–46,238), except for 1 study, which did not indicate the number of participants. There were approximately twice as many studies ($n = 91$) comprising adults aged ≥18 y as those including children aged <18 y ($n = 42$), excluding 4 studies, which did not report on participants' age; the remaining 6 studies included both age groups. Approximately 75% of the studies ($n = 108$) were cross-sectional, followed by 14 case-control, 10 prospective cohort, 3 interventional, and 2 ecological studies.

FIGURE 2 Number of epidemiological studies on intake of sugars from each Asian country.

Approximately 60% of the studies ($n = 85$) investigated the diet–disease relation. Their outcomes were mainly metabolic disease or its indicators, including metabolic syndrome/cardiometabolic risk factors ($n = 19$), weight status/adiposity ($n = 17$), blood glucose/diabetes mellitus ($n = 7$), and cardiovascular disease ($n = 5$); in contrast, 6 studies focused on dental caries (**Table 1**). On the contrary, 40 studies predominantly focused on estimating dietary intake, and their main aim was to estimate the contribution of specific foods/dietary patterns/meal occasions to dietary intake ($n = 12$), energy/nutrient/food intake ($n = 11$), diet quality/adequacy ($n = 10$), and intake of sugars and their food source ($n = 7$). Of 9 studies pertaining to methodology, 6 were validation studies of FFQs. Five of the remaining 9 studies investigated the relation of nutrition education/knowledge and attitudes with dietary intake.

With regard to the exposure/outcome, 62 studies assessed sugars as the primary exposure/outcome, whereas the remaining 81 studies considered sugars as one of the several exposures/outcomes (e.g., one of several nutrients). Upon assessing the quality of studies based on the dietary assessment methodology, the prevalence of studies with high-quality data ranged from 10% (diet–disease relation: 10/85) to 22% (methodology: 2/9).

Dietary assessment methodology

More than the 80% of studies ($n = 120$) assessed intake of sugars from the whole diet (**Table 2** and **Figure 3**). The remaining studies assessed the whole dietary intake, but estimated intake of sugars from specific food items or occasions or particularly evaluated the intake of specific food items (i.e., sugary foods/beverages). More than 40% of the studies used validated FFQs ($n = 7$) or multiple-day dietary assessment methods ($n = 55$, including 24-h dietary recall, DR, and diet history). However, the remaining studies primarily used a nonvalidated dietary assessment questionnaire, including an FFQ ($n = 47$) or single-day dietary assessment methods ($n = 31$). With regard to the data sources used for estimating the content of sugars, 39 studies predominantly used a comprehensive FCD developed for commonly consumed food items in individual countries. In contrast, 2 studies directly measured the content of sugars in the food items. Other studies principally used an FCD for other countries ($n = 40$), an arbitrary FCD of commercial software from other countries ($n = 28$), an FCD developed for individual countries with information on content of sugars in restricted food items ($n = 15$), or information on food labels ($n = 2$). However, the remaining 15 studies did not specify the data sources. Eventually, only 12% (17/143) of the total studies and approximately 20% (12/62) of those with sugars as the primary exposure/outcome were considered to have reported high-quality data.

Types of estimated sugars

The intake of total sugars was estimated in 95 studies (66%), followed by the estimation of sucrose ($n = 30$), added sugars

TABLE 1 Main aims and quality of studies included in a scoping review of epidemiological studies on intake of sugars in Asian countries[1]

Main aim	Sugars are the primary exposure/outcome	Quality[2]		Reference no.
		High	Low	
Diet–disease relation		10[3]	75[3]	
Blood glucose/diabetes mellitus	Yes	1	1	High quality (89), low quality (90)
	No	1	4	High quality (91), low quality (92–95)
Blood lipids	Yes	0	3	(96–98)
Blood pressure	Yes	1	0	(89)
Cardiovascular disease	Yes	0	3	(99–101)
	No	1	1	High quality (102), low quality (103)
Dental caries	Yes	0	4	(100, 104–106)
	No	1	1	High quality (107), low quality (108)
Gastrointestinal disease	Yes	0	4	(110–113)
	No	0	3	(109, 114, 115)
Mental disorder	Yes	0	4	(116–119)
	No	0	2	(120, 121)
Mets/cardiometabolic risk factors	Yes	1	8	High quality (122), low quality (100, 101, 123–128)
	No	0	10	(36, 129–137)
Mortality	Yes	1	4	High quality (75), low quality (99–101, 138)
	No	1	0	High quality (102)
NAFLD/NASH	Yes	0	2	(139, 140)
	No	0	2	(141, 142)
Neoplasms	Yes	1	3	High quality (143), low quality (100, 144, 145)
Sleep disorder	Yes	0	3	(146–148)
Weight status/adiposity	Yes	2	6[4]	High quality (76, 149), low quality (99, 147, 150–152)
	No	2	7	High quality (107, 153), low quality (154–160)
Other	Yes	0	3	(138, 161, 162)
	No	0	7[5]	(163–168)
Estimate dietary intake		4[3]	36[3]	
Contribution of specific food/dietary pattern/meal occasion on dietary intake	Yes	1	5[6]	High quality (169), low quality (170)
	No	1	5	High quality (171), low quality (172–176)
Determinants of dietary intake	Yes	1	1	High quality (73), low quality (177)
	No	0	1	(178)
Diet quality/adequacy	Yes	0	2	(179, 180)
	No	1	7	High quality (171), low quality (181–187)
Energy/nutrient/food intake	No	0	11[7]	(188–197)
Intake of sugars and their food source	Yes	2	5	High quality (72, 73), low quality (177, 198–201)
Methodology		2	7	
Development/validation of dietary index/menu	No	0	3	(202–204)
Validation of FFQ	Yes	2	1	High quality (74, 205), low quality (206)
	No	0	3	(207–209)
Other		1	8	
Relation of nutrition education/knowledge and attitude with dietary intake	Yes	1	2	High quality (210), low quality (211, 212)
	No	0	2	(213, 214)
Other[8]	No	0	4	(215–218)

[1] Mets, metabolic syndrome; NAFLD, nonalcoholic fatty liver disease; NASH, nonalcoholic steatohepatitis.
[2] Quality of each study was evaluated based on 3 components of the methodology. A score of 1 point was assigned to each of the 3 items when the studies were classified to be of "sufficient" quality—that is, *1*) assessed intake of sugars from the whole dietary sources and for all occasions of dietary intake; *2*) assessed dietary intake using dietary record, dietary recall, diet history over multiple days, or dietary assessment questionnaire validated for estimating the sugar intake; and *3*) used a food-composition database developed in individual countries and included the content of sugars in most of the food items within the database. Studies that scored 3 points were considered to report high-quality data.
[3] Some studies had multiple objectives.
[4] Reference 150 reported on 2 populations.
[5] Reference 164 reported on 2 populations.
[6] Reference 170 reported on 5 populations.
[7] Reference 188 reported on 2 populations.
[8] Dietary intake was investigated as one of the participant characteristics.

TABLE 2 Dietary assessment methodology of intake of sugars in studies included in a scoping review of epidemiological studies on intake of sugars in Asian countries[1]

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Zhou, 2003 (188)	Eastern	China	Yes	Four 24-h recalls	Food-composition database in the UK and the US and published literature sources (219, 220)	No	2
Daviglus, 2005 (164)	Eastern	China	Yes	Four 24-h recalls	Food composition database in the UK and the US and published literature sources (219, 220)	No	2
Guelinckx, 2015 (170)	Eastern	China	All fluids	7-d DR	USDA National Nutrient Database for Standard Reference, release 27 (2014) (221)	—	1
Piernas, 2016 (36)	Eastern	China	Yes	Three 24-h recalls	USDA Food and Nutrient Database for Dietary Studies or National Nutrient Database for Standard Reference, release 27 (2014) (221)	No	2
Huo, 2017 (109)	Eastern	China	Yes	FFQ (not validated)	Database in FoodCalc software	Yes	1
Afeiche, 2018 (198)	Eastern	China	Yes	Three 24-h recalls	USDA National Nutrient Database for Standard Reference (2016) (222) and MyPyramid Equivalents Database, 2.0 (2003–2004) (223)	No	2
Liu, 2018a (99)	Eastern	China	Yes	FFQ (not validated)	Food Nutrient Finder from the Government of Hong Kong Special Administrative Region (2009) (81), information on ingredients of foods, and the USDA Pyramid Servings Database (224)	Yes	2
Liu, 2018b (138)	Eastern	China	Yes	FFQ (not validated)	Food Nutrient Finder from the Government of Hong Kong Special Administrative Region (2009) (81), information on ingredients of foods, and the USDA Pyramid Servings Database (224)	Yes	2
Wang, 2018 (172)	Eastern	China	Snacking occasions	A 24-h recall	USDA Food and Nutrient Database for Dietary Studies (2013–2014) (225)	No	0
Huang, 2019 (161)	Eastern	China	Soft drinks	FFQ (not validated)	NR	—	0
Zhang, 2019 (116)	Eastern	China	Soft drinks	FFQ (not validated)	NR	—	0
Kato, 1973 (96)	Eastern	Japan	Yes	A 24-h recall	STFCJ	Yes	1
Tillotson, 1973 (189)	Eastern	Japan	Yes	A 24-h recall	STFCJ, 3rd revision (1963) (57)	Yes	1
Kawate, 1979 (215)	Eastern	Japan	Yes	Diet history	NR	NR	1

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Ueshima, 1982 (97)	Eastern	Japan	Refined sugars added to foods and drinks, confectioneries, and soft drinks	A 24-h recall	STFCJ, 3rd revision (1963) (57)	Yes	0
Matsui, 1990 (110)	Eastern	Japan	Yes	Dietary interview	STFCJ	Yes	1
Egusa, 1993 (98)	Eastern	Japan	Yes	7-d diet history	STFCJ, 4th revision (1982) (226)	Yes	2
Zhou, 2003 (188)	Eastern	Japan	Yes	Four 24-h recalls	Food-composition database in the UK and the US and published literature sources (219, 220)	No	2
Daviglus, 2005 (164)	Eastern	Japan	Yes	Four 24-h recalls	Food-composition database in the UK and the US and published literature sources (219, 220)	No	2
Miura, 2006 (129)	Eastern	Japan	Yes	Four 24-h recalls	NR	NR	2
Nakamura, 2006 (114)	Eastern	Japan	Yes	Simplified Questionnaire for Food Intake State (not validated)	NR	NR	1
Toshimitsu, 2007 (141)	Eastern	Japan	Yes	NASH and simple steatosis: 3-d DR NHNSJ: 1-d DR	STFCJ, 5th revised and enlarged edition (2005) (227)	Yes	2
Takeichi, 2012 (199)	Eastern	Japan	Foods other than meals	Three 24-h recalls	Sugar-composition table for snacks and beverages in Japan (58, 59)	No	1
Shikanai, 2014 (150)	Eastern	Japan	Foods other than meals	Three 24-h recalls	Sugar-composition table for snacks and beverages in Japan (58, 59)	No	1
Wang, 2014 (144)	Eastern	Japan	Confectioneries and soft drinks	FFQ (not validated)	Starch- and sugar-composition table in Japan (228), USDA Food Composition Database (229), and information on Japanese websites	No	1
Guelinckx, 2015 (170)	Eastern	Japan	All fluids	7-d DR	USDA National Nutrient Database for Standard Reference, Release 27 (2014) (221)	—	1
Kikuchi, 2015 (216)	Eastern	Japan	Yes	FFQ (not validated)	STFCJ, 2010 (230)	Yes	1
Saido, 2016 (104)	Eastern	Japan	Yes	FFQ (not validated)	Japanese governmental reports, Saccharose Composition Table of Confectionaries in Japan (231), sugar-composition table for snacks and beverages in Japan (58, 59), books, and point of sales data	No	2

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Fujiwara, 2018 (72)	Eastern	Japan	Yes	Toddlers: 1-d DR Preschool and school children: 3-d DR Adults: 4-d DR	STFCJ, 7th revised edition (2015 and 2016) (27, 232), published literature sources, and food composition databases in the UK (23), the US (222), Australia (22), and Denmark (233)	No	3
Kanauchi, 2018 (181)	Eastern	Japan	Yes	FFQ (not validated)	STFCJ, 2010 (230)	Yes	1
Kromhout, 2018 (102)	Eastern	Japan	Yes	4-d or 7-d DR	Directly measured	Yes	3
Murakami, 2018 (173)	Eastern	Japan	Yes	1-d DR	Japanese starch- and sugar-composition database (72, 73)	No	2
Fujiwara, 2019 (73)	Eastern	Japan	Yes	3-d DR	STFCJ, 7th revised edition (2015 and 2016) (27, 232), published literature sources, and food composition databases in the UK (23), the US (222), Australia (22), and Denmark (233)	No	3
Kanehara, 2019 (74)	Eastern	Japan	Yes	14-d or 28-d DR	STFCJ, 7th revised edition (2015) (27)	Yes	3
Nagata, 2019 (75)	Eastern	Japan	Yes	FFQ (validated)	STFCJ, 7th revised edition (2015) (27)	No	3
Tomata, 2019 (182)	Eastern	Japan	Yes	FFQ (not validated)	STFCJ, 2010 (230)	Yes	1
Cho, 2020 (143)	Eastern	Japan	Yes	FFQ (validated)	STFCJ, 7th revised edition (2015) (27)	Yes	3
Fujiwara, 2020a (205)	Eastern	Japan	Yes	16-d DR	Japanese starch- and sugar-composition database (72)	No	3
Fujiwara, 2020b (179)	Eastern	Japan	Yes	1-d DR	Japanese starch- and sugar-composition database (72)	No	2
Fujiwara, 2020c (123)	Eastern	Japan	Yes	1-d DR	Japanese starch- and sugar-composition database (72)	No	2
Hashimoto, 2020 (111)	Eastern	Japan	Yes	FFQ (not validated)	STFCJ, 2010 (230)	Yes	1
Minato-Inokawa, 2020 (163)	Eastern	Japan	Yes	FFQ (not validated)	STFCJ, 2010 (230)	Yes	1
Murakami, 2020 (183)	Eastern	Japan	Yes	1-d DR	Japanese starch- and sugar-composition database (73)	No	2
Okuda, 2020 (124)	Eastern	Japan	Yes	FFQ (not validated)	Japanese starch- and sugar-composition database (72)	No	2
Yamakawa, 2020 (76)	Eastern	Japan	Yes	FFQ (validated)	STFCJ, 7th revised edition (2015) (27)	No	3
Fujiwara, 2021 (180)	Eastern	Japan	Yes	1-d DR	Japanese starch- and sugar-composition database (72)	No	2
Tajima, 2021 (171)	Eastern	Japan	Yes	3-d DR	Japanese starch- and sugar-composition database (72, 73)	No	3
Cho, 2010 (165)	Eastern	Korea	Yes	A 24-h recall	NR	NR	1

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Kim, 2011 (117)	Eastern	Korea	Snacks and beverages	Structured questionnaire for snacks (not validated)	Information on product labels, USDA National Nutrient Database for Standard Reference, Release 16 (2004) (234), and data of content of total sugars in snacks from Korea Food and Drug Administration (2007)	No	0
Kim, 2013 (118)	Eastern	Korea	Sweet foods	FFQ (not validated)	Content of total sugars in sweet foods in Korea (60)	No	0
Chung, 2015 (125)	Eastern	Korea	Yes	A 24-h recall	Total sugar composition table in Korea (77)	No	2
Hur, 2015 (122)	Eastern	Korea	Yes	3-d DR	Information from the Ministry of Food and Drug Safety, food company websites, product labels, Korea Food Research Institute, and revised data from the Rural Development Administration's research analysis	No	3
Ha, 2016a (149)	Eastern	Korea	Yes	3–7-d DR	Total sugar composition table in Korea (77)	No	3
Ha, 2016b (169)	Eastern	Korea	Yes	3–7-d DR	Total sugar composition table in Korea (77)	No	3
Nakitto, 2017 (178)	Eastern	Korea	Yes	A 24-h recall	Total sugar composition table in Korea (77)	No	2
Wang, 2018 (151)	Eastern	Korea	Yes	A 24-h recall	Sugar Database Compilation for Commonly Consumed Foods, 2015 in Korea (78)	No	2
Choi, 2019 (126)	Eastern	Korea	Yes	A 24-h recall	Total sugar composition table in Korea (77)	No	2
Seo, 2019 (127)	Eastern	Korea	Yes	FFQ (not validated)	Sugar Database Compilation for Commonly Consumed Foods, 2015 in Korea (78)	No	2
Shim, 2019 (100)	Eastern	Korea	Yes	A 24-h recall	Sugar Database Compilation for Commonly Consumed Foods, 2015 in Korea (78)	No	2
Yeom, 2019 (210)	Eastern	Korea	Yes	Three 24-h recalls	Korean food-composition table, 9th edition (2017) (28), ingredients food and nutrition from Korea Ministry of Food and Drug Safety (2017) (235), and USDA food-composition database (2018) (229)	No	3
Lee, 2008 (202)	Eastern	Taiwan	Yes	FFQ (not validated)	NR	NR	1

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Hou, 2014 (92)	Eastern	Taiwan	Yes	A 24-h recall	Food-composition database in Taiwan (included in Nutrition Chamberlain Line, Nutritionist Edition, Enhancement version 2002, E Kitchen Business Corporation, Taiwan)	Yes	2
Lin, 2016 (152)	Eastern	Taiwan	Sugar-sweetened beverages, snacks, and desserts	Three 24-h recalls	Sugar-composition table for snacks and beverages in Taiwan (61)	No	1
Shikanai, 2014 (150)	South-Eastern	Cambodia	Foods other than meals	Three 24-h recalls	Sugar-composition table for snacks and beverages in Vietnam	No	1
Guelinckx, 2015 (170)	South-Eastern	Indonesia	All fluids	7-d DR	USDA National Nutrient Database for Standard Reference, Release 27 (2014) (221)	—	1
Setyowati, 2018 (174)	South-Eastern	Indonesia	Yes	A 24-h recall	Database in Nutrisurvey 2007 software	Yes	1
Desmawati, 2019 (162)	South-Eastern	Indonesia	Yes	FFQ (not validated)	Database in Nutrisurvey software	Yes	1
Shanita, 2012 (206)	South-Eastern	Malaysia	Yes	Development: a 24-h recall Validity: 7-d DR	USDA ARS Nutrient Data Lab, version 21.0 (2009), Food Composition Guide Singapore (2003), and information on product labels (for branded or specific items)	—	2
Sulaiman, 2014 (145)	South-Eastern	Malaysia	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference, Release 21 (2006) (236)	No	1
Kaur, 2015 (105)	South-Eastern	Malaysia	Sugary foods and beverages	FFQ (not validated)	NR	—	0
Abdul Majid, 2016 (190)	South-Eastern	Malaysia	Yes	7-d diet history	Database in Nutritionist Pro Diet Analysis software (Axxya Systems, US) and Malaysian food recipes	Yes	2
Shariff, 2016 (154)	South-Eastern	Malaysia	Yes	1–6 y: 24-h recall and 2-d DR	USDA database and Malaysian food recipes	Yes	2
	South-Eastern	Malaysia		7–10 y: two 24-h recalls			
Mohd Nasir, 2017 (175)	South-Eastern	Malaysia	Packaged foods	6–9 y: 2-d DR 10–12 y: two 24-h recalls	Information on product labels	No	1
Mohamed, 2018 (207)	South-Eastern	Malaysia	Yes	7-d diet history	Database in Nutritionist Pro software (Axxya Systems, US)	No	2

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Alaini, 2019 (203)	South-Eastern	Malaysia	Yes	3-d DR	Database in Nutritionist Pro software version 4.0.0 (Axxya Systems, US) and market survey	Yes	2
Asma, 2019 (89)	South-Eastern	Malaysia	Yes	Two 24-h recalls	Malaysian Food Composition Database (29) and product labels	Yes	3
Chong, 2019 (119)	South-Eastern	Malaysia	Yes	FFQ (not validated)	Sugar-composition database for Malaysia (65), USDA food-composition table (2015) (229), The Composition of Foods Commonly Eaten in Singapore (2000), and several local studies.	No	2
Yap, 2019 (155)	South-Eastern	Malaysia	Yes	Three 24-h recalls	USDA food database	No	2
Appannah, 2020 (120)	South-Eastern	Malaysia	Yes	FFQ (validated)	Database in Nutritionist Pro software version 3.1 (Axxya Systems, US)	No	2
Emi, 2020 (130)	South-Eastern	Malaysia	Yes	FFQ (validated)	Database in Nutritionist Pro software version 3.1 (Axxya Systems, US)	No	2
Ali, 2021 (176)	South-Eastern	Philippines	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference	No	1
Yabao, 2005 (106)	South-Eastern	Singapore	Snacks and beverages	FFQ (not validated)	The Nutrition Values of Australian Foods (1991)	—	0
Chen, 2017 (156)	South-Eastern	Singapore	Yes	A 24-h recall	Energy & Nutrient Composition of Foods from Singapore Health Promotion Board (31), USDA Food Composition Database (229), and information on food labels	Yes	2
Brownlee, 2019 (184)	South-Eastern	Singapore	Yes	Two 24-h recalls	Database in dietary software (WinDiets, Robert Gordon University, UK)	Yes	2
Li, 2019 (139)	South-Eastern	Thailand	Yes	FFQ (not validated)	Energy & Nutrient Composition of Food from Singapore Health Promotion Board (31) and Food Standards Australia and New Zealand (for fructose contents for fruit and fruit juice) (22)	Yes	2
Promdee, 2007 (200)	South-Eastern	Thailand	Snacks and beverages	3-d DR	Directly measured	—	2
Taechangam, 2008 (204)	South-Eastern	Thailand	Yes	3-d DR	NR	NR	2
Mitrakul, 2016 (107)	South-Eastern	Thailand	Yes	Three 24-h recalls	Database in INMUCAL software (Mahidon University, Thailand)	Yes	3

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Thewjitcharoen, 2018 (91)	Southern	India	Yes	3-d or 7-d DR	Thai Dietary Database, 4th edition	Yes	3
Sachan, 1999 (191)	Southern	India	Yes	FFQ (not validated) and 4-d DR	Database in Nutritionist IV (N-squared computing, US, 1993) and the Nutrient Value of Indian Foods Handbook (1991)	Yes	2
Mohan, 2001 (217)	Southern	India	Yes	FFQ (not validated) and three 24-h recalls	NR	NR	2
Rao, 2002 (93)	Southern	India	Yes	Dietary interview	NR	NR	1
Joshi, 2014 (94)	Southern	India	Yes	Three 24-h recalls	NR	NR	2
Dhillon, 2016 (95)	Southern	India	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference, release 14 (2002) (237) and McCance and Widdowson's Composition of Foods (1995)	No	1
Priyadarshini, 2020 (108)	Southern	India	Yes	Four 24-h recalls	NR	NR	2
Hosseini-Esfahani, 2011a (131)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference, Release 19 (238) and Food Composition Table of Iran (for some Iranian foods)	Yes	1
Hosseini-Esfahani, 2011b (128)	Southern	Iran	Yes	FFQ (not validated)	USDA Food Composition Table and Food Composition Table of Iran (1980) (for some Iranian foods)	Yes	1
Nazeminezhad, 2014 (103)	Southern	Iran	Yes	A 24-h recall	Database in DIET PLAN 6 software (Forest Field Software, UK)	Yes	1
Guelinckx, 2015 (170)	Southern	Iran	All fluids	7-d DR	USDA National Nutrient Database for Standard Reference, release 27 (2014) (221)	—	1
Doostan, 2016 (185)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference (2015) (221)	Yes	1
Khayyatzadeh, 2016 (132)	Southern	Iran	Yes	A 24-h recall	Database in DIET PLAN 6 software (Forest Field Software, UK)	Yes	1
Salehi-Abargouei, 2016 (157)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database	Yes	1
Zolfaghari, 2016 (142)	Southern	Iran	Yes	A 24-h recall	Database in Nutritionist IV software, version 7 (N-squared computing, US)	Yes	1
Bahadoran, 2017 (101)	Southern	Iran	Yes	FFQ (not validated)	USDA Food Composition Table and USDA database for added sugars	Yes	1

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Jafari Giv, 2018 (166)	Southern	Iran	Yes	A 24-h recall and FFQ (not validated)	Database in DIET PLAN 6 software (Forest Field Software, UK)	Yes	1
Joulaei, 2018 (213)	Southern	Iran	Yes	FFQ (not validated)	USDA Food Composition Table and Food Composition Table of Iran (for Iranian food items)	Yes	1
Pourmand, 2018 (112)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database	Yes	1
Rashidi, 2018 (158)	Southern	Iran	Yes	A 24-h recall	Database in DIET PLAN 6 software (Forest Field Software, UK)	Yes	1
Arab, 2019 (214)	Southern	Iran	Yes	3-d DR	Database in Nutritionist IV software (First Databank, Hearst Corporation, US)	Yes	2
Darand, 2019 (140)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference, release 27 (2014) (221)	Yes	1
Khodarahmi, 2019 (133)	Southern	Iran	Yes	FFQ (not validated)	USDA Food Composition Table and Food Composition Table of Iran (1980)	Yes	1
Salehi-Abargouei, 2019 (121)	Southern	Iran	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference	Yes	1
Toorang, 2019 (208)	Southern	Iran	Yes	At least four 24-h recalls	McCance and Widdowson's Food Composition Table in the UK and Food Composition Table of Iran (1980) (for some Iranian foods)	Yes	2
Boozari, 2020 (146)	Southern	Iran	Yes	FFQ (not validated)	Database in Nutritionist IV software, version 4.1 (First Databank, Hearst Corporation, US)	Yes	1
Mahmoudi-Nezhad, 2020 (134)	Southern	Iran	Yes	FFQ (not validated)	Iranian Food Composition Table[4]	—[4]	1[4]
Mottaghian, 2020 (135)	Southern	Iran	Yes	FFQ (not validated)	USDA Food Composition Table and Food Composition Table of Iran (for Iranian food items)	Yes	1
Hassani Zadeh, 2020 (136)	Southern	Iran	Yes	FFQ (not validated)	NR	NR	1
Kiani, 2021 (167)	Southern	Iran	Yes	FFQ (not validated)	Database in Nutritionist IV Database Manager 4.0 software (Tinuviel Software, UK)	Yes	1
Hakeem, 1999 (192)	Southern	Pakistan	Yes	3-d DR	Database in COMP-EAT software and food composition of South Asian dishes (1996)	Yes	2

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Gharib, 2011 (193)	Western	Bahrain	Yes	A 24-h recall	American food database and Bahraini food recipes	Yes	1
Hunsberger, 2015 (147)	Western	Cyprus	Yes	A 24-h recall	The respective national food-composition table[5]	—[5]	2[5]
Vassilopoulou, 2017 (168)	Western	Cyprus	Yes	Two 24-h recalls	Database in DIET PLAN 6 software (Forest Field Software, UK)	Yes	2
Graffe, 2020 (201)	Western	Cyprus	Yes	A 24-h recall	German (239) and Swedish (240) food composition tables	Yes	1
Silkoff, 1980 (113)	Western	Israel	Yes	Structured questionnaire (not validated)	Food Composition Tables in Israel (1977)	Yes	2
Kaufmann, 1982a (194)	Western	Israel	Table sugars, sugars added at home, and sucrose added to commercial foods	A 24-h recall	Food Composition Tables in Israel, 6th edition (1977), USDA Composition of Foods (1963), information from local food producers and retailers, and local laboratory analysis	Yes	1
Kaufmann, 1982b (195)	Western	Israel	Table sugars, sugars added at home, and sucrose added to commercial foods	A 24-h recall	Food Composition Tables in Israel, 6th edition (1977), USDA Composition of Foods (1963), information from local food producers and retailers, and local laboratory analysis	Yes	1
Ianco, 2013 (115)	Western	Israel	Yes	FFQ (not validated)	USDA Food and Nutrient Database for Dietary Studies, 4.1. (241) and Israeli Health Ministry TZAMERET databases (for some Israeli food items)	Yes	1
Al-Hourani, 2007 (153)	Western	Jordan	Yes	Two 3-d DR	The food-composition tables for use in the Middle East, 2nd edition (1970)	Yes	3
Bawadi, 2014 (196)	Western	Jordan	Yes	FFQ (not validated)	Database in the Food Processor Nutrition Analysis Software, version 7.71 (ESHA Research, US)	Yes	1
Tayyem, 2019a (186)	Western	Jordan	Yes	FFQ (validated)	Database in the Food Processor Nutrition Analysis Software, version 11.6.0 (ESHA Research, US) and Food Composition Tables for Use in the Middle East (2013) (for Jordan food)	Yes	2
Tayyem, 2019b (137)	Western	Jordan	Yes	FFQ (validated)	Database in the Food Processor Nutrition Analysis Software, version 10.1.0 (ESHA Research, US)	Yes	2

(*Continued*)

TABLE 2 (*Continued*)

First author, year (reference)	Area	Country	Assessing sugar intake in the whole diet	Dietary assessment method[2]	Data source of content of sugars[3]	Same data source for other nutrients	Quality score
Tayyem, 2020 (209)	Western	Jordan	Yes	Three 24-h recalls	Database in the Food Processor Nutrition Analysis Software, version 10.1.1 (ESHA Research, US) and data on foods consumed in Jordan	Yes	2
Al-Shawi, 1992 (187)	Western	Kuwait	Yes	3-d DR	USDA Agriculture Handbooks No. 8–1 (1976) to 8–16 (1986) and No. 456 (1975); Bowes and Church's Food Values of Portions Commonly Used; and food-composition tables for Near East (1982) (242)	Yes	2
Al-Ansari, 2006 (197)	Western	Kuwait	Snacks	Question survey for the composition of meals (not validated)	Database in Nutritionist III software, version 7 (N-squared computing, US)	Yes	0
Jomaa, 2021 (177)	Western	Lebanon	Yes	A 24-h recall	USDA database	Yes	1
Collison, 2010 (159)	Western	Saudi Arabia	Yes	FFQ (not validated)	USDA National Nutrient Database for Standard Reference, Release 21 (2007) (236) and nutritional information from food manufacturers	Yes	1
Alahmary, 2019 (148)	Western	Saudi Arabia	Yes	Two 24-h recalls	Database in the Food Processor Nutrition Analysis Software, ver. 11.5 (ESHA Research, US)	Yes	2
Mumena, 2020a (211)	Western	Saudi Arabia	Yes	Two 24-h recalls	Database (includes universal Arabic food items) in Nutritics software, version 5.09 (Nutritics, Ireland) and information on product labels	Yes	2
Mumena, 2020b (212)	Western	Saudi Arabia	Yes	Two 24-h recalls	Database in Nutritics software, version 5.09 (Nutritics, Ireland), product labels, and local food recipes	Yes	2
Jebril, 2020 (90)	Western	State of Palestine	Yes	Questionnaire for dietary habits (not validated)	NR	NR	1
Yabanci, 2010 (160)	Western	Turkey	Yes	A 24-h recall	Database in a computer program (BeBiS, Germany)	Yes	1
Guelinckx, 2015 (170)	Western	Turkey	All fluids	7-d DR	USDA National Nutrient Database for Standard Reference, release 27 (2014) (221)	—	1
Al-Sarraj, 2010 (218)	Western	United Arab Emirates	Yes	A 24-h recall	Nutritional Data System 9.0 (University of Minnesota, US) and Emirati recipe	Yes	1

[1] DR, dietary record; NHNSJ, National Health and Nutrition Survey, Japan; NR, not reported; STFCJ, Standard Tables of Food Composition in Japan.
[2] For validation studies of FFQ, the dietary assessment method, which was used as a gold standard, was shown.
[3] Full citations were given for databases, which provided sufficient citations for specifying and could be accessed and the contents checked.
[4] Although the authors stated that the Iranian Food Composition Table was used for estimating all nutrition intake, the USDA food-composition database was considered to be used due to the incompleteness of this food-composition table (44).
[5] Although the authors stated that the national food-composition table was used for estimating all nutrient intake, content of sugars is not available in the Cyprus Food Composition Tables (37).

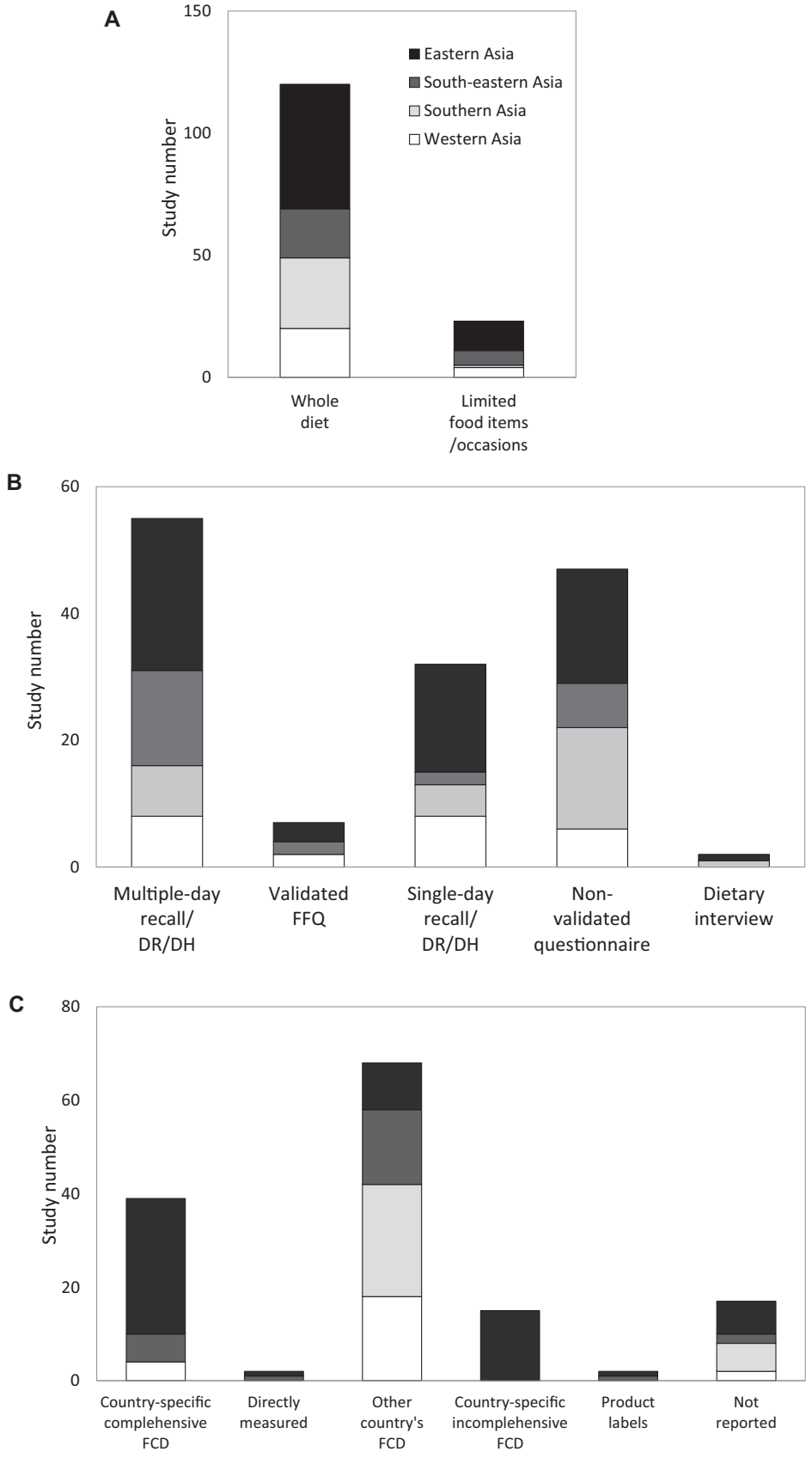

FIGURE 3 Dietary assessment methodology of sugar intake in studies included in a scoping review of epidemiological studies on intake of sugars in Asian countries. (A) Estimation of intake of sugars. (B) Dietary assessment methods. (C) Data source of sugar contents. DH, diet history; DR, dietary record; FCD, food-composition database.

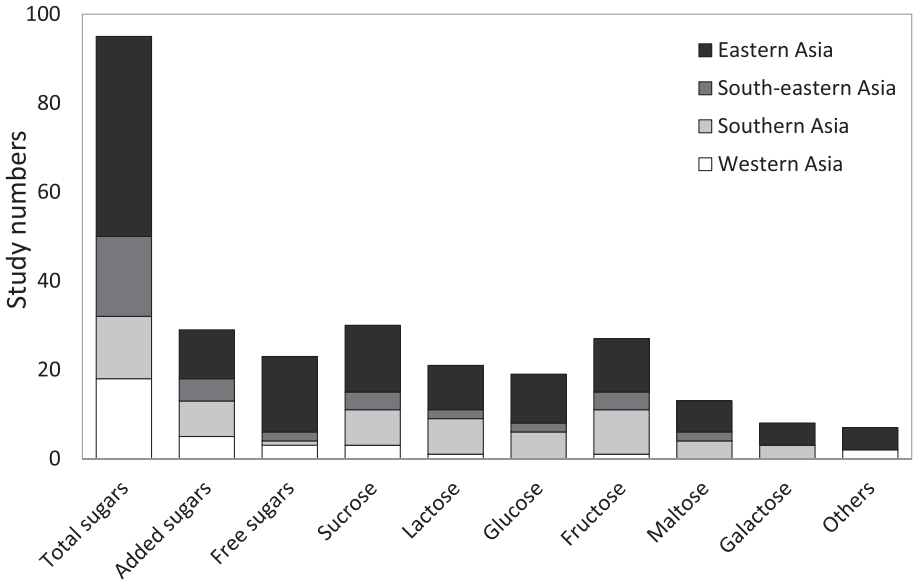

FIGURE 4 Type of sugars estimated in studies included in a scoping review of epidemiological studies on intake of sugars in Asian countries.

(n = 29), fructose (n = 27), free sugars (n = 23), lactose (n = 21), glucose (n = 19), maltose (n = 13), galactose (n = 8), naturally occurring sugars (n = 4), trehalose (n = 2), monosaccharides (n = 2), and disaccharides (n = 2) (**Supplemental Table 3** and **Figure 4**). Of the studies estimating the intake of added sugars, 9 studies predominantly used USDA FCDs (with 1 study defining added sugars), whereas 9 studies (with 6 studies defining added sugars) estimated the added-sugar intake based on the saccharide content and food sources (including FCDs developed based on similar methods). The remaining 4 studies defined added sugars but did not explain the estimation methods, whereas 7 neither mentioned the definition nor the estimation methods. For the estimation of free sugars, 17 studies defined free sugars according to the WHO definition and estimated their intake based on the saccharide content and food sources (except for 1 study, which did not state the estimation method). The remaining 6 studies neither mentioned the definition nor the estimation methods.

Discussion

This novel comprehensive review identified epidemiological studies on the intake of sugars in Asian countries and assessed their quality with regard to dietary assessment methodology. In this review, we identified 143 epidemiological studies that estimated the intake of sugars in Asian countries. More than 40% of the studies were conducted in Eastern Asia, whereas 20% of the studies were conducted in South-Eastern, Southern, and Western Asia each, except for Central Asia, where no studies were conducted. The highest number of studies were conducted in Japan, followed by Iran, Malaysia, Korea, and China, with these countries accounting for approximately 70% of the total studies. Variations in the number of studies conducted across regions and countries may be partially explained by the level of economic development of each country. For example, the majority of countries in Eastern Asia, which reported the highest number of studies, have been recognized as high-income countries over the last 2 decades (56). In contrast, the South-Eastern and Southern Asian countries included in this review were principally lower- or higher-middle-income ones; their Western Asian counterparts are predominantly high-income countries (56). Therefore, compared with studies assessing micronutrient intake, the level of economic development could impose constraints related to the feasibility of epidemiological studies assessing the intake of sugars because sugars are nonessential nutrients. With regard to the main aim, studies investigating diet–disease relations principally focused on metabolic diseases or their indicators, whereas only a few studies focused on dental caries.

According to the dietary assessment methodology, a relatively low proportion of studies reported high-quality data, which included 12% of the total studies and 20% of those investigating sugars as the primary exposure/outcome. With regard to assessing intake of sugars from the whole diet, one-sixth of the studies estimated the intake from limited dietary sources (e.g., sugary foods and/or beverages or snacking occasions), partially because of insufficient information on the content of sugars in commonly consumed food items in Asian countries (57–61). The contribution of specific food items to the intake of sugars is relatively high in Asian countries, similar to Western countries (9). However, estimating sugars only from limited food items leads to more underestimation than that from whole dietary intake.

Moreover, studies focusing on limited food items could not estimate the total energy intake, thereby causing a degree of misreporting of dietary intake, which is a common problem in self-reported dietary surveys (62, 63).

Approximately 60% of the studies used 1-d dietary assessment methods or nonvalidated dietary assessment questionnaires to estimate the intake of sugars. Therefore, their findings may be of low quality. It is essential to collect dietary data over multiple days for assessing the habitual intake at an individual level (64). In addition, the significant contribution of specific food items (e.g., confectioneries and soft drinks) to the intake of sugars (9) can lead to a relatively large day-to-day variation in the intake of sugars compared with that of other nutrients. Meanwhile, dietary assessment questionnaires, including FFQs, are required to evaluate the accuracy of the estimated intake by comparing it to that estimated by more accurate methods (i.e., a gold standard) (64). For dietary assessment questionnaires validated for nutrient intake except for sugars, the validity of the intake of sugars should at least be confirmed using the previous dataset used to validate the intake of other nutrients.

With regard to the data sources used for estimating the content of sugars, only 40% of the studies used a comprehensive FCD developed for individual countries. The use of FCDs in other countries (including those of commercial software) may lead to the overestimation or underestimation of the intake of sugars, since they do not consider the differences in the content of sugars in food items between countries (65). Moreover, the use of FCDs with information on the content of sugars in restricted food items and food labels can underestimate the intake of sugars from items not included in the FCDs or without labels. Moreover, of the 130 studies estimating the intakes of other nutrients, 46 referred to different data sources for other nutrients to estimate the intake of sugars. This is a specific problem in epidemiological studies assessing the intake of sugars in Asian countries.

The types of estimated sugars depend on both the degree of scientific interest and their availability in the FCDs. More than 65% of the studies investigated total sugars, whereas 15–20% of the studies investigated sucrose, fructose, added sugars, and free sugars. The reason for the greater number of studies estimating total sugars or sucrose was that a substantial number of studies, particularly early studies, estimated only these types of sugars due to the lack of information on individual monosaccharides and disaccharides in the FCDs (for total sugars), or that these studies considered only table sugar as a source of intake (for sucrose). Furthermore, some of these studies may have used total sugars and/or sucrose as a surrogate for saccharides. Meanwhile, recent studies have investigated the intake of individual monosaccharides and disaccharides. The recent interest in the health effects of fructose (66) resulted in the inclusion of a substantial number of studies in this review. Other saccharides are rarely estimated alone, and their intake and health effects have been examined for some saccharides, particularly galactose and trehalose, which are listed in limited FCDs (21, 23, 27).

The definition of added and free sugars can influence their estimated intake (4, 5, 42, 54); therefore, studies should clearly state the definition or at least the name and version of the FCD used. In this review, few studies on added sugars provided the definition, whereas the majority of studies on free sugars used the WHO definition (5) of free sugars. This is because added sugars are considered a general concept, whereas free sugars are considered a specific concept proposed by the WHO (5). Nevertheless, none of the studies considered the total sugars in vegetable juices and their concentrates as added or free sugars. Due to the broken cellular structure, the total sugars in vegetable juices and their concentrates can be considered the same as those in fruit juices and their concentrates (54, 67). Therefore, these studies may have possibly underestimated the intake of added and free sugars and their influence on health outcomes (68).

The contents of free and added sugars should be estimated based on the saccharide content of the ingredients of each food item. This is because these sugars and naturally occurring sugars do not differ chemically (55). The majority of studies estimating the intake of added (8/9 studies) and free sugars (12/16 studies) referred to the 10-step systematic method developed by Louie et al. It consists of 6 objective and 4 subjective decision steps to estimate the content of these sugars based on the saccharide content and the types of food groups (69–71). Due to the decision steps with instructions to minimize the interrater difference in decisions (69–71), the content of sugars estimated by this method can be compared across different countries, notwithstanding variations in the content of sugars in country-specific food items. However, the accuracy of the reported intake of sugars and its association with health outcomes are unreliable for the remaining studies that did not use the USDA FCDs (for added sugars) or that described the estimation methods (for added and free sugars).

In countries with several studies, such as Japan and Korea, the inclusion of information on the content of sugars in a national FCD and development of a comprehensive sugar-composition database may generate studies with high-quality data. Japan had the highest number of studies ($n = 36$) and those with the earliest publication year. However, all studies published before 2015 reported on low-quality data, predominantly because of insufficient information on the content of sugars in the FCDs (with only sucrose content in sweeteners, confectioneries, and beverages) (27). Information on the content of several saccharides was introduced in the national FCD in Japan in 2015; however, it was only available for 40% of the food items (27). Hence, Fujiwara et al. (72, 73), Kanehara et al. (74), Nagata et al. (75), and Yamakawa et al. (76) developed comprehensive sugar-composition databases for Japanese food items based on the national FCD (27) and validated FFQs for estimating the intake of sugars. The majority of studies (15/18) published after 2018 used the previously mentioned databases and/or FFQs, of which 8 reported high-quality data. Additionally, the fourth highest number of studies were conducted in Korea ($n = 13$) including 4 with high-quality data. Prior to introducing

information on the content of sugars in the national FCD in 2017 (28), comprehensive sugar-composition databases for Korean food items were developed and used in 9 studies, of which 8 used the identical database [i.e., the database developed by Lee et al. (77, 78)]. However, few studies reported high-quality data, principally due to the use of a single 24-h dietary recall, thus suggesting the need for a feasible dietary assessment method for a large population survey in Korea.

In contrast, the introduction of the content of sugars in the national FCD since 2011 (29) did not contribute to the recent increase in Malaysian studies, where the third highest number of studies ($n = 14$) were reported, albeit only including 1 high-quality study. The majority of Malaysian studies have used FCDs in other countries and those in commercial software. Despite unknown reasons, this finding may be attributed to the ongoing update of the information on the content of sugars in the national FCD (65). Furthermore, the accuracy of the estimated intake of sugars is unknown in the study that reported high-quality data, because it estimated only the intake of added sugars but referred to the national FCD without their content (29). Meanwhile, Iran and China, without information on the content of sugars in their national FCDs, reported the second ($n = 23$) and fifth ($n = 11$) highest number of studies, respectively; however, none of them reported high-quality data. In Iran, not only the intake of sugars but also that of other nutrients was estimated based on FCDs from other countries due to the inclusion of limited food items and nutrients in the national FCD (44). None of the FFQs used were validated for the intake of sugars (44) or other nutrients (79, 80). In China, studies conducted in the mainland primarily used USDA FCDs, whereas those conducted in Hong Kong used the local FCD, with information on the content of sugars (81). Nonetheless, they used an invalidated FFQ to estimate the intake of sugars (82). Addressing these identified gaps can improve the quality of data regarding the estimated intake of sugars obtained from future studies conducted in individual Asian countries.

This scoping review has implications for future studies and policies. First, it is necessary to develop country-specific FCDs with information on the content of sugars in comprehensive food items to accurately estimate intake of sugars in Asian countries. For countries with difficulty in developing a country-specific FCD, the development of a regional FCD with neighboring countries having similar dietary habits may be a feasible and practical approach (83). The additional steps required to estimate the contents of added and free sugars based on the saccharide contents of the ingredients of each food item (55) may hinder the development of country-specific FCDs. The semi-automation of the procedure using machine-learning techniques (e.g., decision-tree–based algorithm) will reduce the burden in FCD development (67). FCD updates to reflect reductions in/reformulation of these sugars in commercial products is another systemic problem (84). Combining former techniques and approaches to automate data collection [e.g., the web scraping of supermarket and manufacturers' websites (85)] is one of the possible solutions (67).

Second, the development of validated dietary assessment questionnaires for estimating the intake of sugars may lead to large-scale epidemiological studies (64). Such development is expected to clarify the relation between the intake of sugars and health status, even in populations with relatively low intakes of sugars. In contrast, the absolute intake of sugars and their food sources should be estimated based on 24-h dietary recall or DR. This is because an FFQ is developed to rank the respondents' answers based on limited food items (64). Information on the precise amount of sugars and their primary contributors is required for the effective implementation of public health promotion (19). DRs are burdensome and require literate respondents (64); therefore, a 24-h dietary recall is a reasonable option, particularly in some Asian countries with lower literacy rates (86). The development of a web-based and computer-assisted version of a 24-h dietary recall, adopted for local dietary habits and with a lower burden on both the respondents and staff (87), will presumably advance future research on sugars as well as other nutrients (88).

The strength of this scoping review was the extensive nature of the search strategy supplemented by references and website searches, and the use of a systematic approach according to the dietary assessment methodology. The findings will provide useful information for the implementation of future surveys in Asian countries. However, we should acknowledge several limitations of this review and the studies analyzed. First, we used broad search terms and manually searched the reference lists; however, all relevant articles were not extracted. This could possibly be attributed to the use of only 2 databases (i.e., PubMed and Web of Science Core Collection). Furthermore, the restriction to English-language publications contributed to publication bias because studies from Asian countries may not always be published in English. However, papers with higher quality are likely to be written in English for submission to international journals. The restriction of the publication language may have partially contributed to the scientific robustness of our present findings. Second, only the first author (AF) screened the titles and abstracts, principally due to feasibility. Hence, we cannot rule out the possibility of missing a substantial number of studies from this review. Third, despite evaluating the quality of each study based on its assessment of intake of sugars from the whole diet, dietary assessment methods, and data sources used for estimating content of sugars, the mentioned items were not major components of previous scoring systems; thus, they may have been arbitrary. In addition, the present scoring systems may be insufficient to assess the data quality of studies on the intake of added and/or free sugars. The content of these sugars was not included in the country-specific FCDs of Asian countries, and should be estimated in individual studies. Hence, it is difficult to qualify such studies based on the data sources of the content of sugars, similar to those on total sugar and saccharide intake. However, the insufficiency of these factors is a specific problem in

epidemiological studies estimating the content of sugars, particularly that of added and free sugars. Nonetheless, we identified the necessity of scoring systems for evaluating the quality of future epidemiological studies estimating the intake of sugars. Finally, we searched the reference lists and websites of national institutes, universities, and companies to obtain maximum information on the validity of the dietary assessment methods and the types of nutrients included in the FCDs. However, the insufficient description in previously published articles and lack of information on websites could result in the misclassification of studies when assessing their quality.

This scoping review elucidated a substantial number of epidemiological studies estimating the intake of sugars across Asian countries that focused on several types of sugars, including added and free sugars, and estimated dietary intake and diet–disease relations. However, the data quality in most studies was considered low according to the dietary assessment methodology. This warrants both feasible and validated dietary assessment methods and comprehensive country-specific sugar-composition databases in individual Asian countries to guarantee the accuracy of the estimated intake of sugars and to examine its relation with health outcomes in the future.

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Data Availability

No new data were generated for this review.

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