REVIEW

Dietary Assessment Methods to Estimate (Poly)phenol Intake in Epidemiological Studies: A Systematic Review

Yifan Xu,[1] Melanie Le Sayec,[1] Caroline Roberts,[1] Sabine Hein,[1,2] Ana Rodriguez-Mateos,[1] and Rachel Gibson[1]

[1] Department of Nutritional Sciences, School of Life Course Sciences, Faculty of Life Sciences and Medicine, King's College London, London, United Kingdom; and [2] School of Psychology and Clinical Language Sciences, University of Reading, Reading, United Kingdom

ABSTRACT

Nutritional epidemiological studies have frequently reported associations between higher (poly)phenol intake and a decrease in the risk or incidence of noncommunicable diseases. However, the assessment methods that have been used to quantify the intakes of these compounds in large-population samples are highly variable. This systematic review aims to characterize the methods used to assess dietary (poly)phenol intake in observational studies, report the validation status of the methods, and give recommendations on method selection and data reporting. Three databases were searched for publications that have used dietary assessment methods to measure (poly)phenol intake and 549 eligible full texts were identified. Food-frequency questionnaires were found to be the most commonly used tool to assess dietary (poly)phenol intake (73%). Published data from peer-reviewed journals were the major source of (poly)phenol content data (25%). An increasing number of studies used open-access databases such as Phenol-Explorer and USDA databases on flavonoid content since their inception, which accounted for 11% and 23% of the data sources, respectively. Only 16% of the studies reported a method that had been validated for measuring the target (poly)phenols. For future research we recommend: *1*) selecting a validated dietary assessment tool according to the target compounds and target period of measurement; *2*) applying and combining comprehensive (poly)phenol content databases such as USDA and Phenol-Explorer; *3*) detailing the methods used to assess (poly)phenol intake, including dietary assessment method, (poly)phenol content data source; *4*) follow the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology (STROBE-nut) framework; and *5*) complementing dietary intake assessment based on questionnaires with measurement of (poly)phenols in biofluids using appropriate and validated analytical methods. *Adv Nutr* 2021;12:1781–1801.

Keywords: dietary (poly)phenol, dietary intake, dietary assessment method, epidemiology study, method validation, systematic review

Introduction

Diet is one of the most important modifiable factors for the prevention and management of noncommunicable diseases (1, 2). In recent decades, the understanding of diet has evolved from what was believed to be a limited combination of 150 identified nutrients into a much wider range of components including non-nutrients and potentially bioactive compounds such as phytochemicals (3). The development of sensitive and high-resolution analytical methods such as ultra-high-performance liquid chromatography (UPLC) coupled with MS has enabled the rapid identification of these compounds in foods in recent years. There are >26,000 definable biochemicals found in foods and this number is still increasing (4). Consistent evidence has shown plant-based foods such as whole grains (5), fruits, vegetables (6, 7), legumes (8, 9), and nuts (8) to be beneficial for overall health. However, to determine the underlying mechanisms of how and why these heterogenous food groups are beneficial to health we need to fully characterize their differing chemical compounds.

Nutritional epidemiological studies provide valuable evidence to determine the associations between long-term dietary exposures against a range of health outcomes in free-living populations. The results of these studies are key to identifying dietary components for further testing in

YX is supported by a King's-China Scholarship (K-CSC).
Author disclosures: The authors report no conflicts of interest.
Supplemental Tables 1 and 2 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/advances/.
Address correspondence to RG (e-mail: rachel.gibson@kcl.ac.uk) or AR-M (e-mail: ana.rodriguez-mateos@kcl.ac.uk).
Abbreviations used: EPIC, European Prospective Investigation into Cancer and Nutrition; FFQ, food-frequency questionnaire; STROBE-nut, Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology; UPLC, ultra-high-performance liquid chromatography.

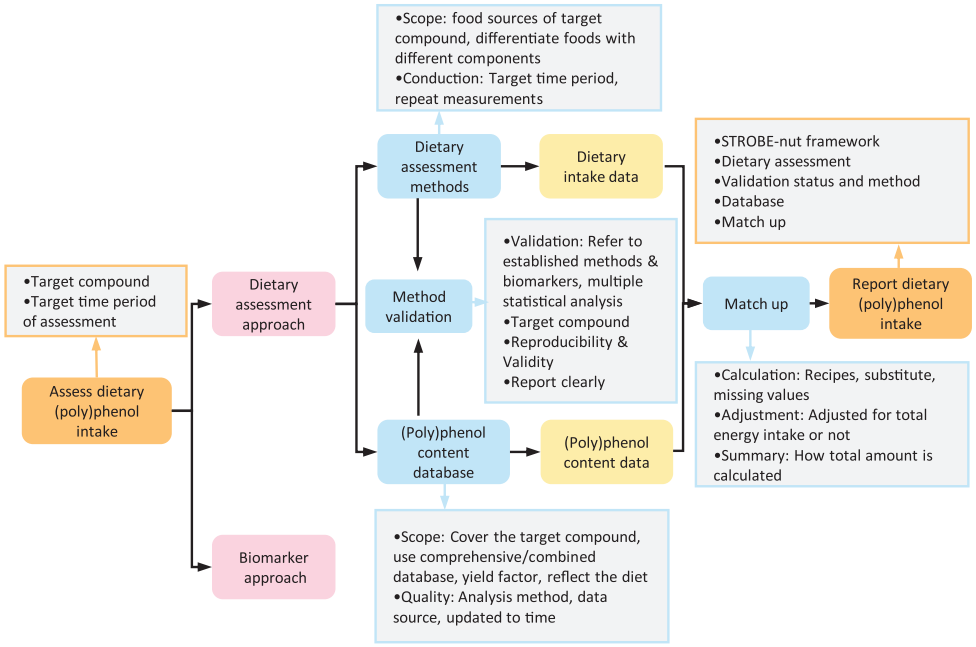

FIGURE 1 Assessment methods of (poly)phenol intake and key points to notice. Dietary assessment and biomarker are 2 approaches to estimate dietary (poly)phenol intake. In the dietary assessment approach, dietary intakes via food sources of (poly)phenols are estimated by dietary assessment tools such as FFQs, food records, or 24-h recalls. Food content data of (poly)phenols can be obtained from Phenol-Explorer, USDA, some country-based databases, or self-analyzed data. Food intake data are matched with available (poly)phenol content data by individual items and multiplied to calculate (poly)phenol intakes (mg/d). Key points to notice from each step are also listed in the corresponding boxes. FFQ, food-frequency questionnaire; STROBE-nut, Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology.

nutritional intervention trials (10). Several large prospective studies such as the Nurses' Health Study (11, 12), the Health Professionals Follow-Up Study (13), and the European Prospective Investigation into Cancer and Nutrition (EPIC) (14) have reported that higher intake of (poly)phenols is associated with a lower risk of cancer and cardiovascular incidence. However, the results of epidemiological studies are based on the assumption that the assessment of the exposure of interest is reliable and accurate. While dietary assessments of various nutrients (macronutrients, fibers, minerals, and vitamins) are well established through routine nutrient database assessment and validated assay methods (15), the assessment of novel bioactives such as (poly)phenols in free-living population groups is still in its infancy (**Figure 1**). Challenges remain in unknown errors from self-reporting, various study designs and tools, unstandardized data coding and processing, and limited sources in food content data.

To better understand the health benefits of (poly)phenols, accurate and reliable methods to measure (poly)phenol intake are required. Given the increasing reporting in nutritional epidemiology of (poly)phenol intake there is an urgent need to understand the strengths and limitations of currently used methods in published studies. Previous systematic reviews investigating the relation between polyphenol intake and health outcomes (16–19) have reported significant heterogeneity across studies reported, which could largely come from the different assessment methods used. To date, no study has described and compared the performance of different tools for estimating (poly)phenol intake.

This systematic review aims to *1*) characterize the observational studies reporting (poly)phenol intake, *2*) report current validation status of the assessment methods of (poly)phenol intake, and *3*) provide recommendations on choosing the right tools and framework on reporting (poly)phenol intake in nutritional epidemiological studies.

Methods

The methodology applied to this study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (20). Details of the protocol for this systematic review were registered on PROSPERO and can be accessed at https://www.crd.york.ac.uk/prospero/display_record.php?CID=118810.

Search strategy and study selection

A systematic search was conducted to collect published information on the methods used for assessing dietary polyphenol in health-related observational studies. Three databases—EMBASE, Web of Science, and MEDLINE (obtained from Ovid)—were searched from inception until January 2019.

The same strategies were then applied again to include the papers published from the last search until May 2020.

The criteria for inclusion were as follows: *1*) epidemiological observational studies (cross-sectional, cohort, case-control, prospective, or retrospective), *2*) measurement of dietary (poly)phenol intake, *3*) reporting of the distribution of intake or associations between (poly)phenol intake and health-related outcomes, and *4*) having data presented in full texts. Exclusion criteria included *1*) studies conducted in animals or in vitro or *2*) (poly)phenol intake was only measured by urinary or plasma biomarkers.

No restriction on year of publication was applied to the search. Search terms included free texts and subject headings about "Dietary intake" AND "Polyphenol classes and subclasses." The following filters were applied: English language, human as the subject and Scottish Intercollegiate Guidelines Network filter for observational studies (https://www.sign.ac.uk/search-filters.html). Details of the search terms in this study are shown in **Supplemental Table 1**.

Screening strategy

Records were screened according to criteria through 3 stages: titles, abstracts, and full texts. The search was conducted by 4 researchers (CR, MLS, SH, and YX). In the first 2 stages, titles and abstracts were reviewed against inclusion and exclusion criteria by 2 groups of researchers (YX with CR, MLS with SH) in parallel. Potentially relevant papers included by both groups were screened in the next stage while inconsistent results were determined together by 2 reviewers from the other group. Full-text reading and information extraction were conducted by 4 reviewers together.

Quality assessment

The quality of the included papers was assessed by a set of 6 questions adapted from the Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology (STROBE-nut) framework (21). The questions determined study quality over 6 domains: *1*) definition of the target (poly)phenol, *2*) method to obtain and calculate (poly)phenol intake, *3*) dietary assessment methods, *4*) food-composition database, *5*) biomarker measured (if applicable), and *6*) validation of the dietary (poly)phenol assessment method. The papers were rated in the above aspects and overall by "good," "fair" or "poor" after the full texts were examined by CR, MLS, SH, and YX individually, and the quality rating results were checked by YX. The papers that had a clear and detailed description of the above 6 aspects in the methods section were rated as "good"; papers that reported the above aspects but were lacking some important details were rated as "fair"; and papers that mentioned the above aspects without giving details were rated as "poor." "NA" was applied to papers when the assessment was not applicable. For example, papers that did not measure biomarker concentrations were not rated "NA" in *5*) biomarker measured and papers that did not validate dietary assessment methods were rated as "NA" in *6*) validation of the dietary assessment method.

Information extraction and synthesis

An information extraction tool was first developed and tested on pilot data of 3 full texts to refine the tool. Reviewers read the full texts of studies that met the inclusion criteria and retrieved information using a standard database in Microsoft Excel (Microsoft Corporation). The following information was extracted: *1*) first and corresponding author's name; *2*) year of publication; *3*) country or region, study name, study design, and number and characteristics of subjects; *4*) dietary assessment methods (including validation status of the method); *5*) (poly)phenol content database; and *6*) adjustments made in reporting (poly)phenols.

A narrative approach was taken in the synthesis of the results. The included papers from the same study or cohort were grouped. Qualitative analyses were conducted to determine the frequency of different dietary assessment methods and (poly)phenol content databases used in the included papers. For studies that had reported using a validated method to measure (poly)phenol intake, additional information on *1*) reference methods, *2*) statistical analysis method, and *3*) validity of the method was extracted. For papers reporting both dietary intake and biomarker concentrations, the analytical methods and correlations between the 2 measurements were also extracted.

Results

The study selection process of the systematic review is presented in **Figure 2**. Among a total of 7882 records obtained from searching, 5386 unique records were screened for titles and 1567 were screened for abstracts. Then, 729 full texts were examined further and 182 papers were excluded for the following reasons: no (poly)phenol assessment conducted ($n = 25$), (poly)phenol assessment based only on biomarkers ($n = 46$), data not available as a full text ($n = 61$), intervention conducted ($n = 14$), identical as included paper ($n = 23$), review ($n = 11$) and not relevant ($n = 2$). Two papers were included through hand-search. In the end, 549 papers were included in the qualitative synthesis of data. Characteristics of the included studies are shown in **Supplemental Table 2**. Quality of the included papers based on the 6 questions was as follows: 33% were ranked good, 60.5% were fair, and 6.5% were poor (**Table 1**).

Dietary assessment methods

To identify the dietary assessment tools used to measure the intake of (poly)phenol food sources, the frequency of different tools used in the 549 included papers was calculated. As shown in **Figure 3**, an FFQ was the most widely used (73%, $n = 401$) dietary assessment tool, followed by the 24-h or 48-h dietary recall (9%, $n = 51$). The number of items measured in the FFQs varied widely, from <10 items in a specific food group (i.e., soy food such as soft and firm tofu, tofu products, soy milk, bean curd products, and soy beans were measured to assess isoflavone intake) (22–31) to >200 detailed food items (i.e., fruits, vegetables, legumes, grains, oils, dairy, fish, eggs, beverages, and commercially processed products) (32–34). In addition, the time period

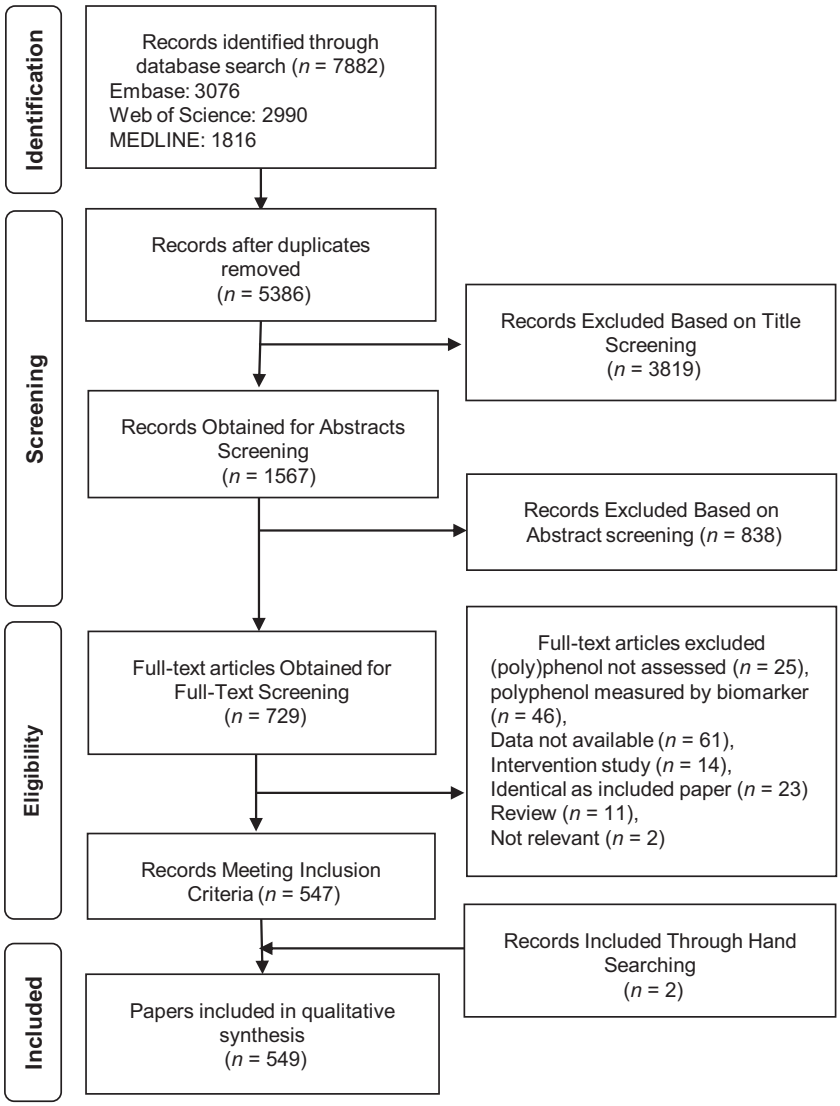

FIGURE 2 Flow chart of study selection process.

measured by FFQs varied extensively from the past week (35, 36) to the past 20 y (37–41). There were very few (3.5%, $n = 14$) studies using FFQs that were designed to estimate (poly)phenol intake (42–55), whereas the majority of papers used FFQs aimed to estimate food intake or energy and nutrient intake, such as EPIC FFQs (56–59), Block FFQ (60), and Willett FFQ (61). Estimated food diaries or records were reported in 4.6% ($n = 25$) of the included papers, whereas diet history questionnaires/interviews accounted for 3% ($n = 16$) and weighed food records accounted for 2% ($n = 10$). From the studies reviewed, 5.6% ($n = 31$) reported using a combination of different types of tools to measure

TABLE 1 Quality rating of the included papers[1]

Quality aspects	Good, *n* (%)	Fair, *n* (%)	Poor, *n* (%)	Not applicable, *n* (%)
Clearly define research question	366 (66.55)	168 (30.55)	15 (2.73)	0 (0.00)
Method description	233 (42.36)	254 (46.18)	62 (11.27)	0 (0.00)
Dietary assessment	234 (42.55)	273 (49.64)	42 (7.64)	0 (0.00)
Food-composition database	200 (36.36)	282 (51.27)	67 (12.18)	0 (0.00)
Biomarker applied	42 (7.64)	14 (2.55)	1 (0.18)	492 (89.45)
Validation of the method	152 (27.64)	214 (38.91)	51 (9.27)	132 (24.00)
Overall quality rating	180 (32.73)	333 (60.55)	36 (6.55)	0 (0.00)

[1] $n = 549$. "*n*" indicates the number of papers rated in each grade.

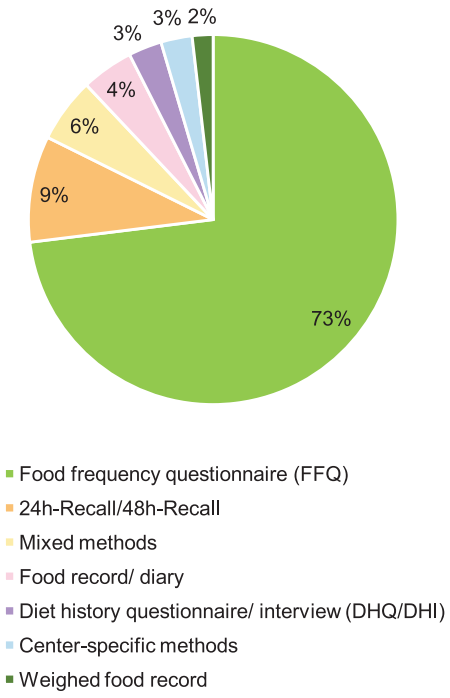

FIGURE 3 Percentage of dietary assessment methods to measure (poly)phenol intake in the published papers.

dietary intake. This was mainly for the purpose of validating the FFQ on measuring (poly)phenol intake (42, 44–46, 50, 62–71). In 15 studies (2.7%) that pooled data from different population samples, such as the EPIC study (72–86), tools that are specific to different research centers were used.

Food content databases

Figure 4 presents the number of papers published over time and sources of food content databases. It is apparent that there is an increasing number of papers published over the years, with a rapid increase after the development of the USDA database of Flavonoids Content in Food in the 2000s and Phenol-Explorer in the 2010s. Overall, Phenol-Explorer and USDA databases were used in 11% ($n = 59$) and 23% ($n = 125$) of the studies we reviewed, respectively. The number of studies using these 2 databases is increasing. In 2019–2020, the percentages of studies reportedly using Phenol-Explorer and USDA databases were 35% ($n = 22$) and 19% ($n = 12$), respectively. It needs to be noted that in this current study we did not specify a different sub-database from USDA such as the USDA Database for the Flavonoid Content of Selected Foods (87), the USDA Database for the Isoflavone Content of Selected Foods (88), and the USDA Database for the Proanthocyanidin Content of Selected Foods (89). In addition, one-quarter of the studies ($n = 138$) we reviewed used (poly)phenol content data previously published in peer-reviewed journals, whereas 3% ($n = 18$) of studies directly analyzed the (poly)phenol content of food in their studies (46, 90–106). Country-based food content databases were used in 10% ($n = 56$) of the studies, mainly from China (32%, $n = 18$) (23, 25, 107–121), Japan (29%, $n = 16$) (30, 122–135), and Singapore ($n = 9$, 16%) (136–144). A mixed source of databases was used in 20% ($n = 111$) of the papers.

Validation of the method

Of the 549 papers included, 417 (76%) papers reported using validated dietary assessment tools. However, only 86 (16%)

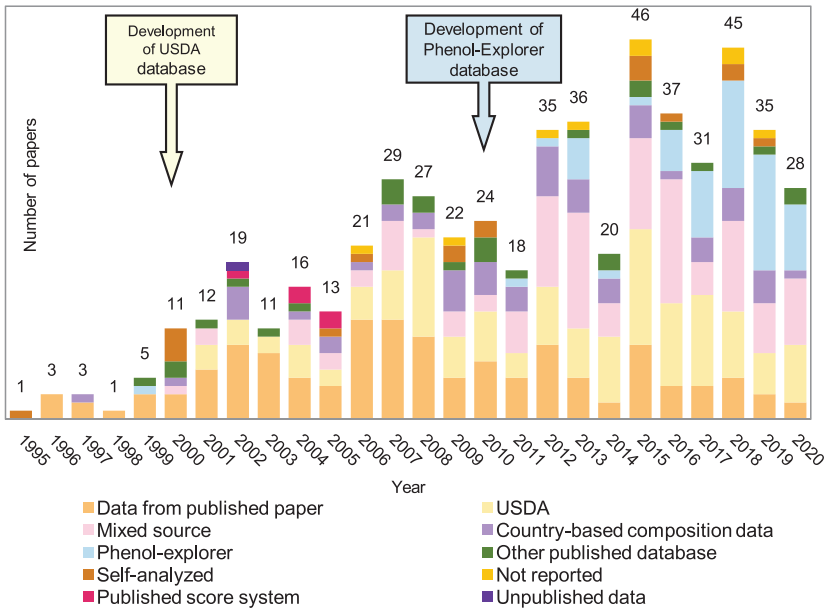

FIGURE 4 Sources of (poly)phenol content data in the published papers. The number of papers in the area have increased during recent years, especially after the development of USDA databases in the 2000s and the development of Phenol-Explorer database in the 2010s.

reported the validity or reproducibility of the tool to estimate (poly)phenol intake, which referred to 46 validation papers (42, 44, 45, 48–50, 52, 62–64, 66, 68, 69, 90, 94, 114, 145–174). The remaining papers referred to validated methods for nutrients or food intake and not (poly)phenol intake. Details of the (poly)phenol validation papers are shown in **Table 2**. Among all the dietary assessment methods, FFQs were the most frequently reported validated tools ($n = 39$, 85%) (42, 44, 45, 48–50, 52, 62–64, 66, 68, 69, 114, 145–147, 149, 151–153, 155–157, 159–161, 163–174). Other validated dietary collection tools included dietary records or diary ($n = 7$, 15%) (42, 44, 62, 68, 90, 150, 158), 24-h or 48-h recalls ($n = 6$, 13%) (44, 45, 66, 69, 148, 154), brief diet history questionnaire ($n = 1$, 2%) (94), and dietary history interviews ($n = 1$, 2%) (162). These methods were used to measure intakes of isoflavones ($n = 19$, 41%) (48, 49, 52, 63, 64, 68, 69, 145, 148, 149, 153, 155, 160, 161, 166, 167, 170, 171, 174), flavonoids ($n = 13$, 28%) (42, 46, 63, 114, 146, 147, 156, 162–165, 169, 172, 174, 175), lignans ($n = 3$, 7%) (147, 154, 173), phytoestrogens (both isoflavones and lignans) ($n = 6$, 13%) (45, 66, 150, 151, 157, 175), and total (poly)phenols ($n = 6$, 13%) (44, 62, 94, 158, 159, 168), whereas 1 paper (2%) reported validation of tea flavonoids (50).

To determine the validity of the dietary assessment tool, 34 (74%) studies used other dietary assessment methods as references, including multiple ($n = 7$, 21%) (145, 154, 161, 164, 165, 172, 176) or single ($n = 11$, 32%) (42, 44, 62, 68, 94, 150, 154, 155, 161, 166, 170) measurement(s) of dietary records, multiple ($n = 1$, 3%) (171) or single ($n = 4$, 12%) (64, 146, 163, 175) weighed food records, multiple 24-h ($n = 9$, 26%) (44, 66, 149, 156, 157, 160, 167–169) or 48-h ($n = 1$, 3%) recalls (69), or other FFQs ($n = 3$, 9%) (50, 158, 168). Meanwhile, 17 (37%) studies compared dietary assessment methods against (poly)phenol biomarkers, from 24-h urine ($n = 4$, 24%) (45, 52, 69, 170), spot urine ($n = 6$, 35%) (44, 52, 62, 148–150), fasting plasma/serum ($n = 7$, 41%) (48, 49, 66, 90, 154, 170, 173), or nonfasting spot plasma/serum ($n = 4$, 24%) (68, 150, 174, 175). The statistical methods reported in the validations were Spearman's or Pearson's correlation coefficients ($n = 41$, 89%), cross-classification ($n = 9$, 20%) (44, 45, 62, 66, 163, 167, 168, 172, 175), Bland-Altman plots ($n = 5$, 11%) (42, 44, 167, 168, 172), method of triads ($n = 3$, 7%) (44, 62, 66), and ANOVA between different concentrations ($n = 1$, 2%) (174). Validation by sole correlations was reported in 36 out of 46 studies (78%) (48–50, 52, 63, 64, 68, 69, 90, 94, 114, 145, 146, 148–151, 154–158, 160–162, 164–166, 169–171, 173, 176, 177).

Statistical adjustment in reporting (poly)phenol intake

A total of 197 (36%) papers reported adjusted values of (poly)phenol intake, mostly adjusted by total energy intake ($n = 188$, 95%) using the residual method or nutrient density described by Willett and Stampfer (178). Other factors adjusted for included age ($n = 12$, 6%) (82, 179–189), season ($n = 6$, 3%) (82, 180–184), gender ($n = 4$, 2%) (185, 187–189), ethnicity ($n = 1$, 0.5%) (186), and income ($n = 1$, 0.5%) (186).

Analysis of (poly)phenol metabolites in biofluids

Among the 549 papers assessing dietary (poly)phenol intake using dietary assessment tools, 57 (10%) papers also reported concentrations of (poly)phenols in biofluids at the same time. The correlations between biomarkers and dietary assessment methods were reported in 43 (75%) studies (44–49, 52, 62, 64–69, 71, 82, 86, 90, 111, 116, 123, 134, 147–150, 152, 154, 190–204). In these studies, correlation coefficients ranged from 0.12 to 0.71 in urine, from 0.06 to 0.80 in plasma, and from 0.08 to 0.43 in serum (Supplemental Table 2). In a few studies among the above, dietary (poly)phenols measured by food records or recalls were found to correlate better with biomarker concentrations than FFQs (44, 45, 62, 67, 68). In addition, plasma or urinary isoflavones showed higher correlation coefficients with dietary intake than lignans (45, 66, 71).

Discussion

The creditability of nutritional epidemiological research relies on the use of valid and reliable tools to measure dietary exposures. To our knowledge, this is the first systematic review that has characterized and critically evaluated the methods used to measure dietary (poly)phenol intake in epidemiological studies.

A multistage process is used for the estimation of dietary (poly)phenol intake in nutritional epidemiological studies as detailed in Figure 1. Dietary assessment requires the recording of food and beverage intake by participants; however, the method of collection differs in the level of detail. Different dietary assessment tools, such as FFQs, food diaries, and 24-h recalls, vary in their ability to capture the food sources of dietary (poly)phenols according to their design and method of validity (**Table 3**). In this study we found that FFQs are the most popular dietary assessment tools used to measure food sources of (poly)phenol intake. This is likely due to the low burden of the method towards participants and researchers alike, and their ability to measure long-term exposure to dietary factors (205). However, compared with dietary recall and records, FFQs have limited ability to cover the wide range of food sources of (poly)phenols and differentiate the food items due to the predefined list of food groups covered in the questionnaire. Moreover, the structure and food groups included in FFQs can differ between studies depending on the research questions. For example, if an FFQ is used to measure total and subclasses of flavonoid intake, important sources of flavonoids should be covered in the list such as tea, fruits and vegetables, soy products, legumes and beans, cocoa products, and red wine (206). At the same time, each FFQ item should cover only 1 type of food that has a different (poly)phenol content profile, and all items should be listed separately (207). In many FFQs the potential to measure subclasses of polyphenols is hampered by combining of items in FFQ categories—for example, red and white wine (67) and apples and pears (12, 67). Unlike FFQs consisting of a predefined list of food groups and frequencies of intake, dietary recalls or food records are not restricted and allow matching of individual food items with

TABLE 2 Validation of the assessment tools for estimating (poly)phenol intake[1]

First author (ref)	Year	Dietary assessment methods	Reproducibility	Reference		Number of participants	Statistical methods	Validated polyphenol(s)
				Dietary	Biomarker			
Chun (148)	2009	24-h recall	−		Urine-spot	2908	Partial correlations after adjusting for sex, age, ethnicity, BMI, income level, alcohol consumption, and cigarette smoking	Isoflavones
Kilkkinen (154)	2003	24-h recall	+	DR, S, 48-h recall, S	Serum-fasting	48-h recall: 233/3DD: 334	Attenuation regression coefficients	Lignans
Cao (90)	2010	7DD	−		Plasma-fasting	92	Correlation coefficients	Flavonoids
Grace (150)	2004	7DD	−	DR, S	Serum-spot + urine spot	248/333	Pearson's correlation coefficients on log-transformed data	Phytoestrogens: isoflavones and lignans
Taguchi (158)	2017	7DD	−	FFQ		37	Correlation coefficients	Total polyphenols
Taguchi (94)	2018	BDHQ	−	DR, S		37	Spearman's correlation coefficients	Total polyphenols
Jarvinen (162)	1993	DHI	+[2]			121	Interclass correlation coefficients	Flavonoids
Budhathoki (145)	2011	FFQ	+	DR, M		28	Pearson's correlation coefficients	Isoflavones
Butchart (146)	2011	FFQ	+	WR, S		83	Spearman's rank correlation coefficients	Flavonoids
Chavez-Suarez (147)	2017	FFQ	+[2]			50	Adjusted correlation coefficients	Flavonoids and lignans
Cuervo (159)	2014	FFQ	−			38	NR	Polyphenols
Frankenfeld (48)	2002	2 FFQs	−		Plasma-fasting	77	Pearson's correlation coefficients	Isoflavones
Frankenfeld (49)	2003	2 FFQs	+		Plasma-fasting	96	Pearson's correlation coefficients	Isoflavones
Fraser (149)	2016	FFQ	+	24-h recall, M	Urine-spot	Urine: 909; questionnaires: 96,116	Deattenuated correlations	Isoflavones
Hankin (160)	2001	FFQ	−	24-h recall, M		858	Correlation coefficients	Isoflavones
Hernandez-Ramirez (151)	2009	FFQ	+[2]			50	Energy adjusted (by means of energy residuals) intraclass correlation coefficients	Phytoestrogens: isoflavone and lignans
Ishihara (63)	2009	FFQ, 4DD, Arizona tea questionnaires	+	DR, M		55	Spearman's rank correlation coefficients	Isoflavones
Iwasaki (153)	2009	FFQ	−	DR, M		215	Spearman's correlation coefficients	Isoflavones
Kurahashi (155)	2009	FFQ	+	DR, S		NR	Spearman's rank correlation coefficients	Isoflavones
Kyle (163)	2002	FFQ	−	WR, S		41 men and 40 women	Energy-adjusted and Spearman rank correlation coefficients, cross-classification	Flavonols, procyanidins, flavon-3-ols, flavanones and flavones
Li (156)	2013	FFQ	+	24-h recall, M		121	Correlation coefficients	Flavonoids and stilbenes

(*Continued*)

TABLE 2 (*Continued*)

First author (ref)	Year	Dietary assessment methods	Reproducibility	Reference		Number of participants	Statistical methods	Validated polyphenol(s)
				Dietary	Biomarker			
Lin (41)	2013	FFQ	−		Serum-fasting	135	Correlation coefficients adjusted for energy intake	Lignans
Luo (157)	2015	FFQ	−	24-h recall, M		70	Spearman's correlation coefficients	Phytoestrogens: isoflavone and lignans
Yue (164)	2020	FFQ	+	DR, M		641 men and 724 women	Spearman's rank correlation coefficients adjusted and non-adjusted for total energy intake, variance captured by top food contributors	Total flavonoids and subclasses
Pietinen (165)	1988	FFQ	+	DR, M		133 men for validity/190 men for reliability	Pearson's correlation coefficients between log-transformed, energy-adjusted intake values	Total flavonoids and subclasses
Sasaki (166)	2003	FFQ	+			209	Spearman's correlation coefficients	Isoflavones
Segovia-Siapco (167)	2016	FFQ	−	24-h recall, M		55	Pearson's bivariate correlation, cross-classification quartiles, Bland-Altman plots	Soy isoflavones
Shahar (168)	2014	FFQ	−	24-h recall, M		93	Spearman correlation and intraclass correlation, Bland-Altman plot, cross-classification and Cohen's κ	Total polyphenols
Thompson (169)	2008	FFQ	−	24-h recall, M		2053	Deattenuated correlation coefficients	Flavonoids
Tsubono (170)	2003	FFQ	+	DR, M		201	Spearman's correlation coefficients	Isoflavones
Wu (174)	2004	FFQ	−		Plasma-spot	194	ANOVA and ANCOVA between quartiles	Isoflavones
Yamamoto (64)	2001	FFQ	+	WR, S	Serum-fasting + urine-24 h	215	Spearman's correlation coefficients, energy-adjusted correlation coefficients	Isoflavones
Yao (114)	2019	FFQ	+	DR, NR		NR	Spearman's rank correlation coefficients	Quercetin, myricetin
Yokoyama (171)	2016	FFQ	−	WR, M		142	Spearman's correlation coefficients	Isoflavones: daidzein and genistein
Zhang (172)	2009	FFQ	+	DR, M		61	Pearson's correlation coefficients, cross-classification, Bland-Altman plots	Flavonoids
Heald (152)	2006	FFQ	−	WR, S	Serum-spot	Serum: 203	Spearman's correlation coefficients and Pearson's correlation coefficients/energy-adjusted and Spearman's rank correlation coefficient, cross-classification	Serum: phytoestrogen; weighed diet records: flavonoids

(*Continued*)

TABLE 2 (*Continued*)

First author (ref)	Year	Dietary assessment methods	Reproducibility	Reference		Number of participants	Statistical methods	Validated polyphenol(s)
				Dietary	Biomarker			
Tseng (52)	2008	SFQ, FFQ (DAF)	−	DAF (FFQ)	Urine-24 h/overnight urine-spot, multiple	Questionnaire: 451/urine: 27	Spearman's correlations	Isoflavones: daidzein, genistein, glycitein, ODMA, equol
Bhakta (66)	2005	FFQ, 24-h recall	−	24-h recall, M		133	Cross-classification, energy adjusted and unadjusted Spearman's correlation coefficients, method of triads	Phytoestrogens: isoflavone and lignans
French (45)	2007	FFQ, 48-h recall	−		Urine-24 h	26	Spearman rank correlation coefficients, cross-classification (κ, tertile)	Phytoestrogens: isoflavone and lignans
Huang (69)	2000	FFQ, 48-h recall	−	48-h recall, M	Urine-24 h	61	Spearman's correlations	Isoflavones: daidzein and genistein
Hoge (62)	2019	FFQ, 3DD	−	DR, S	Urine-spot	53	Pearson's correlation, cross-classification by median, Cohen κ coefficient, method of triads	Total polyphenols
Somerset (42)	2014	FFQ and 3DD	+	DR, S		60	Spearman's rank correlations, Bland-Altman plots	Flavonoids
Ishihara (161)	2003	FFQ	+	DR, S		392	Spearman's correlation coefficients	Genistein
Hakim (50)	2001	FFQ, 4DD, Arizona tea questionnaires	+	FFQ, S, DR, S		120	Pearson and Spearman correlation coefficients; precision was examined using intraclass correlation coefficients between the log-transformed (natural log) estimates of black tea polyphenols for the 2 tea questionnaires (ATQ1 and ATQ2)	Total tea polyphenols
Verkasalo (68)	2001	FFQ, 7DD	−	DR, S	Plasma-spot	80	Spearman's correlation coefficients	Isoflavones: daidzein and genistein
Vian (44)	2015	FFQ, 3DD, 24-h recall	+	24-h recall, M + DR, S	Urine-spot	120	Method of triads, Pearson's correlation coefficients, intraclass correlation (κ) and Bland-Altman plots, classification by quartiles of consumption	Total polyphenols

[1] ATQ, The Arizina Tea Questionnaire, BDHQ, brief diet history questionnaire; DAF, Harvard Diet Assessment Form; DHI, dietary history interview; DR, dietary records; FFQ, food-frequency questionnaire; M, multiple conduction; NR, not reported; ODMA, O-Desmethylangolensin; , ref, reference; S, single conduction; SFQ soy food questionnaire; WR, weighed records; 3DD, 3-d food diary (records); 7DD, 7-d food diary (records); +, reproducibility was evaluated; −, reproducibility was not evaluated.

[2] Only reproducibility of the tools was evaluated in the study.

TABLE 3 Comparison of different methods for assessing dietary (poly)phenol intake

Dietary assessment tools	Characteristics	Strengths	Limitations	Ability to capture food sources of (poly)phenols
Food-frequency questionnaires (FFQs)	Finite food items (10–200+) targeting focused food groups or general diet; able to assess long-term intake (3 mon to 5 y)	Easy to conduct, low burden to participants and researchers; suitable to measure long-term intake (205)	Less able to capture day-to-day variability in diet; lack of specificity when foods were grouped together; prone to misreport and memory bias	Ability depends on the number of food items measured and whether foods with different (poly)phenol contents were distinguished; able to capture intake of nondaily or weekly consumed foods
24-h/48-h Recall	Recall of food intake in last 24 h or 48 h; usually conducted at multiple different time points during a longer period to capture habitual diet	Easy to conduct; not restricted to a predefined list of foods (208)	High participant burden if conducted multiple times; prone to misreport and memory bias; not able to reflect interday variability if only conducted once	More specificity as (poly)phenol content can be linked to individual foods rather than food groups; repeat measurement will increase the ability to capture infrequently consumed foods
Estimated food diary or food records	Record of intake for 3 d, 1 wk, 1 mo, etc.; usually assisted with photos of portion sizes	Able to capture day-to-day variabilities; not limited to a predefined list of foods; repeat measurement will increase the ability to capture infrequently consumed foods (209)	High participant burden; prone to coding error (standard protocol and training is needed for coding); prone to error from misreport	More specificity as (poly)phenol content can be linked to individual foods rather than food groups; able to capture intake of less common foods
Weighed food records (3 d, 7 d)	Weigh and record the portion of every food intake for a consecutive period of time	Accurate in portion size and less memory bias; not restricted to a predefined list of foods; repeat measurement will increase the ability to capture infrequently consumed foods	High participant burden (need weighing tools and instructions); high researcher burden (standard protocol and training is needed for coding)	Able to capture (poly)phenol intakes from less common foods; repeat measurement will increase the ability to capture infrequently consumed foods
Duplicate diet	A duplicated portion of foods consumed is retained, weighed, and chemically analyzed; often referred to as gold standard (210)	Accurate in portion size; not restricted to a predefined list of foods; able to measure dietary intake of food components not available in databases	High participant burden (to collect the food duplicates and preserve of each meal); high researcher burden (standard protocol and training is needed for weighing and coding); expertise and resources for chemical analysis are needed	Able to measure the (poly)phenol intake more precisely than using database; need accurate analytical methods to measure target (poly)phenol content in foods
Diet history questionnaire/interview	Structured questionnaire/interview on food intake frequencies during a specific period with open-ended questions and cross-checked with specific amounts	Not restricted to a predefined list of foods; suitable to measure long-term intake/intake during a specific period	High researcher burden (standard protocol and training is needed for the interview and coding); prone to misreport and memory bias	Able to capture (poly)phenol intake from less common food and infrequently consumed foods

TABLE 4 Challenges and recommendations in dietary assessment of (poly)phenol intakes[1]

Challenges	Recommendations/resources needed
Dietary assessment tool not designed to capture (poly)phenol diet sources and variabilities	*1*) Choose a tool that covers the food sources of target compounds, and has foods with different (poly)phenol profiles differentiated *2*) Consider the frequency and timing of measurement to make sure the target time period is represented *3*) Use multiple measurements of dietary records rather than FFQs if possible
Dietary assessment methods not validated/insufficiently validated to measure (poly)phenol intakes	*1*) Validate the tool specifically for measuring the intake of target (poly)phenols *2*) Use other well-established dietary assessments and established biomarkers as reference methods *3*) Conduct multiple statistical analysis to reflect validation status: correlation coefficients, cross-classification (Cohen's κ), Bland-Altman *4*) Provide evidence of validity and reproducibility
Limited data on (poly)phenol content in foods	*1*) Choose a database that covers the content data of all food sources of the target compound; combine different sources of data to make up the limitations of single databases *2*) Choose databases of high quality: with reliable analytical methods and data source, and consistent data between multiple sources; use data from comparable analytical methods if need to summarize the total *3*) Choose the data that can match up with the food item in the measured diet, in terms of food origin and species; apply food-processing yield factors if applicable *4*) Check the updates of the database and search for newly published data if possible *5*) Use standard recipes that can reflect the diet in target population
Insufficient reporting on methods	*1*) Follow STROBE-nut framework (21) *2*) Describe the dietary assessment methods used in detail: food groups and number of items measured, whether similar foods are distinguished in items; how the assessment was conducted, time range measured, and validation of the methods *3*) Report clearly whether the dietary assessment method is validated for targeted (poly)phenols; if it is validated, describe the reference method used including sample size and characteristics of the population, how the reference method was conducted, statistical analysis methods used and validity/reproducibility results; if biomarkers are used to validate the dietary assessment, report details of the biomarkers and analytical methods applied *4*) Report the name of the database used or cite the reference paper; describe the analytical method used to get the food content data and whether compounds were measured individually or in aglycones; report the retention factors used *5*) Report how food items were matched, how missing items and missing compound values were analyzed, and the adjustment made on the intake amount

[1] FFQ, food frequency questionnaire; STROBE-nut, Strengthening the Reporting of Observational Studies in Epidemiology—Nutritional Epidemiology.

(poly)phenol content data. However, repeat measurements are needed to enable the dietary data to represent the time period of estimation, especially for 24-h dietary recalls (208). For example, 24-h recalls should be repeated 3 times during a 7-d period, including 2 weekdays and 1 weekend day, to represent habitual dietary intake (134, 199, 211). Food records should be conducted in different seasons to be able to represent yearly intake (46, 212). In this review we found that ~15% of the studies used 24-h/48-h recalls or food diaries to measure food sources of (poly)phenols, which is much lower compared with studies using FFQs. This may result in a higher burden on participants and researchers when using dietary recalls or records (209). Clear instructions on completion and photos of portion sizes (45, 47, 213–215) are recommended to support the participants, while standardized coding protocols and trained coders are needed to interpret the questionnaires in high quality consistently (209). The strengths and limitations of different methods in measuring (poly)phenol intakes are listed in **Table 4**.

In terms of (poly)phenol content data source, we found that open-access databases are becoming the most widely used resources for estimating (poly)phenol content of foods in the studies we reviewed. The development of the USDA databases in 1999 (216) and Phenol-Explorer in 2010 (217) has led to a growing number of researchers using these comprehensive databases in their studies over the last 20 y. Many papers combined different sources of (poly)phenol data to serve the purpose and scope of the individual studies. For example, many studies applied both USDA and Phenol-Explorer databases to cover the wide range of food items measured in the dietary assessment. Meanwhile, some other studies combined data from domestic databases to match up with the diet of the local population, such as Chinese food (218–221), Korean food (222–225), and UK food (81, 182, 226, 227). Data from published papers are also commonly applied to cover the food sources of (poly)phenols that do not appear in the databases. A systematic review that included 157 studies published between 2004 and 2014 reporting food-composition tools for (poly)phenol intake assessment (228) found that 60% of studies used published accessible databases (including USDA, Phenol-Explorer, country-based databases, and other public databases according to the groupings in the current study), and 33% of the literature

applied >1 database. The result is in accordance with our findings, where 49% of studies used publicly accessible databases and 20% of studies used >1 data source of (poly)phenol contents. The Phenol-Explorer database and USDA database are the 2 most comprehensive databases on (poly)phenol content in foods. The Phenol-Explorer database retrieves all classes and subclasses of (poly)phenol content data in foods published in scientific papers, books, and reviews and includes critical evaluations of experiment details on sampling, (poly)phenol extraction, and analytical methods (217). Mean values of each (poly)phenol content are provided in different categories of analytical methods used such as chromatography, chromatography after hydrolysis, and the Folin assay method (217). In addition, retention factors of compounds after food processing are also available (229). The USDA database for flavonoid content is mainly focused on a specific number of flavonoids compounds, which are retrieved from published papers and evaluated for quality using a standardized procedure and scoring system developed by the Nutrient Data Laboratory of the USDA (87). Flavonoid content data from the United States and other countries are included in the database. Only the data generated by acceptable analytical methods that can result in good separation of the target compounds, such as HPLC, capillary zone electrophoresis, and micellar electrokinetic capillary chromatography, are included (87). Different from Phenol-Explorer, which shows content data from different methods separately, the USDA content data are measured as glucosides and converted into aglycones to be comparable and consistent across the database. These 2 databases are free to access for the public, include data with relative acceptable analytical methods, and integrate different sources to provide reliable (poly)phenol content data.

The current available databases have limitations that may hinder the accuracy of (poly)phenol measurement. First, many foods and compounds are missing from the databases due to the lack of analytical data, which would lead to underestimation of the dietary intake of less-studied compounds and foods. In both Phenol-Explorer and USDA databases, frequently, content data of only a small number of phenolic compounds are available for a food item. Therefore, underestimation of intake can occur when calculating total (poly)phenol intake by summarizing the intakes of individual classes and subclasses of compounds. Second, the analytical methods that have been used to measure (poly)phenols in food are not consistent in accuracy. Some of the food content data are only available from spectrophotometric methods such as the Folin-Ciocalteu method (230). The Folin method is a colorimetric method measuring levels of total antioxidant capacity rather than total phenolics (231). Data from these spectrophotometric methods are highly inaccurate compared with the content data from analytical methods that can quantify the compounds individually, such as HPLC. In addition, many (poly)phenols are quantified with standards of their parent compounds (e.g., quantify resveratrol glucosides with resveratrol) or similar compounds (e.g., quantify tyrosol with hydroxytyrosol) (232). Even though this is common practice, especially when authentic standards are not commercially available, quantifying compounds with other standards can lead to inaccurate results (233). In addition, the content data may not be reliable if they are derived from a small number of studies due to interlaboratory variability. Furthermore, the databases are usually updated after long periods; therefore, there is a time lag between newly published values and database update. Last, the information can lack details on the multiple factors influencing polyphenol content of food such as origin, species, storage, and processing procedures. Similar to nutrients, the food contents of phytochemicals can be highly variable under the influence of the above factors (207). Domestic data may be more accurate than using data from other countries; however, there are limited compounds in country-based databases (234, 235) because of the huge expense and difficulties in analysis. Phenol-Explorer has been updated on yield factors related to cooking in recent years (229); however, the data available are still limited. Although more data and improvements in data quality are needed, the establishment of these databases is a very useful step towards more accurate analysis.

While many studies used a validated tool to measure nutrient intake, most of them were not validated for the target (poly)phenols. This limitation may introduce an unknown amount of systematic error in the estimation. The validity of measuring (poly)phenol intake could vary from the validity of measuring other nutrients or foods, especially considering the challenges in dietary assessment tools and food content databases mentioned previously. In addition to the low number of validated studies, we found the quality of the validation studies to be low, with 50% of the studies ranked as "fair" and 13% as "poor." We identified the following concerns: *1*) most of the validation evidence was provided only by correlation coefficients with estimations derived from other dietary assessment methods, *2*) no evidence of reproducibility was provided in most studies, and *3*) the validation study design and results were insufficiently reported. The poor validation and reporting of (poly)phenol assessment restrict the evaluation of the existing evidence in meta-analysis.

The last data extraction of this study was conducted in May 2020. At the time of writing the manuscript, further papers reporting dietary assessment of (poly)phenol intakes have been published (236–239). In agreement with our findings, most of the papers (236–238) used FFQs to estimate (poly)phenol intake. Phenol-Explorer (236, 239) and USDA databases (236–238) were used as (poly)phenol composition data sources. Yue et al. (236) reported moderate to high validity (Spearman's rank correlation coefficients were 0.4–0.7 or ≥0.7) and high reproducibility (rank interclass correlation coefficients were ∼0.8) of an FFQ on reporting flavonoids compared with two 7-d weighed dietary records with both Phenol-Explorer database and a Harvard database that was mainly based on the USDA database.

Outside the remit of this review, it is important to mention that another approach to estimate (poly)phenol

intake in epidemiological studies is the use of biomarkers of (poly)phenol intake in biofluids. This approach is considered to be more objective as it directly reflects "bioavailable" (poly)phenol exposure levels and does not depend on self-reported data and inaccuracies of tools and databases. The dietary assessment polyphenol database method is simple and easy to conduct, although it is prone to errors resulting from misreport (240) and limited information in the current databases (241). Biomarkers of (poly)phenol intake can be used to validate or calibrate the dietary assessment approach. Therefore, the integration of (poly)phenol biomarkers into the dietary assessment can provide a more robust result, especially when linking (poly)phenol intakes to health outcomes (242). However, the biomarker method requires access to specialized analytical techniques such as LC and MS, which are less accessible compared with dietary assessment. The accuracy of the analytical methods depends largely on the availability of authentic chemical standards, and validation of the methods is also needed. In addition, the short half-life of many (poly)phenol metabolites could hamper their potentials to represent habitual diet (242). Despite the fast development in this field, there are very few validated, efficient, and accessible methods that are available for use in epidemiology studies (210). In this study we found a limited number of studies ($n = 57$, 10%) that reported both dietary intake and biomarker concentrations of (poly)phenols and, of these, only 43 (75%) reported the correlation coefficients between the 2 measurements. The correlation coefficients varied widely between different samples, compounds, and analytical methods used to measure biomarkers and dietary assessment methods. Interestingly, better correlations between dietary intake of (poly)phenols and (poly)phenol biomarkers were found between food diaries or recalls than FFQs in a few studies (44, 45, 62, 67, 68), which indicated the advantage of food records or recalls. In future studies that measure dietary intake of (poly)phenols, measurement of biomarkers should be taken into consideration. Also, more efforts are needed in the development of analytical methods that are validated for measuring (poly)phenol biomarkers and, at the same time, are suitable (fast, high-throughput) to use in large epidemiological studies.

There has been an exponential increase in nutritional epidemiology studies reporting associations between (poly)phenol intake and health outcomes (17–19). However, it remains a challenge to be able to advise the public on the likely intake level that is beneficial to health due to the existence of methodological issues in measuring (poly)phenol intake identified in this review, including limited ability and validity of the dietary assessment tools, limited food content data of (poly)phenols, and insufficient reporting of the results (Table 4). To strengthen the quality of evidence on (poly)phenol intake and health, our recommendations on choosing dietary assessment methods are summarized in Table 4. The first step is to describe clearly the scope of the estimation and have a target compound or a group of (poly)phenols and define a target time period of measurement according to the research question. When choosing the dietary assessment tool, careful consideration should be given to select the one that can cover the food sources of the target compounds and represent the diet in the target time range. The dietary assessment tool should be validated for the target compounds with the use of other, more robust dietary assessment tools or ideally provide correlations with biomarkers of (poly)phenol intake. If possible, the use of multiple measurements of dietary records to collect dietary intake data is recommended. The chosen food content database of (poly)phenols should cover the content data of food sources of the target compounds. The combination of USDA and Phenol-Explorer databases is the most comprehensive approach at the moment. The use of domestic databases and recipes to match with the diet of the population if available is also recommended. The reporting of observational studies estimating (poly)phenol intake should follow the STROBE-nut framework (21), including additional details that are specific to (poly)phenol analysis as described in Table 4.

In summary, the findings of this systematic review suggest that further research is needed to develop tools that are specifically designed to measure (poly)phenol intake. Improvements in current food content databases are also essential to provide more reliable, detailed, and up-to-date data. International collaborations on setting up standards and guidance on food content analysis regarding phytochemical compounds are also needed. Validation of the tools, especially combining the biomarker or metabolomics approach to validate or calibrate the dietary assessment methods, could provide more reliable evidence on relations between (poly)phenol intake and health outcomes. Future research should complement the dietary intake data with quantification of biomarkers of (poly)phenol intake. Therefore, development of fast, high-throughput, sensitive, and accurate analytical methods to measure concentrations of phenolic metabolites in biofluids is also needed. Understanding the different methods of measurement and their strengths and limitations, as set out in this review, is an important step towards developing a standardized approach to measurement and reporting dietary (poly)phenol intake. This will enable comparison between studies and future pooling of results in systematic reviews to strengthen the evidence base.

Acknowledgments

The authors' responsibilities were as follows—YX, AR-M, and RG: designed the study and prepared the figures, tables, and wrote the first draft; YX: performed the literature search through scientific databases; YX, MLS, CR, and SH: reviewed titles, abstracts, and full texts; verified eligibility of the papers; and extracted information; MLS and CR: improved and critically revised the manuscript, figures, and tables; and all authors: read and approved the final manuscript.

References

1. Global Burden of Disease Diet Collaborators. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for

the Global Burden of Disease Study 2017. Lancet North Am Ed 2019;393(10184):1958–72.
2. Forouhi NG, Unwin N. Global diet and health: old questions, fresh evidence, and new horizons. Lancet North Am Ed 2019;393(10184):1916–8.
3. Barabási A-L, Menichetti G, Loscalzo J. The unmapped chemical complexity of our diet. Nat Food 2020;1(1):33–7.
4. Russo GI, Solinas T, Urzi D, Privitera S, Campisi D, Cocci A, Carini M, Madonia M, Cimino S, Morgia G. Adherence to Mediterranean diet and prostate cancer risk in Sicily: population-based case-control study. Int J Impot Res 2018, 31;(4):269–75; http://dx.doi.org/10.1038/s41443-018-0088-5
5. Aune D, Keum N, Giovannucci E, Fadnes LT, Boffetta P, Greenwood DC, Tonstad S, Vatten LJ, Riboli E, Norat T. Whole grain consumption and risk of cardiovascular disease, cancer, and all cause and cause specific mortality: systematic review and dose-response meta-analysis of prospective studies. BMJ 2016;353:i2716. doi: 10.1136/bmj.i2716.
6. Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol 2017;46(3):1029–56.
7. Shin JY, Kim JY, Kang HT, Han KH, Shim JY. Effect of fruits and vegetables on metabolic syndrome: a systematic review and meta-analysis of randomized controlled trials. Int J Food Sci Nutr 2015;66(4):416–25.
8. Afshin A, Micha R, Khatibzadeh S, Mozaffarian D. Consumption of nuts and legumes and risk of incident ischemic heart disease, stroke, and diabetes: a systematic review and meta-analysis. Am J Clin Nutr 2014;100(1):278–88.
9. Marventano S, Izquierdo Pulido M, Sanchez-Gonzalez C, Godos J, Speciani A, Galvano F, Grosso G. Legume consumption and CVD risk: a systematic review and meta-analysis. Public Health Nutr 2017;20(2):245–54.
10. Satija A, Yu E, Willett WC, Hu FB. Understanding nutritional epidemiology and its role in policy. Adv Nutr 2015;6(1):5–18.
11. Cassidy A, Mukamal KJ, Liu L, Franz M, Eliassen AH, Rimm EB. High anthocyanin intake is associated with a reduced risk of myocardial infarction in young and middle-aged women. Circulation 2013;127(2):188–96.
12. Cassidy A, O'Reilly EJ, Kay C, Sampson L, Franz M, Forman JP, Curhan G, Rimm EB. Habitual intake of flavonoid subclasses and incident hypertension in adults. Am J Clin Nutr 2011;93(2):338–47.
13. Cassidy A, Bertoia M, Chiuve S, Flint A, Forman J, Rimm EB. Habitual intake of anthocyanins and flavanones and risk of cardiovascular disease in men. Am J Clin Nutr 2016;104(3):587–94.
14. Zamora-Ros R, Knaze V, Rothwell JA, Hemon B, Moskal A, Overvad K, Tjonneland A, Kyro C, Fagherazzi G, Boutron-Ruault MC, et al. Dietary polyphenol intake in Europe: the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Eur J Nutr 2016;55(4):1359–75.
15. Bingham SA, Gill C, Welch A, Cassidy A, Runswick SA, Oakes S, Lubin R, Thurnham DI, Key TJ, Roe L, et al. Validation of dietary assessment methods in the UK arm of EPIC using weighed records, and 24-hour urinary nitrogen and potassium and serum vitamin C and carotenoids as biomarkers. Int J Epidemiol 1997;26:137S. doi: 10.1093/ije/26.suppl_1.s137.
16. Del Bo C, Bernardi S, Marino M, Porrini M, Tucci M, Guglielmetti S, Cherubini A, Carrieri B, Kirkup B, Kroon P, et al. Systematic review on polyphenol intake and health outcomes: is there sufficient evidence to define a health-promoting polyphenol-rich dietary pattern? Nutrients 2019;11(6); doi: 10.3390/nu11061355.1355.
17. Grosso G, Micek A, Godos J, Pajak A, Sciacca S, Galvano F, Giovannucci EL. Dietary flavonoid and lignan intake and mortality in prospective cohort studies: systematic review and dose-response meta-analysis. Am J Epidemiol 2017;185(12):1304–16.
18. Godos J, Vitale M, Micek A, Ray S, Martini D, Del Rio D, Riccardi G, Galvano F, Grosso G. Dietary polyphenol intake, blood pressure, and hypertension: a systematic review and meta-analysis of observational studies. Antioxidants 2019;8(6). doi: 10.3390/antiox8060152.152.
19. Rienks J, Barbaresko J, Oluwagbemigun K, Schmid M, Nothlings U. Polyphenol exposure and risk of type 2 diabetes: dose-response meta-analyses and systematic review of prospective cohort studies. Am J Clin Nutr 2018;108(1):49–61.
20. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. PLoS Med 2009;6(7):e1000097. doi: 10.1371/journal.pmed.1000097.
21. Lachat C, Hawwash D, Ocke MC, Berg C, Forsum E, Hornell A, Larsson C, Sonestedt E, Wirfalt E, Akesson A, et al. Strengthening the Reporting of Observational Studies in Epidemiology–Nutritional Epidemiology (STROBE-nut): an extension of the STROBE statement. PLoS Med 2016;13(6):e1002036. doi: 10.1371/journal.pmed.100203610.1371/journal.pmed.1002036.
22. Zhang M, Xie X, Lee AH, Binns CW. Soy and isoflavone intake are associated with reduced risk of ovarian cancer in Southeast China. Nutr Cancer 2004;49(2):125–30.
23. Zhang YF, Kang HB, Li BL, Zhang RM. Positive effects of soy isoflavone food on survival of breast cancer patients in China. Asian Pac J Cancer Prev 2012;13(2):479–82.
24. Wang Q, Wang YP, Li JY, Yuan P, Yang F, Li H. Polymorphic catechol-O-methyltransferase gene, soy isoflavone intake and breast cancer in postmenopausal women: a case-control study. Chin J Cancer 2010;29(7):683–8.
25. Cao Y, Taylor AW, Zhen S, Adams R, Appleton S, Shi Z. Soy isoflavone intake and sleep parameters over 5 years among Chinese adults: longitudinal analysis from the Jiangsu Nutrition Study. J Acad Nutr Diet 2017;117(4):536–44, e2.
26. Wong SYS, Lau WWY, Leung PC, Leung JCS, Woo J. The association between isoflavone and lower urinary tract symptoms in elderly men. Br J Nutr 2007;98(6):1237–42.
27. Yamamoto S, Kobayashi M, Tsugane S, Sasaki S, Sobue T, Ogata J, Baba S, Miyakawa K, Saito F, Koizumi A, et al. Soy, isoflavones, and breast cancer risk in Japan. J Natl Cancer Inst 2003;95(12):906–13.
28. Lee SA, Choi JY, Shin CS, Hong YC, Chung H, Kang D. SULT1E1 genetic polymorphisms modified the association between phytoestrogen consumption and bone mineral density in healthy Korean women. Calcif Tissue Int 2006;79(3):152–9.
29. Goodman-Gruen D, Kritz-Silverstein D. Usual dietary isoflavone intake and body composition in postmenopausal women. Menopause 2003;10(5):427–32.
30. Michikawa T, Yamazaki S, Ono M, Kuroda T, Nakayama SF, Suda E, Isobe T, Iwai-Shimada M, Kobayashi Y, Yonemoto J, et al. Isoflavone intake in early pregnancy and hypospadias in the Japan Environment and Chi ldren's Study. Urology 2018;124:229–36. doi: http://dx.doi.org/10.1016/j.urology.2018.11.008.
31. Wilunda C, Sawada N, Goto A, Yamaji T, Iwasaki M, Tsugane S, Noda M. Soy food and isoflavones are not associated with changes in serum lipids and glycohemoglobin concentrations among Japanese adults: a cohort study. Eur J Nutr 2019;59:2075–87. doi: http://dx.doi.org/10.1007/s00394-019-02057-7.
32. Lu YX, Zamora-Ros R, Chan S, Cross AJ, Ward H, Jakszyn P, Luben R, Opstelten JL, Oldenburg B, Hallmans G, et al. Dietary polyphenols in the aetiology of crohn's disease and ulcerative colitis—a multicenter European prospective cohort study (EPIC). Inflamm Bowel Dis 2017;23(12):2072–82.
33. Garcia V, Arts ICW, Sterne JAC, Thompson RL, Shaheen SO. Dietary intake of flavonoids and asthma in adults. Eur Respir J 2005;26(3):449–52. doi: 10.1183/09031936.05.00142104.
34. Tan A, Morton KR, Lee JW, Hartman R, Lee G. Adverse childhood experiences and depressive symptoms: protective effects of dietary flavonoids. J Psychosom Res 2020;131 http://dx.doi.org/10.1016/j.jpsychores.2020.109957.
35. Woo J, Lynn H, Lau WY, Leung J, Lau E, Wong SYS, Kwok T. Nutrient intake and psychological health in an elderly Chinese population. Int J Geriat Psychiatry 2006;21(11):1036–43 10.1002/gps.1603.

36. Fisher ND, Hurwitz S, Hollenberg NK. Habitual flavonoid intake and endothelial function in healthy humans. J Am Coll Nutr 2012;31(4):275–9.
37. Ekstrom AM, Serafini M, Nyren O, Wolk A, Bosetti C, Bellocco R. Dietary quercetin intake and risk of gastric cancer: results from a population-based study in Sweden. Ann Oncol 2011;22(2):438–43.
38. Lu Y, Shivappa N, Lin Y, Lagergren J, Hebert JR. Diet-related inflammation and oesophageal cancer by histological type: a nationwide case-control study in Sweden. Eur J Nutr 2016;55(4):1683–94; http://dx.doi.org/10.1007/s00394-015-0987-x
39. Lin Y, Yngve A, Lagergren J, Lu Y. A dietary pattern rich in lignans, quercetin and resveratrol decreases the risk of oesophageal cancer. Br J Nutr 2014;112(12):2002–9. doi: https://dx.doi.org/10.1017/S0007114514003055.
40. Lin YL, Yngve A, Lagergren J, Lu YX. Dietary intake of lignans and risk of adenocarcinoma of the esophagus and gastroesophageal junction. Cancer Causes Control 2012;23(6):837–44. doi: 10.1007/s10552-012-9952-7.
41. Lin YL, Wolk A, Hakansson N, Lagergren J, Lu YX. Dietary intake of lignans and risk of esophageal and gastric adenocarcinoma: a cohort study in Sweden. Cancer Epidemiol Biomarkers Prev 2013;22(2):308–12. doi: 10.1158/1055-9965.Epi-12-1138.
42. Somerset S, Papier K. A food frequency questionnaire validated for estimating dietary flavonoid intake in an Australian population. Nutr Cancer 2014;66(7):1200–10. doi: 10.1080/01635581.2014.951728.
43. Hanna KL, O'Neill S, Lyons-Wall PM. Intake of isoflavone and lignan phytoestrogens and associated demographic and lifestyle factors in older Australian women. Asia Pac J Clin Nutr 2010;19(4):540–9.
44. Vian I, Zielinsky P, Zilio AM, Mello A, Lazzeri B, Oliveira A, Lampert KV, Piccoli A, Nicoloso LH, Bubols GB, et al. Development and validation of a food frequency questionnaire for consumption of polyphenol-rich foods in pregnant women. Matern Child Nutr 2015;11(4):511–24. doi: 10.1111/mcn.12025.
45. French MR, Thompson LU, Hawker GA. Validation of a phytoestrogen food frequency questionnaire with urinary concentrations of isoflavones and lignan metabolites in premenopausal women. J Am Coll Nutr 2007;26(1):76–82. doi: 10.1080/07315724.2007.10719588.
46. Cao J, Chen W, Yang J, Hao D, Zhang Y, Chang P, Zhao X. Reproducibility and relative validity of a food frequency questionnaire to assess intake of dietary flavonol and flavone in Chinese university campus population. Nutr Res 2010;30(8):520–6. doi: http://dx.doi.org/10.1016/j.nutres.2010.07.001.
47. Ranka S, Gee JM, Biro L, Brett G, Saha S, Kroon P, Skinner J, Hart AR, Cassidy A, Rhodes M, et al. Development of a food frequency questionnaire for the assessment of quercetin and naringenin intake. Eur J Clin Nutr 2008;62(9):1131–8. doi: 10.1038/sj.ejcn.1602827.
48. Frankenfeld CL, Patterson RE, Kalhorn TF, Skor HE, Howald WN, Lampe JW. Validation of a soy food frequency questionnaire with plasma concentrations of isoflavones in US adults. J Am Diet Assoc 2002;102(10):1407–13. doi: 10.1016/s0002-8223(02)90313-5.
49. Frankenfeld CL, Patterson RE, Horner NK, Neuhouser ML, Skor HE, Kalhorn TF, Howald WN, Lampe JW. Validation of a soy food-frequency questionnaire and evaluation of correlates of plasma isoflavone concentrations in postmenopausal women. Am J Clin Nutr 2003;77(3):674–80.
50. Hakim IA, Hartz V, Harris RB, Balentine D, Weisgerber UM, Graver E, Whitacre R, Alberts D. Reproducibility and relative validity of a questionnaire to assess intake of black tea polyphenols in epidemiological studies. Cancer Epidemiol Biomarkers Prev 2001;10(6):667–78.
51. Lammersfeld CA, King J, Walker S, Vashi PG, Grutsch JF, Lis CG, Gupta D. Prevalence, sources, and predictors of soy consumption in breast cancer. Nutr J 2009;8:7. doi: 10.1186/1475-2891-8-2.
52. Tseng M, Olufade T, Kurzer MS, Wahala K, Fang CY, van der Schouw YT, Daly MB. Food frequency questionnaires and overnight urines are valid indicators of daidzein and genistein intake in US women relative to multiple 24-h urine samples. Nutr Cancer 2008;60(5):619–26. doi: 10.1080/01635580801993751.
53. Reed SD, Lampe JW, Qu C, Gundersen G, Fuller S, Copeland WK, Newton KM. Self-reported menopausal symptoms in a racially diverse population and soy food consumption. Maturitas 2013;75(2):152–8. doi: 10.1016/j.maturitas.2013.03.003.
54. Minguez-Alarcon L, Afeiche MC, Chiu YH, Vanegas JC, Williams PL, Tanrikut C, Toth TL, Hauser R, Chavarro JE. Male soy food intake was not associated with in vitro fertilization outcomes among couples attending a fertility center. Andrology 2015;3(4):702–8. doi: https://dx.doi.org/10.1111/andr.12046.
55. Portman MA, Navarro SL, Bruce ME, Lampe JW. Soy isoflavone intake is associated with risk of Kawasaki disease. Nutr Res 2016;36(8):827–34. doi: 10.1016/j.nutres.2016.04.002.
56. Ocke MC, Bueno-de-Mesquita HB, Goddijn HE, Jansen A, Pols MA, van Staveren WA, Kromhout D. The Dutch EPIC food frequency questionnaire. I. Description of the questionnaire, and relative validity and reproducibility for food groups. Int J Epidemiol 1997;26:37S. doi: 10.1093/ije/26.suppl_1.s37.
57. Ocke MC, Bueno-de-Mesquita HB, Pols MA, Smit HA, van Staveren WA, Kromhout D. The Dutch EPIC food frequency questionnaire. II. Relative validity and reproducibility for nutrients. Int J Epidemiol 1997;26:49S. doi: 10.1093/ije/26.suppl_1.s49.
58. Pisani P, Faggiano F, Krogh V, Palli D, Vineis P, Berrino F. Relative validity and reproducibility of a food frequency dietary questionnaire for use in the Italian EPIC centres. Int J Epidemiol 1997;26:152S. doi: 10.1093/ije/26.suppl_1.s152.
59. Bingham SA, Gill C, Welch A, Day K, Cassidy A, Khaw KT, Sneyd MJ, Key TJ, Roe L, Day NE. Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records. Br J Nutr 1994;72(4):619–43. doi: 10.1079/bjn19940064.
60. Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. J Clin Epidemiol 1990;43(12):1327–35. doi: 10.1016/0895-4356(90)90099-b.
61. Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J, Hennekens CH, Speizer FE. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol 1985;122(1):51–65.
62. Hoge A, Guillaume M, Albert A, Tabart J, Dardenne N, Donneau AF, Kevers C, Defraigne JO, Pincemail J. Validation of a food frequency questionnaire assessing dietary polyphenol exposure using the method of triads. Free Radic Biol Med 2019;130:189–95. doi: 10.1016/j.freeradbiomed.2018.11.001.
63. Ishihara J, Iwasaki M, Kunieda CM, Hamada GS, Tsugane S. Food frequency questionnaire is a valid tool in the nutritional assessment of Brazilian women of diverse ethnicity. Asia Pac J Clin Nutr 2009;18(1):76–80.
64. Yamamoto S, Sobue T, Sasaki S, Kobayashi M, Arai Y, Uehara M, Adlercreutz H, Watanabe S, Takahashi T, Iitoi Y, et al. Validity and reproducibility of a self-administered food-frequency questionnaire to assess isoflavone intake in a Japanese population in comparison with dietary records and blood and urine isoflavones. J Nutr 2001;131(10):2741–7.
65. Carrion-Garcia CJ, Guerra-Hernandez EJ, Garcia-Villanova B, Molina-Montes E. Non-enzymatic antioxidant capacity (NEAC) estimated by two different dietary assessment methods and its relationship with NEAC plasma levels. Eur J Nutr 2017;56(4):1561–76. doi: https://dx.doi.org/10.1007/s00394-016-1201-5.
66. Bhakta D, dos Santos Silva I, Higgins C, Sevak L, Kassam-Khamis T, Mangtani P, Adlercreutz H, McMichael A. A semiquantitative food frequency questionnaire is a valid indicator of the usual intake of phytoestrogens by south Asian women in the UK relative to multiple 24-h dietary recalls and multiple plasma samples. J Nutr 2005;135(1):116–23.
67. Bingham S, Luben R, Welch A, Low YL, Khaw KT, Wareham N, Day N. Associations between dietary methods and biomarkers, and between fruits and vegetables and risk of ischaemic heart disease, in

the EPIC Norfolk Cohort Study. Int J Epidemiol 2008;37(5):978–87. doi: https://dx.doi.org/10.1093/ije/dyn111.
68. Verkasalo PK, Appleby PN, Allen NE, Davey G, Adlercreutz H, Key TJ. Soya intake and plasma concentrations of daidzein and genistein: validity of dietary assessment among eighty British women (Oxford arm of the European Prospective Investigation into Cancer and Nutrition). Br J Nutr 2001;86(3):415–21. doi: 10.1079/bjn2001424.
69. Huang MH, Harrison GG, Mohamed MM, Gornbein JA, Henning SM, Go VLW, Greendale GA. Assessing the accuracy of a food frequency questionnaire for estimating usual intake of phytoestrogens. Nutr Cancer 2000;37(2):145–54. doi: 10.1207/s15327914nc372_5.
70. Yang M, Wang Y, Davis CG, Lee SG, Fernandez ML, Koo SI, Cho E, Chun OK. Validation of an FFQ to assess antioxidant intake in overweight postmenopausal women. Public Health Nutr 2014;17(7):1467–75. doi: 10.1017/s1368980013001638.
71. Horn-Ross PL, Barnes S, Lee VS, Collins CN, Reynolds P, Lee MM, Stewart SL, Canchola AJ, Wilson L, Jones K. Reliability and validity of an assessment of usual phytoestrogen consumption (United States). Cancer Causes Control 2006;17(1):85–93. doi: 10.1007/s10552-005-0391-6.
72. Kyro C, Zamora-Ros R, Scalbert A, Tjonneland A, Dossus L, Johansen C, Bidstrup PE, Weiderpass E, Christensen J, Ward H, et al. Pre-diagnostic polyphenol intake and breast cancer survival: the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. Breast Cancer Res Treat 2015;154(2):389–401. doi: https://dx.doi.org/10.1007/s10549-015-3595-9.
73. Vermeulen E, Zamora-Ros R, Duell EJ, Lujan-Barroso L, Boeing H, Aleksandrova K, Bueno-de-Mesquita HB, Scalbert A, Romieu I, Fedirko V, et al. Dietary flavonoid intake and esophageal cancer risk in the European Prospective Investigation into Cancer and Nutrition Cohort. Am J Epidemiol 2013;178(4):570–81. doi: 10.1093/aje/kwt026.
74. Zamora-Ros R, Agudo A, Lujan-Barroso L, Romieu I, Ferrari P, Knaze V, Bueno-de-Mesquita HB, Leenders M, Travis RC, Navarro C, et al. Dietary flavonoid and lignan intake and gastric adenocarcinoma risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Am J Clin Nutr 2012;96(6):1398–408.
75. Zamora-Ros R, Forouhi NG, Sharp SJ, Gonzalez CA, Buijsse B, Guevara M, van der Schouw YT, Amiano P, Boeing H, Bredsdorff L, et al. The Association between dietary flavonoid and lignan intakes and incident type 2 diabetes in European populations: the EPIC-InterAct study. Diabetes Care 2013;36(12):3961–70. doi: 10.2337/dc13-0877.
76. Zamora-Ros R, Barupal DK, Rothwell JA, Jenab M, Fedirko V, Romieu I, Aleksandrova K, Overvad K, Kyro C, Tjonneland A, et al. Dietary flavonoid intake and colorectal cancer risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. Int J Cancer 2017;140(8):1836–44. doi: 10.1002/ijc.30582.
77. Zamora-Ros R, Cayssials V, Jenab M, Rothwell JA, Fedirko V, Aleksandrova K, Tjonneland A, Kyro C, Overvad K, Boutron-Ruault MC, et al. Dietary intake of total polyphenol and polyphenol classes and the risk of colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. Eur J Epidemiol 2018;33(11):1063–75. doi: 10.1007/s10654-018-0408-6.
78. Zamora-Ros R, Fedirko V, Trichopoulou A, Gonzalez CA, Bamia C, Trepo E, Nothlings U, Duarte-Salles T, Serafini M, Bredsdorff L, et al. Dietary flavonoid, lignan and antioxidant capacity and risk of hepatocellular carcinoma in the European Prospective Investigation into Cancer and Nutrition study. Int J Cancer 2013;133(10):2429–43.
79. Zamora-Ros R, Forouhi NG, Sharp SJ, Gonzalez CA, Buijsse B, Guevara M, van der Schouw YT, Amiano P, Boeing H, Bredsdorff L, et al. Dietary intakes of individual flavanols and flavonols are inversely associated with incident type 2 diabetes in European populations. J Nutr 2014;144(3):335–43.
80. Molina-Montes E, Sanchez MJ, Zamora-Ros R, Bueno-de-Mesquita HB, Wark PA, Obon-Santacana M, Kuhn T, Katzke V, Travis RC, Ye WM, et al. Flavonoid and lignan intake and pancreatic cancer risk in the European Prospective Investigation into Cancer and Nutrition cohort. Int J Cancer 2016;139(7):1480–92. doi: 10.1002/ijc.30190.
81. Zamora-Ros R, Rothwell JA, Scalbert A, Knaze V, Romieu I, Slimani N, Fagherazzi G, Perquier F, Touillaud M, Molina-Montes E, et al. Dietary intakes and food sources of phenolic acids in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Br J Nutr 2013;110(8):1500–11. doi: https://dx.doi.org/10.1017/S0007114513000688.
82. Zamora-Ros R, Rothwell JA, Achaintre D, Ferrari P, Boutron-Ruault MC, Mancini FR, Affret A, Kuhn T, Katzke V, Boeing H, et al. Evaluation of urinary resveratrol as a biomarker of dietary resveratrol intake in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Br J Nutr 2017;117(11):1596–602. doi: 10.1017/s0007114517001465.
83. Lako J, Wattanapenpaiboon N, Wahlqvist M, Trenerry C. Phytochemical intakes of the Fijian population. Asia Pac J Clin Nutr 2006;15(2):275–85.
84. Nothlings U, Murphy SP, Wilkens LR, Boeing H, Schulze MB, Bueno-De-Mesquita HB, Michaud DS, Roddam A, Rohrmann S, Tjonneland A, et al. A food pattern that is predictive of flavonol intake and risk of pancreatic cancer. Am J Clin Nutr 2008;88(6):1653–62.
85. Zamora-Ros R, Cayssials V, Franceschi S, Kyro C, Weiderpass E, Hennings J, Sandstrom M, Tjonneland A, Olsen A, Overvad K, et al. Polyphenol intake and differentiated thyroid cancer risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. Int J Cancer 2020;146(7):1841–50. doi: https://dx.doi.org/10.1002/ijc.32589.
86. Tahiri I, Garro-Aguilar Y, Cayssials V, Achaintre D, Mancini FR, Mahamat-Saleh Y, Boutron-Ruault MC, Kuhn T, Katzke V, Boeing H, et al. Urinary flavanone concentrations as biomarkers of dietary flavanone intakes in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Br J Nutr 2020;123(6):691–8. doi: http://dx.doi.org/10.1017/S0007114519003131.
87. Bhagwat S, Haytowitz DB. USDA Database for the Flavonoid Content of Selected Foods. Nutrient Data Lab oratory, Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA, Release 3.2. :Beltsville (MD); 2016.
88. Bhagwat S, Haytowitz DB. USDA Database for the Isoflavone Content of Selected Foods. Release 3.2.Beltsville (MD): Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA; 2016.
89. Bhagwat S, Haytowitz DB. USDA Database for the Proanthocyanidin Content of Selected Foods. Release 2. Beltsville (MD): Nutrient Data Laboratory, Beltsville Human Nutrition Research Center, Agricultural Research Service, USDA; 2015.
90. Cao J, Zhang Y, Chen W, Zhao X. The relationship between fasting plasma concentrations of selected flavonoids and their ordinary dietary intake. Br J Nutr 2010;103(2):249–55. doi: http://dx.doi.org/10.1017/S000711450999170X.
91. Hertog MG, Kromhout D, Aravanis C, Blackburn H, Buzina R, Fidanza F, Giampaoli S, Jansen A, Menotti A, Nedeljkovic S, et al. Flavonoid intake and long-term risk of coronary heart disease and cancer in the Seven Countries Study [Erratum appears in Arch Intern Med 1995;155(11):1184]. Arch Intern Med 1995;155(4):381–6.
92. Brat P, George S, Bellamy A, Du Chaffaut L, Scalbert A, Mennen L, Arnault N, Amiot MJ. Daily polyphenol intake in France from fruit and vegetables. J Nutr 2006;136(9):2368–73.
93. Arai Y, Watanabe S, Kimira M, Shimoi K, Mochizuki R, Kinae N. Dietary intakes of flavonols, flavones and isoflavones by Japanese women and the inverse correlation between quercetin intake and plasma LDL cholesterol concentration. J Nutr 2000;130(9):2243–50.
94. Taguchi C, Kishimoto Y, Kondo K, Tohyama K, Goda T. Serum gamma-glutamyltransferase is inversely associated with dietary total and coffee-derived polyphenol intakes in apparently healthy Japanese men. Eur J Nutr 2018;57(8):2819–26. doi: 10.1007/s00394-017-1549-1.
95. Nishimuro H, Ohnishi H, Sato M, Ohnishi-Kameyama M, Matsunaga I, Naito S, Ippoushi K, Oike H, Nagata T, Akasaka H, et al. Estimated

daily intake and seasonal food sources of quercetin in Japan. Nutrients 2015;7(4):2345–58. doi: http://dx.doi.org/10.3390/nu7042345.
96. Torres-Sanchez L, Galvan-Portillo M, Wolff MS, Lopez-Carrillo L. Dietary consumption of phytochemicals and breast cancer risk in Mexican women. Public Health Nutr 2009;12(6):825–31. doi: 10.1017/s136898000800325x.
97. Zamora-Ros R, Biessy C, Rothwell JA, Monge A, Lajous M, Scalbert A, Lopez-Ridaura R, Romieu I. Dietary polyphenol intake and their major food sources in the Mexican Teachers' Cohort. Br J Nutr 2018;120(3):353–60.
98. Adebamowo CA, Cho E, Sampson L, Katan MB, Spiegelman D, Willett WC, Holmes MD. Dietary flavonols and flavonol-rich foods intake and the risk of breast cancer. Int J Cancer 2005;114(4):628–33.
99. Dower JI, Geleijnse JM, Hollman PCH, Soedamah-Muthu SS, Kromhout D. Dietary epicatechin intake and 25-y risk of cardiovascular mortality: the Zutphen Elderly Study. Am J Clin Nutr 2016;104(1):58–64.
100. Horn-Ross PL, Barnes S, Lee M, Coward L, Mandel JE, Koo J, John EM, Smith M. Assessing phytoestrogen exposure in epidemiologic studies: development of a database (United States). Cancer Causes Control 2000;11(4):289–98. doi: 10.1023/a:1008995606699.
101. Horn-Ross PL, Lee M, John EM, Koo J. Sources of phytoestrogen exposure among non-Asian women in California, USA. Cancer Causes Control 2000;11(4):299–302. doi: 10.1023/a:1008968003575.
102. Hakim IA, Weisgerber UM, Harris RB, Balentine D, van-Mierlo CAJ, Paetau-Robinson I. Preparation, composition and consumption patterns of tea-based beverages in Arizona. Nutr Res 2000;20(12):1715–24. doi: 10.1016/s0271-5317(00)00275-x.
103. Goni I, Hernandez-Galiot A. Intake of nutrient and non-nutrient dietary antioxidants. contribution of macromolecular antioxidant polyphenols in an elderly Mediterranean population. Nutrients 2019;11(9):10. doi: https://dx.doi.org/10.3390/nu11092165.
104. Guha N, Kwan ML, Quesenberry Jr CP, Weltzien EK, Castillo AL, Caan BJ. Soy isoflavones and risk of cancer recurrence in a cohort of breast cancer survivors: the Life after Cancer Epidemiology study. Breast Cancer Res Treat 2009;118(2):395–405.
105. Zujko ME, Witkowska AM, Waskiewicz A, Mironczuk-Chodakowska I. Dietary antioxidant and flavonoid intakes are reduced in the elderly. Oxid Med Cell Longev 2015:843173, doi:10.1155/2015/843173.2015
106. Zujko ME, Witkowska AM, Waskiewicz A, Piotrowski W, Terlikowska KM. Dietary antioxidant capacity of the patients with cardiovascular disease in a cross-sectional study. Nutr J 2015;14:13. doi: 10.1186/s12937-015-0005-4.
107. Baglia ML, Gu K, Zhang X, Zheng Y, Peng P, Cai H, Bao PP, Zheng W, Lu W, Shu XO. Soy isoflavone intake and bone mineral density in breast cancer survivors. Cancer Causes Control 2015;26(4): 571–80.
108. Lee SA, Shu XO, Li HL, Yang G, Cai H, Wen WQ, Ji BT, Gao J, Gao YT, Zheng W. Adolescent and adult soy food intake and breast cancer risk: results from the Shanghai Women's Health Study. Am J Clin Nutr 2009;89(6):1920–6.
109. Qu RG, Jia YB, Liu JY, Jin SS, Han TS, Na LX. Dietary flavonoids, copper intake, and risk of metabolic syndrome in Chinese adults. Nutrients 2018;10(8):991. doi: 10.3390/nu10080991.
110. Wu SH, Shu XO, Chow WH, Xiang YB, Zhang XL, Li HL, Cai QY, Ji BT, Cai H, Rothman N, et al. Soy food intake and circulating levels of inflammatory markers in Chinese women. J Acad Nutr Diet 2012;112(7):996–1004. doi: 10.1016/j.jand.2012.04.001.
111. Wu X, Cai H, Gao YT, Dai Q, Li H, Cai Q, Yang G, Franke AA, Zheng W, Shu XO. Correlations of urinary phytoestrogen excretion with lifestyle factors and dietary intakes among middle-aged and elderly Chinese women. Int J Mol Epidemiol Genet 2012;3(1): 18–29.
112. Xu WH, Zheng W, Xiang YB, Ruan ZM, Cheng JR, Dai Q, Gao YT, Shu XO. Soya food intake and risk of endometrial cancer among Chinese women in Shanghai: population based case-control study. BMJ 2004;328(7451):1285–8. doi: 10.1136/bmj.38093.646215.AE.
113. Yang G, Shu XO, Li H, Chow WH, Cai H, Zhang X, Gao YT, Zheng W. Prospective cohort study of soy food intake and colorectal cancer risk in women. Am J Clin Nutr 2009;89(2):577–83.
114. Yao Z, Gu Y, Zhang Q, Liu L, Meng G, Wu H, Xia Y, Bao X, Shi H, Sun S, et al. Estimated daily quercetin intake and association with the prevalence of type 2 diabetes mellitus in Chinese adults. Eur J Nutr 2019;58(2):819–30. doi: https://dx.doi.org/10.1007/s00394-018-1713-2.
115. Yao Z, Li C, Gu Y, Zhang Q, Liu L, Meng G, Wu H, Bao X, Zhang S, Sun S, et al. Dietary myricetin intake is inversely associated with the prevalence of type 2 diabetes mellitus in a Chinese population. Nutr Res 2019;68:82–91. doi: http://dx.doi.org/10.1016/j.nutres.2019.06.004.
116. Yu DX, Shu XO, Li HL, Yang G, Cai QY, Xiang YB, Ji BT, Franke AA, Gao YT, Zheng W, et al. Dietary isoflavones, urinary isoflavonoids, and risk of ischemic stroke in women. Am J Clin Nutr 2015;102(3):680–6.
117. Zhang CX, Ho SC, Lin FY, Cheng SZ, Fu JH, Chen YM. Soy product and isoflavone intake and breast cancer risk defined by hormone receptor status. Cancer Sci 2010;101(2):501–7. doi: 10.1111/j.1349-7006.2009.01376.x.
118. Zhang X, Shu XO, Li H, Yang G, Li Q, Gao YT, Zheng W. Prospective cohort study of soy food consumption and risk of bone fracture among postmenopausal women. Arch Intern Med 2005;165(16):1890–5.
119. Zhu YY, Zhou L, Jiao SC, Xu LZ. Relationship between soy food intake and breast cancer in China. Asian Pac J Cancer Prev 2011;12(11):2837–40.
120. Zhang W, Wang J, Gao J, Li HL, Han LH, Lan Q, Rothman N, Zheng W, Shu XO, Xiang YB. Prediagnostic level of dietary and urinary isoflavonoids in relation to risk of liver cancer in Shanghai, China. Cancer Epidemiol Biomarkers Prev 2019;28(10):1712–9. doi: 10.1158/1055-9965.Epi-18-1075.
121. Liu YT, Fan YY, Xu CH, Lin XL, Lu YK, Zhang XL, Zhang CX, Chen YM. Habitual consumption of soy products and risk of nasopharyngeal carcinoma in Chinese adults: a case-control study. PLoS One 2013;8(10):e77822. doi: 10.1371/journal.pone.0077822.
122. Akhter M, Iwasaki M, Yamaji T, Sasazuki S, Tsugane S. Dietary isoflavone and the risk of colorectal adenoma: a case-control study in Japan. Br J Cancer 2009;100(11):1812–6.
123. Arai Y, Uehara M, Sato Y, Kimira M, Eboshida A, Adlercreutz H, Watanabe S. Comparison of isoflavones among dietary intake, plasma concentration and urinary excretion for accurate estimation of phytoestrogen intake. J Epidemiol 2000;10(2):127–35.
124. Cui Y, Huang C, Momma H, Niu K, Nagatomi R. Daily dietary isoflavone intake in relation to lowered risk of depressive symptoms among men. J Affect Disord 2020;261:121–5. doi: http://dx.doi.org/10.1016/j.jad.2019.10.001.
125. Cui YF, Niu K, Huang C, Momma H, Guan L, Kobayashi Y, Guo H, Chujo M, Otomo A, Nagatomi R. Relationship between daily isoflavone intake and sleep in Japanese adults: a cross-sectional study. Nutr J 2015;14:7. doi: 10.1186/s12937-015-0117-x.
126. Hirayama F, Lee AH, Binns CW, Hiramatsu N, Mori M, Nishimura K. Dietary intake of isoflavones and polyunsaturated fatty acids associated with lung function, breathlessness and the prevalence of chronic obstructive pulmonary disease: possible protective effect of traditional Japanese diet. Mol Nutr Food Res 2010;54(7):909–17. doi: 10.1002/mnfr.200900316.
127. Miyake Y, Tanaka K, Okubo H, Sasaki S, Furukawa S, Arakawa M. Soy isoflavone intake and prevalence of depressive symptoms during pregnancy in Japan: baseline data from the Kyushu Okinawa Maternal and Child Health Study. Eur J Nutr 2018;57(2):441–50. doi: 10.1007/s00394-016-1327-5.
128. Nagata Y, Sonoda T, Mori M, Miyanaga N, Okumura K, Goto K, Naito S, Fujimoto K, Hirao Y, Takahashi A, et al. Dietary isoflavones may protect against prostate cancer in Japanese men. J Nutr 2007;137(8):1974–9.
129. Ohfuji S, Fukushima W, Watanabe K, Sasaki S, Yamagami H, Nagahori M, Watanabe M, Hirota Y; Japanese Case-Control

Study Group for Ulcerative Colitis. Pre-illness isoflavone consumption and disease risk of ulcerative colitis: a multicenter case-control study in Japan. PLoS One 2014;9(10):e110270. doi: https://dx.doi.org/10.1371/journal.pone.0110270.
130. Sonoda T, Suzuki H, Mori M, Tsukamoto T, Yokomizo A, Naito S, Fujimoto K, Hirao Y, Miyanaga N, Akaza H. Polymorphisms in estrogen related genes may modify the protective effect of isoflavones against prostate cancer risk in Japanese men. Eur J Cancer Prev 2010;19(2):131–7. doi: 10.1097/CEJ.0b013e328333fbe2.
131. Toi M, Hirota S, Tomotaki A, Sato N, Hozumi Y, Anan K, Nagashima T, Tokuda Y, Masuda N, Ohsumi S, et al. Probiotic beverage with soy isoflavone consumption for breast cancer prevention: a case-control study. Curr Nutr Food Sci 2013;9(3):194–200. doi: http://dx.doi.org/10.2174/15734013113099990001.
132. Uemura H, Katsuura-Kamano S, Nakamoto M, Yamaguchi M, Fujioka M, Iwasaki Y, Arisawa K. Inverse association between soy food consumption, especially fermented soy products intake and soy isoflavone, and arterial stiffness in Japanese men. Sci Rep 2018;8:9. doi: 10.1038/s41598-018-28038-0.
133. Wada K, Nakamura K, Masue T, Sahashi Y, Ando K, Nagata C. Soy intake and urinary sex hormone levels in preschool Japanese children. Am J Epidemiol 2011;173(9):998–1003. doi: 10.1093/aje/kwr006.
134. Wada K, Ueno T, Uchiyama S, Abiru Y, Tsuji M, Konishi K, Mizuta F, Goto Y, Tamura T, Shiraki M, et al. Relationship of equol production between children aged 5–7 years and their mothers. Eur J Nutr 2017;56(5):1911–7. doi: 10.1007/s00394-016-1233-x.
135. Iwasaki M, Mizusawa J, Kasuga Y, Yokoyama S, Onuma H, Nishimura H, Kusama R, Tsugane S. Green tea consumption and breast cancer risk in Japanese women: a case-control study. Nutr Cancer 2014;66(1):57–67. doi: 10.1080/01635581.2014.847963.
136. Clark ML, Butler LM, Koh WP, Wang R, Yuan JM. Dietary fiber intake modifies the association between secondhand smoke exposure and coronary heart disease mortality among Chinese non-smokers in Singapore. Nutrition 2013;29(11-12):1304–9. doi: https://dx.doi.org/10.1016/j.nut.2013.04.003.
137. Mueller NT, Odegaard AO, Gross MD, Koh WP, Yu MC, Yuan JM, Pereira MA. Soy intake and risk of type 2 diabetes mellitus in Chinese Singaporeans soy intake and risk of type 2 diabetes. Eur J Nutr 2012;51(8):1033–40. doi: 10.1007/s00394-011-0276-2.
138. Paul P, Koh WP, Jin A, Michel A, Waterboer T, Pawlita M, Wang R, Yuan JM, Butler LM. Soy and tea intake on cervical cancer risk: the Singapore Chinese Health Study. Cancer Causes Control 2019;30(8):847–57. doi: https://dx.doi.org/10.1007/s10552-019-01173-3.
139. Seow A, Poh WT, Teh M, Eng P, Wang YT, Tan WC, Chia KS, Yu MC, Lee HP. Diet, reproductive factors and lung cancer risk among Chinese women in Singapore: evidence for a protective effect of soy in nonsmokers. Int J Cancer 2002;97(3):365–71. doi: 10.1002/ijc.1615.
140. Sun CL, Yuan JM, Arakawa K, Low SH, Lee HP, Yu MC. Dietary soy and increased risk of bladder cancer: the Singapore Chinese Health Study. Cancer Epidemiol Biomarkers Prev 2002;11(12):1674–7.
141. Talaei M, Koh WP, van Dam RM, Yuan JM, Pan A. Dietary soy intake is not associated with risk of cardiovascular disease mortality in Singapore Chinese adults. J Nutr 2014;144(6):921–8.
142. Wu AH, Koh WP, Wang R, Lee HP, Yu MC. Soy intake and breast cancer risk in Singapore Chinese Health Study. Br J Cancer 2008;99(1):196–200. doi: https://dx.doi.org/10.1038/sj.bjc.6604448.
143. Wu AH, Stanczyk FZ, Seow A, Lee HP, Yu MC. Soy intake and other lifestyle determinants of serum estrogen levels among postmenopausal Chinese women in Singapore. Cancer Epidemiol Biomarkers Prev 2002;11(9):844–51.
144. Koh WP, Wu AH, Wang RW, Ang LW, Heng D, Yuan JM, Yu MC. Gender-specific Associations between soy and risk of hip fracture in the Singapore Chinese Health Study. Am J Epidemiol 2009;170(7):901–9. doi: 10.1093/aje/kwp220.
145. Budhathoki S, Joshi AM, Ohnaka K, Yin G, Toyomura K, Kono S, Mibu R, Tanaka M, Kakeji Y, Maehara Y, et al. Soy food and isoflavone intake and colorectal cancer risk: the Fukuoka Colorectal Cancer Study. Scand J Gastroenterol 2011;46(2):165–72. doi: 10.3109/00365521.2010.522720.
146. Butchart C, Kyle J, McNeill G, Corley J, Gow AJ, Starr JM, Deary IJ. Flavonoid intake in relation to cognitive function in later life in the Lothian Birth Cohort 1936. Br J Nutr 2011;106(1):141–8. doi: 10.1017/s0007114510005738.
147. Chavez-Suarez KM, Ortega-Velez MI, Valenzuela-Quintanar AI, Galvan-Portillo M, Lopez-Carrillo L, Esparza-Romero J, Saucedo-Tamayo MS, Robles-Burgueno MR, Palma-Duran SA, Gutierrez-Coronado ML, et al. Phytoestrogen concentrations in human urine as biomarkers for dietary phytoestrogen intake in Mexican women. Nutrients 2017;9(10):1078. doi: 10.3390/nu9101078.
148. Chun OK, Chung SJ, Song WO. Urinary isoflavones and their metabolites validate the dietary isoflavone intakes in US adults. J Am Diet Assoc 2009;109(2):245–54. doi: https://dx.doi.org/10.1016/j.jada.2008.10.055.
149. Fraser GE, Jaceldo-Siegl K, Henning SM, Fan J, Knutsen SF, Haddad EH, Sabate J, Lawrence Beeson W, Bennett H. Biomarkers of dietary intake are correlated with corresponding measures from repeated dietary recalls and food-frequency questionnaires in the Adventist Health Study-2. J Nutr 2016;146(3):586–94.
150. Grace PB, Taylor JI, Low YL, Luben RN, Mulligan AA, Botting NP, Dowsett M, Welch AA, Khaw KT, Wareham NJ, et al. Phytoestrogen concentrations in serum and spot urine as biomarkers for dietary phytoestrogen intake and their relation to breast cancer risk in European Prospective Investigation of Cancer and Nutrition–Norfolk. Cancer Epidemiol Biomarkers Prev 2004;13(5):698–708.
151. Hernandez-Ramirez RU, Galvan-Portillo MV, Ward MH, Agudo A, Gonzalez CA, Onate-Ocana LF, Herrera-Goepfert R, Palma-Coca O, Lopez-Carrillo L. Dietary intake of polyphenols, nitrate and nitrite and gastric cancer risk in Mexico City. Int J Cancer 2009;125(6):1424–30. doi: 10.1002/ijc.24454.
152. Heald CL, Bolton-Smith C, Ritchie MR, Morton MS, Alexander FE. Phyto-oestrogen intake in Scottish men: use of serum to validate a self-administered food-frequency questionnaire in older men. Eur J Clin Nutr 2006;60(1):129–35. doi: 10.1038/sj.ejcn.1602277.
153. Iwasaki M, Hamada GS, Nishimoto IN, Netto MM, Motola J, Jr, Laginha FM, Kasuga Y, Yokoyama S, Onuma H, Nishimura H, et al. Dietary isoflavone intake and breast cancer risk in case-control studies in Japanese, Japanese Brazilians, and non-Japanese Brazilians. Breast Cancer Res Treat 2009;116(2):401–11. doi: http://dx.doi.org/10.1007/s10549-008-0168-1.
154. Kilkkinen A, Valsta LM, Virtamo J, Stumpf K, Adlercreutz H, Pietinen P. Intake of lignans is associated with serum enterolactone concentration in Finnish men and women. J Nutr 2003;133(6):1830–3.
155. Kurahashi N, Inoue M, Iwasaki M, Tanaka Y, Mizokami M, Tsugane S. Isoflavone consumption and subsequent risk of hepatocellular carcinoma in a population-based prospective cohort of Japanese men and women. Int J Cancer 2009;124(7):1644–9. doi: http://dx.doi.org/10.1002/ijc.24121.
156. Li GL, Zhu YN, Zhang Y, Lang J, Chen YM, Ling WH. Estimated daily flavonoid and stilbene intake from fruits, vegetables, and nuts and associations with lipid profiles in Chinese adults. J Acad Nutr Diet 2013;113(6):786–94. doi: 10.1016/j.jand.2013.01.018.
157. Luo D, Liu Y, Zhou Y, Chen Z, Yang L, Liu Y, Xu Q, Xu H, Kuang H, Huang Q, et al. Association between dietary phytoestrogen intake and bone mineral density varied with estrogen receptor alpha gene polymorphisms in southern Chinese postmenopausal women. Food Funct 2015;6(6):1977–83. doi: https://dx.doi.org/10.1039/c5fo00295h.
158. Taguchi C, Kishimoto Y, Fukushima Y, Saita E, Tanaka M, Takahashi Y, Masuda Y, Goda T, Kondo K. Dietary polyphenol intake estimated by 7-day dietary records among Japanese male workers: evaluation of the within- and between-individual variation. J Nutr Sci Vitaminol (Tokyo) 2017;63(3):180–5. doi: https://dx.doi.org/10.3177/jnsv.63.180.
159. Cuervo A, Valdes L, Salazar N, de los Reyes-Gavilan CG, Ruas-Madiedo P, Gueimonde M, Gonzalez S. Pilot study of diet and

microbiota: interactive associations of fibers and polyphenols with human intestinal bacteria. J Agric Food Chem 2014;62(23):5330–6. doi: 10.1021/jf501546a.
160. Hankin JH, Stram DO, Arakawa K, Park S, Low SH, Lee HP, Yu MC. Singapore Chinese Health Study: development, validation, and calibration of the quantitative food frequency questionnaire. Nutr Cancer 2001;39(2):187–95. doi: 10.1207/S15327914nc392_5.
161. Ishihara J, Sobue T, Yamamoto S, Yoshimi I, Sasaki S, Kobayashi M, Takahashi T, Iitoi Y, Akabane M, Tsugane S, et al. Validity and reproducibility of a self-administered food frequency questionnaire in the JPHC Study Cohort II: study design, participant profile and results in comparison with cohort I. J Epidemiol 2003;13(1 Suppl):134. doi: 10.2188/jea.13.1sup_134.
162. Jarvinen R, Seppanen R, Knekt P. Short-term and long-term reproducibility of dietary history interview data. Int J Epidemiol 1993;22(3):520–7. doi: 10.1093/ije/22.3.520.
163. Kyle J, Masson LF, Grubb DA, Duthie GG, McNeill G. Estimating dietary flavonoid intake: comparison of a semi-quantitative food frequency questionnaire with 4-day weighed diet records in a Scottish population. Proceedings of the Nutrition Society. 2002;61(3a):63A–69A.
164. Yue Y, Petimar J, Willett WC, Smith-Warner SA, Yuan C, Rosato S, SampsonL, Rosner B, C assidy A, Rimm EB et al. Dietary flavonoids and flavenoid-rich food; validity and reporoducilbility of FFQ-derived intake estimates. Public Health Nutrition 2020, 23;(18): 3295–303
165. Pietinen P, Hartman AM, Haapa E, Rasanen L, Haapakoski J, Palmgren J, Albanes D, Virtamo J, Huttunen JK. Reproducibility and validity of dietary assessment instruments. I. A self-administered food use questionnaire with a portion size picture booklet. Am J Epidemiol 1988;128(3):655–66. doi: 10.1093/oxfordjournals.aje.a115013.
166. Sasaki S, Ishihara J, Tsugane S, JPHC. Reproducibility of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I to assess food and nutrient intake. J Epidemiol 2003;13(1 Suppl):115. doi: 10.2188/jea.13.1sup_115.
167. Segovia-Siapco G, Oda K, Sabaté J. Evaluation of the relative validity of a Web-based food frequency questionnaire used to assess soy isoflavones and nutrient intake in adolescents. BMC Nutr 2016;2(1):39. doi: 10.1186/s40795-016-0080-8.
168. Shahar S, Lin CH, Haron H. Development and validation of food frequency questionnaire (FFQ) for estimation of the dietary polyphenol intake among elderly individuals in Klang Valley. JSKM 2014;12(2):33–9. doi: 10.17576/JSKM-2014-1202-05.
169. Thompson FE, Kipnis V, Midthune D, Freedman LS, Carroll RJ, Subar AF, Brown CC, Butcher MS, Mouw T, Leitzmann M, et al. Performance of a food-frequency questionnaire in the US NIH-AARP (National Institutes of Health-American Association of Retired Persons) Diet and Health Study. Public Health Nutr 2008;11(2):183–95. doi: 10.1017/S1368980007000419.
170. Tsubono Y, Kobayashi M, Sasaki S, Tsugane S; Japan Public Health Center–Base Study Group. Validity and reproducibility of a self-administered food frequency questionnaire used in the baseline survey of the JPHC Study Cohort I. J Epidemiol 2003;13(1 Suppl):125. doi: 10.2188/jea.13.1sup_125.
171. Yokoyama Y, Takachi R, Ishihara J, Ishii Y, Sasazuki S, Sawada N, Shinozawa Y, Tanaka J, Kato E, Kitamura K, et al. Validity of short and long self-administered food frequency questionnaires in ranking dietary intake in middle-aged and elderly Japanese in the Japan Public Health Center-Based Prospective Study for the Next Generation (JPHC-NEXT) protocol area. J Epidemiol 2016;26(8):420–32. doi: 10.2188/jea.JE20150064.
172. Zhang CX, Ho SC. Validity and reproducibility of a food frequency questionnaire among Chinese women in Guangdong province. Asia Pac J Clin Nutr 2009;18(2): 240–50.
173. Lin Y, Wolk A, Hakansson N, Penalvo JL, Lagergren J, Adlercreutz H, Lu Y. Validation of FFQ-based assessment of dietary lignans compared with serum enterolactone in Swedish women. Br J Nutr 2013;109(10):1873–80. doi: 10.1017/S000711451200387X.
174. Wu AH, Yu MC, Tseng CC, Twaddle NC, Doerge DR. Plasma isoflavone levels versus self-reported soy isoflavone levels in Asian-American women in Los Angeles County. Carcinogenesis 2003;25(1):77–81. doi: 10.1093/carcin/bgg189.
175. Heald CL, Bolton-Smith C, Ritchie MR, Morton MS, Alexander FE. Phyto-oestrogen intake in Scottish men: use of serum to validate a self-administered food-frequency questionnaire in older men. Eur J Clin Nutr 2006;60(1):129–35. doi: 10.1038/sj.ejcn.1602277.
176. Iwasaki M, Hamada GS, Nishimoto IN, Netto MM, Motola JJr, Laginha FM, Kasuga Y, Yokoyama S, Onuma H, Nishimura H, et al. Dietary isoflavone intake, polymorphisms in the CYP17, CYP19, 17beta-HSD1, and SHBG genes, and risk of breast cancer in case-control studies in Japanese, Japanese Brazilians, and Non-Japanese Brazilians. Nutr Cancer 2010;62(4):466–75. doi: http://dx.doi.org/10.1080/01635580903441279.
177. Huang MH, Harrison GG, Mohamed MM, Gornbein JA, Henning SM, Go VL, Greendale GA. Assessing the accuracy of a food frequency questionnaire for estimating usual intake of phytoestrogens. Nutr Cancer 2000;37(2):145–54. doi: 10.1207/S15327914NC372_5.
178. Willett W, Stampfer MJ. Total energy intake: implications for epidemiologic analyses. Am J Epidemiol 1986;124(1):17–27. doi: 10.1093/oxfordjournals.aje.a114366.
179. Lee MM, Gomez SL, Chang JS, Wey M, Wang RT, Hsing AW. Soy and isoflavone consumption in relation to prostate cancer risk in China. Cancer Epidemiol Biomarkers Prev 2003;12(7): 665–8.
180. Zamora-Ros R, Knaze V, Lujan-Barroso L, Kuhnle GGC, Mulligan AA, Touillaud M, Slimani N, Romieu I, Powell N, Tumino R, et al. Dietary intakes and food sources of phytoestrogens in the European Prospective Investigation into Cancer and Nutrition (EPIC) 24-hour dietary recall cohort. Eur J Clin Nutr 2012;66(8):932–41. doi: http://dx.doi.org/10.1038/ejcn.2012.36.
181. Zamora-Ros R, Knaze V, Lujan-Barroso L, Romieu I, Scalbert A, Slimani N, Hjartaker A, Engeset D, Skeie G, Overvad K, et al. Differences in dietary intakes, food sources and determinants of total flavonoids between Mediterranean and non-Mediterranean countries participating in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Br J Nutr 2013;109(8):1498–507. doi: http://dx.doi.org/10.1017/S0007114512003273.
182. Zamora-Ros R, Knaze V, Romieu I, Scalbert A, Slimani N, Clavel-Chapelon F, Touillaud M, Perquier F, Skeie G, Engeset D, et al. Impact of thearubigins on the estimation of total dietary flavonoids in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Eur J Clin Nutr 2013;67(7):779–82. doi: https://dx.doi.org/10.1038/ejcn.2013.89.
183. Zamora-Ros R, Sacerdote C, Ricceri F, Weiderpass E, Roswall N, Buckland G, St-Jules DE, Overvad K, Kyro C, Fagherazzi G, et al. Flavonoid and lignan intake in relation to bladder cancer risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Br J Cancer 2014;111(9):1870–80. doi: https://dx.doi.org/10.1038/bjc.2014.459.
184. Waskiewicz A, Zujko ME, Szczesniewska D, Tykarski A, Kwasniewska M, Drygas W, Witkowska AM. Polyphenols and dietary antioxidant potential, and their relationship with arterial hypertension: a cross-sectional study of the adult population in Poland (WOBASZ II). Adv Clin Exp Med 2019;28(6):797–806. doi: 10.17219/acem/91487.
185. Zamora-Ros R, Andres-Lacueva C, Lamuela-Raventos RM, Berenguer T, Jakszyn P, Barricarte A, Ardanaz E, Amiano P, Dorronsoro M, Larranaga N, et al. Estimation of dietary sources and flavonoid intake in a Spanish adult population (EPIC-Spain). J Am Diet Assoc 2010;110(3):390–8. doi: 10.1016/j.jada.2009.11.024.
186. Kuczmarski MF, Sebastian RS, Goldman JD, Murayi T, Steinfeldt LC, Eosso JR, Moshfegh AJ, Zonderman AB, Evans MK. Dietary flavonoid intakes are associated with race but not income in an urban population. Nutrients 2018;10(11):1749. doi: http://dx.doi.org/10.3390/nu10111749.

187. Maras JE, Talegawkar SA, Qiao N, Lyle B, Ferrucci L, Tucker KL. Flavonoid intakes in the Baltimore Longitudinal Study of Aging. J Food Compos Anal 2011;24(8):1103–9. doi: 10.1016/j.jfca.2011.04.007.
188. Shishtar E, Rogers GT, Blumberg JB, Au RD, Jacques PF. Long-term dietary flavonoid intake and change in cognitive function in the Framingham Offspring cohort. Public Health Nutr 2020;23(9):1576–88. doi: 10.1017/s136898001900394x.
189. Shishtar E, Rogers GT, Blumberg JB, Au R, DeCarli C, Jacques PF. Flavonoid intake and MRI markers of brain health in the Framingham Offspring Cohort. J Nutr 2020;150:1545–53.
190. Ruidavets J, Teissedre P, Ferrieres J, Carando S, Bougard G, Cabanis J. Catechin in the Mediterranean diet: vegetable, fruit or wine? Atherosclerosis 2000;153(1):107–17.
191. Radtke J, Linseisen J, Wolfram G. Fasting plasma concentrations of selected flavonoids as markers of their ordinary dietary intake. Eur J Nutr 2002;41(5):203–9. doi: 10.1007/s00394-002-0377-z.
192. Cheng G, Remer T, Prinz-Langenohl R, Blaszkewicz M, Degen GH, Buyken AE. Relation of isoflavones and fiber intake in childhood to the timing of puberty. Am J Clin Nutr 2010;92(3):556–64.
193. Rabassa M, Zamora-Ros R, Andres-Lacueva C, Urpi-Sarda M, Bandinelli S, Ferrucci L, Cherubini A. Association between both total baseline urinary and dietary polyphenols and substantial physical performance decline risk in older adults: a 9-year follow-up of the InCHIANTI study. J Nutr Health Aging 2016;20(5):478–84. doi: 10.1007/s12603-015-0600-2.
194. Rabassa M, Zamora-Ros R, Urpi-Sarda M, Bandinelli S, Ferrucci L, Andres-Lacueva C, Cherubini A. Association of habitual dietary resveratrol exposure with the development of frailty in older age: the Invecchiare in Chianti study. Am J Clin Nutr 2015;102(6):1534–42.
195. Rabassa M, Cherubini A, Zamora-Ros R, Urpi-Sarda M, Bandinelli S, Ferrucci L, Andres-Lacueva C. Low levels of a urinary biomarker of dietary polyphenol are associated with substantial cognitive decline over a 3-year period in older adults: the Invecchiare in Chianti Study. J Am Geriatr Soc 2015;63(5):938–46. doi: 10.1111/jgs.13379.
196. Zamora-Ros R, Rabassa M, Cherubini A, Urpi-Sarda M, Llorach R, Bandinelli S, Ferrucci L, Andres-Lacueva C. Comparison of 24-h volume and creatinine-corrected total urinary polyphenol as a biomarker of total dietary polyphenols in the Invecchiare InCHIANTI study. Anal Chim Acta 2011;704(1-2):110–5. doi: 10.1016/j.aca.2011.07.035.
197. Nagata Y, Sugiyama Y, Fukuta F, Takayanagi A, Masumori N, Tsukamoto T, Akasaka H, Ohnishi H, Saitoh S, Miura T, et al. Relationship of serum levels and dietary intake of isoflavone, and the novel bacterium Slackia sp strain NATTS with the risk of prostate cancer: a case-control study among Japanese men. Int Urol Nephrol 2016;48(9):1453–60.
198. Milder IEJ, Kuijsten A, Arts ICW, Feskens EJM, Kampman E, Hollman PCH, Van't Veer P. Relation between plasma enterodiol and enterolactone and dietary intake of lignans in a Dutch endoscopy-based population. J Nutr 2007;137(5):1266–71.
199. Pedret A, Valls RM, Fernandez-Castillejo S, Catalan U, Romeu M, Giralt M, Lamuela-Raventos RM, Medina-Remon A, Arija V, Aranda N, et al. Polyphenol-rich foods exhibit DNA antioxidative properties and protect the glutathione system in healthy subjects. Mol Nutr Food Res 2012;56(7):1025–33.
200. Hedelin M, Klint A, Chang ET, Bellocco R, Johansson JE, Andersson SO, Heinonen SM, Adlercreutz H, Adami HO, Gronberg H, et al. Dietary phytoestrogen, serum enterolactone and risk of prostate cancer: the Cancer Prostate Sweden Study (Sweden). Cancer Causes Control 2006;17(2):169–80.
201. Atkinson C, Skor HE, Fitzgibbons ED, Scholes D, Chen C, Wahala K, Schwartz SM, Lampe JW. Overnight urinary isoflavone excretion in a population of women living in the United States, and its relationship to isoflavone intake [Erratum appears in Cancer Epidemiol Biomarkers Prev 2002;11(11):1511]. Cancer Epidemiol Biomarkers Prev 2002;11(3):253–60.
202. Maskarinec G, Singh S, Meng LX, Franke AA. Dietary soy intake and urinary isoflavone excretion among women from a multiethnic population. Cancer Epidemiol Biomarkers Prev 1998;7(7):613–9.
203. Mervish NA, Gardiner EW, Galvez MP, Kushi LH, Windham GC, Biro FM, Pinney SM, Rybak ME, Teitelbaum SL, Wolff MS, BCERP. Dietary flavonol intake is associated with age of puberty in a longitudinal cohort of girls. Nutr Res 2013;33(7):534–42. doi: http://dx.doi.org/10.1016/j.nutres.2013.04.005.
204. Burkholder-Cooley NM, Rajaram SS, Haddad EH, Oda K, Fraser GE, Jaceldo-Siegl K. Validating polyphenol intake estimates from a food-frequency questionnaire by using repeated 24-h dietary recalls and a unique method-of-triads approach with 2 biomarkers. Am J Clin Nutr 2017;105(3):685–94.
205. Forouhi N, Brage S, Wareham N. DAPA measurement toolkit: food frequency questionnaires. [Internet]. [Accessed 2020 Jan 12]. Available from: https://dapa-toolkit.mrc.ac.uk/diet/subjective-methods/food-frequency-questionnaire.
206. Peterson JJ, Dwyer JT, Jacques PF, McCullough ML. Improving the estimation of flavonoid intake for study of health outcomes. Nutr Rev 2015;73(8):553–76.
207. Kuhnle GGC. Nutrition epidemiology of flavan-3-ols: the known unknowns. Mol Aspects Med 2018;61:2–11. doi: 10.1016/j.mam.2017.10.003.
208. Forouhi N, Brage S, Wareham N. DAPA measurement toolkit: 24-hour dietary recalls. [Internet]. [Accessed 2020 Jan 12]. Available from: https://dapa-toolkit.mrc.ac.uk/diet/subjective-methods/24-hour-dietary-recall.
209. Forouhi N, Brage S, Wareham N. DAPA measurement toolkit: estimated food diaries. [Internet]. [Accessed 2020 Jan 12]. Available from: https://dapa-toolkit.mrc.ac.uk/diet/subjective-methods/estimated-food-diaries .
210. Forouhi N, Brage S, Wareham N. DAPA measurement toolkit: duplicate diets. [Internet]. [Accessed 2020 Jan 12]. Available from: https://dapa-toolkit.mrc.ac.uk/diet/objective-methods/duplicate-diets .
211. Glabska D, Guzek D, Grudzinska D, Lech G. Influence of dietary isoflavone intake on gastrointestinal symptoms in ulcerative colitis individuals in remission. WJG 2017;23(29):5356–63.
212. Kent K, Charlton KE, Russell J, Mitchell P, Flood VM. Estimation of flavonoid intake in older Australians: secondary data analysis of the Blue Mountains Eye Study. J Nutr Gerontol Geriatr 2015;34(4):388–98.
213. Bobe G, Weinstein SJ, Albanes D, Hirvonen T, Ashby J, Taylor PR, Virtamo J, Stolzenberg-Solomoni RZ. Flavonoid intake and risk of pancreatic cancer in male smokers (Finland). Cancer Epidemiol Biomarkers Prev 2008;17(3):553–62. doi: 10.1158/1055-9965.Epi-07-2523.
214. Dilis V, Trichopoulou A. Antioxidant intakes and food sources in Greek adults. J Nutr 2010;140(7):1274–9.
215. Grosso G, Stepaniak U, Micek A, Kozela M, Stefler D, Bobak M, Pajak A. Dietary polyphenol intake and risk of hypertension in the Polish arm of the HAPIEE study. Eur J Nutr 2018;57(4):1535–44. doi: https://dx.doi.org/10.1007/s00394-017-1438-7.
216. US Department of Agriculture. Database for the isoflavone content of selected foods, Release 1.1. Maryland: Agricultural Research Service. 1999.
217. Neveu V, Perez-Jimenez J, Vos F, Crespy V, du Chaffaut L, Mennen L, Knox C, Eisner R, Cruz J, Wishart D, et al. Phenol-Explorer: an online comprehensive database on polyphenol contents in foods. Database 2010;2010:bap024. doi: 10.1093/database/bap024.bap024
218. Xu M, Chen YM, Huang J, Fang YJ, Huang WQ, Yan B, Lu MS, Pan ZZ, Zhang CX. Flavonoid intake from vegetables and fruits is inversely associated with colorectal cancer risk: a case-control study in China. Br J Nutr 2016;116(7):1275–87. doi: 10.1017/s0007114516003196.
219. Abulimiti A, Zhang X, Shivappa N, Hebert JR, Fang YJ, Huang CY, Feng XL, Chen YM, Zhang CX. The dietary inflammatory index is positively associated with colorectal cancer risk

in a Chinese case-control study. Nutrients 2020;12(1). doi: http://dx.doi.org/10.3390/nu12010232.
220. Nechuta SJ, Caan BJ, Chen WY, Lu W, Chen Z, Kwan ML, Flatt SW, Zheng Y, Zheng W, Pierce JP, et al. Soy food intake after diagnosis of breast cancer and survival: an in-depth analysis of combined evidence from cohort studies of US and Chinese women. Am J Clin Nutr 2012;96(1):123–32.
221. Feng XL, Ho SC, Mo XF, Lin FY, Zhang NQ, Luo H, Zhang X, Zhang CX. Association between flavonoids, flavonoid subclasses intake and breast cancer risk: a case-control study in China. Eur J Cancer Prev 2019;14. doi: http://dx.doi.org/10.1097/CEJ.0000000000000561.
222. Woo HW, Kim MK, Lee YH, Shin DH, Shin MH, Choi BY. Habitual consumption of soy protein and isoflavones and risk of metabolic syndrome in adults >= 40 years old: a prospective analysis of the Korean Multi-Rural Communities Cohort Study (MRCohort). Eur J Nutr 2019;58(7):2835–50. doi: http://dx.doi.org/10.1007/s00394-018-1833-8.
223. Yang YJ, Kim YJ, Yang YK, Kim JY, Kwon O. Dietary flavan-3-ols intake and metabolic syndrome risk in Korean adults. Nutr Res Pract 2012;6(1):68–77. doi: 10.4162/nrp.2012.6.1.68.
224. Kim SA, Kim J, Jun S, Wie GA, Shin S, Joung H. Association between dietary flavonoid intake and obesity among adults in Korea. Appl Physiol Nutr Metab 2020;45(2):203–12.
225. Kim HS, Kwon M, Lee HY, Shivappa N, Hebert JR, Sohn C, Na W, Kim MK. Higher pro-inflammatory dietary score is associated with higher hyperuricemia risk: results from the case-controlled Korean Genome and Epidemiology Study Cardiovascular Disease Association Study. Nutrients 2019;11(8). doi: 10.3390/nu11081803.1803
226. Zamora-Ros R, Ferrari P, Gonzalez CA, Tjonneland A, Olsen A, Bredsdorff L, Overvad K, Touillaud M, Perquier F, Fagherazzi G, et al. Dietary flavonoid and lignan intake and breast cancer risk according to menopause and hormone receptor status in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Breast Cancer Res Treat 2013;139(1):163–76.
227. Zamora-Ros R, Not C, Guino E, Lujan-Barroso L, Garcia RM, Biondo S, Salazar R, Moreno V. Association between habitual dietary flavonoid and lignan intake and colorectal cancer in a Spanish case-control study (the Bellvitge Colorectal Cancer Study). Cancer Causes Control 2013;24(3):549–57.
228. Probst Y, Guan V, Kent K. A systematic review of food composition tools used for determining dietary polyphenol intake in estimated intake studies. Food Chem 2018;238:146–52.
229. Rothwell JA, Perez-Jimenez J, Neveu V, Medina-Remon A, M'Hiri N, Garcia-Lobato P, Manach C, Knox C, Eisner R, Wishart DS, et al. Phenol-Explorer 3.0: a major update of the Phenol-Explorer database to incorporate data on the effects of food processing on polyphenol content. Database 2013;2013:bat070. doi: 10.1093/database/bat070.bat070.
230. Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J Enology Viticulture 1965;16(3):144–58.
231. Everette JD, Bryant QM, Green AM, Abbey YA, Wangila GW, Walker RB. Thorough study of reactivity of various compound classes toward the Folin-Ciocalteu reagent. J Agric Food Chem 2010;58(14):8139–44. doi: 10.1021/jf1005935.
232. Perez-Jimenez J, Neveu V, Vos F, Scalbert A. Systematic analysis of the content of 502 polyphenols in 452 foods and beverages: an application of the Phenol-Explorer database. J Agric Food Chem 2010;58(8):4959–69. doi: 10.1021/jf100128b.
233. Ottaviani JI, Fong RY, Borges G, Schroeter H, Crozier A. Use of LC-MS for the quantitative analysis of (poly)phenol metabolites does not necessarily yield accurate results: Implications for assessing existing data and conducting future research. Free Radic Biol Med 2018;124:97–103. doi: 10.1016/j.freeradbiomed.2018.05.092.
234. Yang Y, Wang G, Pan X. China food composition. Beijing (China): Peking University Medical Press; 2002.
235. Ministry of Education, Culture, Sports, Science and Technology - Japan. Standard tables of food composition in Japan. 7th ed. Tokyo (Japan): Ministry of Education, Culture, Sports, Science and Technology; 2015.
236. Yue Y, Petimar J, Willett WC, Smith-Warner SA, Yuan C, Rosato S, Sampson L, Rosner B, Cassidy A, Rimm EB, et al. Dietary flavonoids and flavonoid-rich foods: validity and reproducibility of FFQ-derived intake estimates. Public Health Nutr 2020;23(18):3295–303.
237. Holland TM, Agarwal P, Wang Y, Leurgans SE, Bennett DA, Booth SL, Morris MC. Dietary flavonols and risk of Alzheimer dementia. Neurology 2020;94(16):e1749–e56.
238. Shishtar E, Rogers GT, Blumberg JB, Au R, Jacques PF. Long-term dietary flavonoid intake and risk of Alzheimer disease and related dementias in the Framingham Offspring Cohort. Am J Clin Nutr 2020;112(2):343–53.
239. Schoeller DA. How accurate is self-reported dietary energy intake? Nutr Rev 2009;48(10):373–9.
240. Spencer JP, Abd El Mohsen MM, Minihane AM, Mathers JC. Biomarkers of the intake of dietary polyphenols: strengths, limitations and application in nutrition research. Br J Nutr 2008;99(1):12–22.
241. Guasch-Ferré M, Bhupathiraju SN, Hu FB. Use of metabolomics in improving assessment of dietary intake. Clin Chem 2018;64(1):82–98.
242. Zamora-Ros R, Touillaud M, Rothwell JA, Romieu I, Scalbert A. Measuring exposure to the polyphenol metabolome in observational epidemiologic studies: current tools and applications and their limits. Am J Clin Nutr 2014;100(1):11–26.