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Original Research Article

Dietary patterns and risk of multiple cancers: umbrella review of meta-analyses of prospective cohort studies

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A B S T R A C T

Background: Numerous prospective cohort studies have investigated the influence of dietary patterns on the risks of various cancers, although the findings differed.

Objectives: To evaluate the associations of dietary patterns with risks of various cancers and assess the strength and validity of the evidence.

Methods: Relevant articles were retrieved from the PubMed, EMBASE, Web of Science, and Cochrane library databases from inception to February 22, 2024. The included systematic reviews were meta-analyses of prospective cohort studies that reported an effect size to calculate the association between dietary patterns and cancer risk. The quality of the included studies was evaluated using a measurement tool to assess systematic reviews and the certainty of evidence was assessed using credibility assessment of evidence. Outcomes of interest included any incident cancers. This study was registered with PROSPERO (CRD42023425237).

Results: Overall, 74 meta-analyses from 30 articles were identified. Three meta-analyses (4.1%) were graded as convincing evidence and included associations between adherence to the 2007 World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) dietary recommendations (per 1-unit score increase) and lower risk of all cancers (relative risk [RR] ¼ 0.93, 95% confidence interval [CI]: 0.92, 0.95), whereas negative associations were found comparing the highest compared with lowest categories for a prudent diet (RR ¼ 0.89, 95% CI: 0.85, 0.93) and vegetable-fruit-soybean diet (RR ¼ 0.87, 95% CI: 0.83, 0.92) in relation to breast cancer. After credibility assessment of evidence by Grading of Recommendations, Assessment, Development, and Evaluation, 4 (5.4%) meta-analyses were classified as high, including adherence to the 2007 WCRF/AICR dietary recommendations and decreased risks of all cancers, breast cancer, colorectal cancer, and prostate cancer.

Conclusions: These findings suggest that adherence to certain healthy dietary patterns is associated with lower risk of all cancers and certain individual cancers. This study was registered at crd.york.ac.uk, PROSPERO as CRD42023425237 and /PROSPERO/display_record.php?RecordID¼425237

Keywords: Cancer, cohort studies, diet pattern, risk, umbrella review

Abbreviations: AMSTAR, Assessing the Methodological Quality of Systematic Reviews; BC, breast cancer; CI, confidence interval; CRC, colorectal cancer; DASH, Dietary Approaches to Stop Hypertension; DII, Dietary Inflammatory Index; GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; HR, hazard ratio; MD, Mediterranean diet; NS, nonsignificant; PECOS, Population, Exposure, Comparison, Outcome, Study design; RR, relative risk; RCT, randomized controlled trial; PI, prediction interval; UR, umbrella review; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research.

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Introduction

Cancer is among the most frequent causes of morbidity and the second leading cause of mortality globally, accounting for an estimated 20 million new cases and 9.7 million deaths in 2022 [1]. Besides, the global age-standardized incidence rate of cancer has continued to in-crease, with substantial differences in mortality and morbidity rates among different regions [2]. Obviously, cancer is a major economic burden to public healthcare systems and poses an important barrier to increasing life expectancy worldwide [3]. Therefore, prevention of the occurrence of cancer is crucial to reduce burdens on public healthcare systems [4,5].

Despite unmodifiable factors, including family history, sex, and age, which influence the incidence of cancer, modifiable factors, such as diet, also contribute to the risks of most cancers [6,7]. The third expert report from the World Cancer Research Fund concluded that healthy diets with adequate nutrition were modifiable factors that can reduce the risk of cancer [8]. A previous umbrella review (UR) found that calcium and dairy consumption was inversely associated with the risk of colorectal cancer (CRC), and coffee consumption was inversely associated with the risk of liver cancer [9]. However, interactions be-tween consumed foods and nutrients influence the risks of most cancers [10]. Hence, studies of the diet as a whole should consider the in-teractions of foods and nutrients to yield stronger effect estimates [11, 12]. Of note, a review published in 2020 concluded that the effec-tiveness of different dietary pattern recommendations to reduce risk is likely dependent on the type of cancer and other risk factors, such as family history, sex, age, lifestyle factors, and comorbidities as well as metabolomic signatures and gut microbiota profiles [11]. Over the past decade, many systematic reviews and meta-analyses have summarized the associations between data-driven and index-based dietary patterns and risks of various cancers [13,14]. However, given the potential recall and selection biases of case-control studies, reported estimates of meta-analyses of such studies may diminish the strength of aggregated scientific evidence. Therefore, focusing on cohort studies could improve the strength of evidence and provide suggestions to promote healthy lifestyles.

The UR is used to provide a relatively comprehensive under-standing of published systematic reviews with meta-analyses of a specific topic by assessing the precision of estimates, rating the strength of evidence, and evaluating the risk of bias of the published meta-analyses, thus providing important information for dietary recom-mendations [15–17]. Here, a UR of meta-analyses of prospective cohort studies was conducted to evaluate the associations between dietary patterns and risks of various cancers.

Methods

Protocol registration

The protocol of this UR is registered with the PROSPERO inter-national database of prospectively registered systematic reviews in health and social care (registration no. CRD42023425237). This UR adhered to the guidelines of the Preferred Reporting Items for Sys-tematic Reviews and Meta-Analyses and Meta-analyses of Observa-tional Studies in Epidemiology (Supplemental Tables 1 and 2) [18,19].

Literature search

Two of the authors (J-LY and Y-ZL) independently screened reports without language restrictions retrieved from the PubMed, EMBASE, Web of Science, and Cochrane library databases from inception to February 13, 2023. Furthermore, an additional search was conducted on February 22, 2024, to ensure completeness. The complete search strategy is available in Supplemental Table 3. In addition, the literature search was supplemented by manually reviewing the reference lists of all reviews and meta-analyses for relevant articles.

Eligibility criteria

Studies were included in accordance with the Population, Exposure, Comparison, Outcome, Study design (PECOS) strategy: (1) Popula-tion: adult participants aged ≥18 y. (2) Exposure: dietary patterns depend on knowledge of food, beverage or nutrient intake, or some combination of these factors, which is divided into 2 major groups including a priori dietary patterns and data-driven dietary patterns based on whether the patterns are determined empirically or using investigator-defined criteria [20] (e.g., Dietary Approaches to Stop Hypertension [DASH] diet, Dietary Inflammatory Index [DII], Medi-terranean diet [MD], and World Cancer Research Fund/American Institute for Cancer Research [WCRF/AICR]) (Supplemental Table 4).
(*3*) Comparison: low adherence (lowest category) to dietary patterns. (*4*) Outcomes: any cancer incidence (e.g., total cancer, breast cancer [BC], CRC, and prostate cancer, etc.) (Supplemental Table 4). (*5*) Study design: systematic reviews with meta-analyses of prospective cohort studies.

Studies were excluded based on the following criteria: (1) sys-tematic reviews without quantitative analysis; (2) systematic reviews with meta-analyses not reporting comprehensive data for reanalysis, such as effect sizes (hazard ratio [HR] or relative risk [RR]) and cor-responding 95% confidence intervals (CIs), number of cases, and total participants; (3) systematic reviews with meta-analyses of animal studies and/or in vitro studies, as well as randomized controlled trials (RCTs) because of the potential inapplicability and limited number of RCTs for our topic due to ethical issues [21,22]; or (4) systematic re-views with meta-analyses that included <3 cohort studies [23].

Because the WCRF/AICR recommendations are not dietary pat-terns in the strictest sense, studies recommending an overall lifestyle pattern were excluded, [24,25] whereas studies only referencing dietary recommendations were included [26]. If >1 meta-analysis identified the same association, the one with the most primary studies was chosen to avoid duplication [27]. When >1 meta-analysis included the same number of studies, the most recently published was selected [28]. In addition, if >1 comparison form was analyzed for a given outcome (e.g., dose-response analysis, highest compared with lowest, etc.), all comparison forms were included [29]. The titles and abstracts were screened independently by 2 of the authors (J-LY and RW). All dis-crepancies were resolved by a third author (Q-JW).

Data extraction

Pairs of 8 trained authors (J-LY, RW, X-JS, D-DW, J-CL, P-CL, Y-CS, and J-YW) independently collected the information from each eligible study. All disagreements were resolved by consultation with the senior author (Q-JW). The following data were extracted from each eligible systematic review with meta-analysis: name of the first author, year of publication, name of journal, study design, number of total studies, number of cases, number of participants, exposure, definition of exposure, comparison, cancer type, meta-analysis metrics (HR or RR), and effect. From each cohort study included in the systematic review with meta-analysis, we further recorded the name of the first author, year of publication, number of cases, number of participants, comparison form (dose-response analysis, highest compared with

lowest), specific risk estimates, and corresponding 95% CIs. Common confounding factors included age, sex, ethnicity, education, BMI, smoking, physical activity, energy intake, and specific factors related to cancer risk.

Data analysis

To obtain additional results to assess the level of evidence for the reported associations, we recalculated the data extracted from the original studies included in each eligible meta-analysis [17]. We recalculated the adjusted summary effect size estimates and corre-sponding 95% CIs using a random-effects model, which considers heterogeneity both within and between studies [30]. We also calculated the 95% prediction intervals (PIs) for the summary effect size, which further explains the heterogeneity and examines uncertainty in the expected effect size for new studies with the same relationship [31]. The SE of the effect size was calculated for the component original studies to identify the largest study for each meta-analysis, which corresponded to the smallest SE [32]. Besides, the I^2 statistic was calculated to evaluate heterogeneity, where an I^2 value >50% or >75%indicated significant or considerable heterogeneity, respectively [33].

Egger's regression test was performed to determine whether small studies tended to provide a greater estimated risk than larger studies, commonly referred to as publication bias. An Egger probability (P) value < 0.10 was considered to provide evidence of small studies ef-fects and more conservative effects of larger studies than in a random-effects meta-analysis [34]. Furthermore, the excess significance test was applied to assess whether the number of observed (O) studies with nominally significant results ("negative" studies, P < 0.05) in the published literature was different from the expected (E) number of studies with statistically significant results. The excess significance bias was set at P < 0.10 or one-sided P < 0.05 combined with O > E [35]. The kappa value was applied to explain the degree of consistency [36].

In addition, sensitivity analyses were conducted to verify the robustness of the results. If meta-analyses were excluded due to overlap or the latest meta-analysis did not include the original articles that were included in other meta-analyses, reanalysis was conducted to verify whether the results were consistent with the main analysis [37]. Be-sides, the smaller studies, such as sample size < 25th percentile, of the meta-analyses with evidence of small-study effects were excluded from the reanalysis [38]. All statistical analyses were conducted with Stata software (version 16; StataCorp LLC, College Station) and IBM SPSS Statistics for Windows (version 22.0; IBM Corporation).

Assessment of methodological quality and grading of the evidence

According to the established tools utilized in previous URs, [39,40] the credibility of the evidence of each meta-analysis was categorized as convincing (Class I), highly suggestive (Class II), suggestive (Class III), weak (Class IV), or nonsignificant (NS) by assessing a series of indicators, including the P value of the random-effects models, the number of cases, heterogeneity, 95% PIs, P value of the largest study, small-study effects, and excess significance bias (Supplemental Table 5).

Pairs of 8 trained authors (J-LY, RW, X-JS, D-DW, J-CL, P-CL, Y-CS, and J-YW) independently assessed the methodological quality of qualified systematic reviews and meta-analyses using an established measurement tool (Assessing the Methodological Quality of System-atic Reviews [AMSTAR]) [41]. Discrepancies were resolved through discussion with the senior author (Q-JW). As a valid and dependable measurement tool, AMSTAR assesses the quality of systematic reviews with meta-analyses based on 11 aspects, including a literature search, literature inclusion, data extraction, statistical analysis, and bias evaluation. The AMSTAR scores of the quality of the systematic reviews were classified as high (8–11), moderate (4–7), or low (0–3) [41]. Moreover, based on the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE), the quality of the evidence was classified as high, moderate, low, or very low [42]. The evidence of prospective cohort studies was initially considered low quality and downgraded or upgraded based on prespecified criteria, which included study limitations, inconsistency, indirectness, imprecision, and publi-cation bias [42].

Results

Literature review

In total, 124 articles (8859 records) that met the inclusion criteria were retrieved from 4 electronic databases. After screening the full text of these articles (Figure 1), 94 were excluded based on the eligibility criteria (Supplemental Table 6). Ultimately, 30 articles were included in the present UR [12,26,43–70].

Characteristics of the included meta-analyses

The eligible 30 articles described 74 meta-analyses, which esti-mated the risks of 16 cancer outcomes associated with dietary patterns. These meta-analyses were published from 2010 to 2023. The exposures evaluated in these meta-analyses included 23 types of dietary patterns (Supplemental Table 7). The summary descriptive characteristics of the included meta-analyses by cancer types are presented in Supplemental Table 8. Associations of dietary patterns with BC and CRC accounted for the largest number of meta-analyses (n ¼ 15 and 13, respectively), followed by lung cancer, pancreatic cancer, and prostate cancer (n ¼ 10, 6, and 6, respectively). The median number of primary studies was 5 (range, 3–19), and the median number of cases was 7151 (range, 262–70,877).

Summary findings of the included meta-analyses

Of the 74 meta-analyses, the magnitude of the observed summary random-effects estimates ranged from 0.59 to 2.23 (Figures 2–5). Among these 74 meta-analyses, 23 (31.1%), 17 (23.0%), and 7 (9.5%) were significant at P < 0.05, 0.001, and 10^{-6}, respectively (Supple-mental Table 9). In 44 (59.4%) meta-analyses, the largest data studies were significant at P < 0.05. The results of the largest study had smaller CIs than the summary result in 26 (35.1%) meta-analyses. In addition, 15 (20.3%) and 9 (12.2%) meta-analyses had large and very large heterogeneity, respectively. Additionally, the 95% PI was calculated to assess the uncertainty of summary effects, and 13 (17.6%) meta-analyses excluded the null value (Supplemental Table 9).

Evidence of small-study effects was observed in 3 (4.1%) of 74 meta-analyses about dietary patterns and multiple cancer risks. When taking the largest data study estimate as the plausible effect size, 15 (20.3%) of 74 meta-analyses showed evidence of excess significance (Supplemental Tables 9 and 10).

Methodological quality of the meta-analyses

Using the AMSTAR tool, 9 (30.0%), 19 (63.3%), and 2 (6.7%) articles were classified as high, moderate, and low quality, respectively (Fig. 6). The median AMSTAR score was 6 (range, 2–10). The main reasons for lower AMSTAR scores were the exclusion of grey literature from the literature search, the meta-analyses did not provide a list of

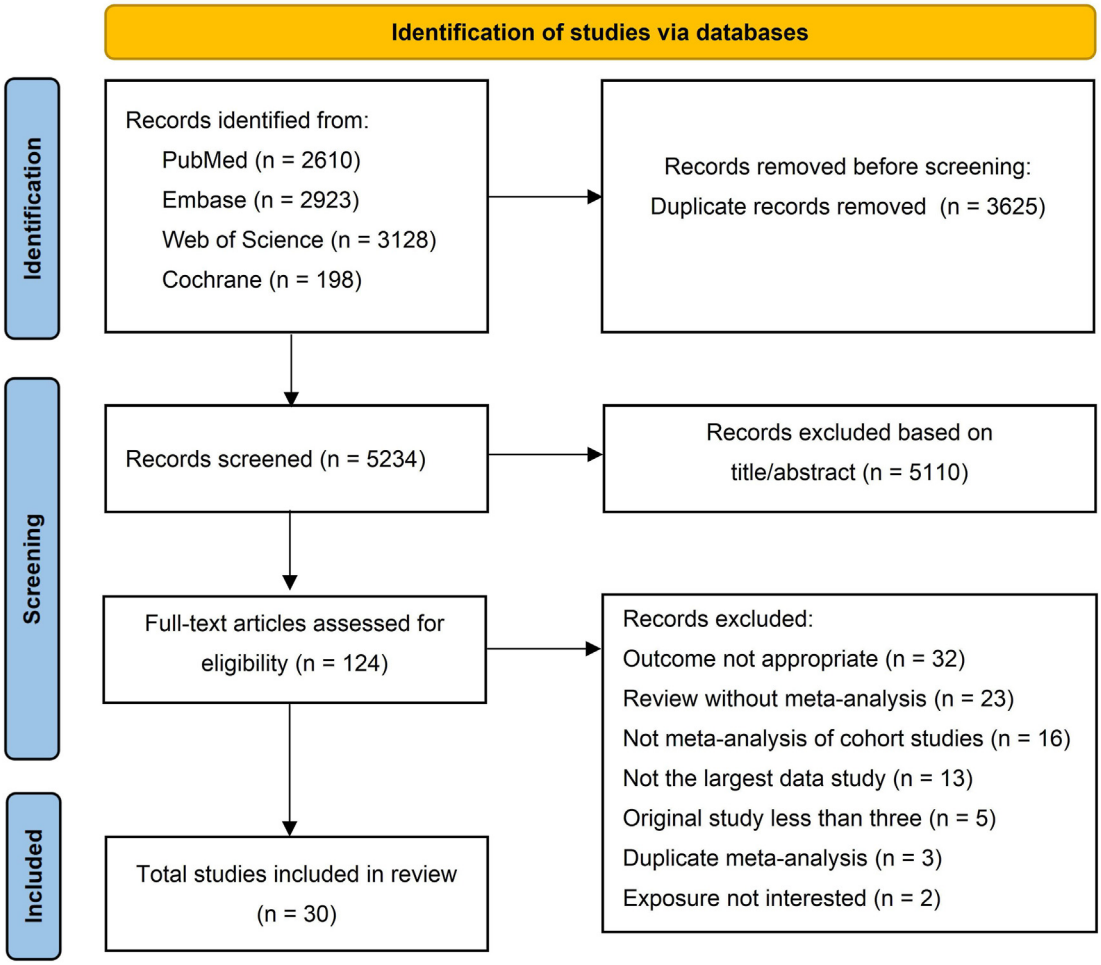

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart for study inclusion.

excluded studies, and the scientific quality of the primary studies was not considered in the conclusions and recommendations.

Assessing sterngth and credibility of the evidence

Of the 74 meta-analyses, 3 (4.1%) provided convincing evidence (Class I) (Figure 2 and Figure 5, Supplemental Tables 9 and 10) and reported associations of dietary patterns (prudent diet, vegetable-fruit-soybean diet, and 2007 WCRF/AICR dietary recommendations) with risks of BC and all cancers. Specifically, a prudent diet (highest compared with lowest) and vegetable-fruit-soybean diet (highest compared with lowest) were inversely associated with the risk of BC (RR ¼ 0.89 and 0.87, 95% CI: 0.85, 0.93 and 0.83, 0.92; P ¼ 2.98 × 10^{-7} and 5.63 × 10^{-7}, respectively, random-effects model). Further-more, a meta-analysis assessing the association between 1-unit score increment in the 2007 WCRF/AICR dietary recommendations and all cancers risk confirmed a decreased risk (RR ¼ 0.93, 95% CI: 0.92, 0.95; P ¼ 1.07 × 10^{-18}, random-effects model).

Four meta-analyses (5.4%) presented highly suggestive evidence (Class II) (Supplemental Table 9), including 3 dietary patterns (2007 WCRF/AICR dietary recommendations, DASH diet, and DII) and 2 outcomes (colon cancer and CRC). Moreover, 15 (20.3%) and 25 (33.8%) meta-analyses provided suggestive (Class III) and weak evi-dence (Class IV), respectively. Finally, no statistical significance was found in the other 27 (36.4%) associations (Supplemental Table 9).

Sensitivity analysis of the 18 excluded meta-analyses was performed due to overlap. The outcomes evaluated in these meta-analyses included 6 types of cancer (bladder cancer, BC, CRC, gastric cancer, lung cancer, and prostate cancer). The evidence of 2 meta-analyses increased from weak (Class IV) to highly suggestive/convincing (Class II/I) for the associations between DII/MD and CRC risk. Furthermore, the evidence of one meta-analysis increased from nonsignificant to weak (Class IV or NS) for the association between an MD and the risk of bladder cancer. However, the evidence provided by 5 meta-analyses decreased to suggestive (Class III) or below, and 11 meta-analyses remained unchanged (Supplemental Table 11). Furthermore, 3 meta-analyses showed evidence of small-study effects. Following removal of the small studies (i.e., <25th percentile), 1 meta-analysis increased from weak (Class IV) to suggestive (Class III) for the association between the DASH diet and risk of rectal cancer, and a second decreased from weak (Class IV) to nonsignificant for the as-sociation between an alternate MD and risk of lung cancer. One meta-analysis remained unchanged (Supplemental Table 12).

Quality assessment of outcomes using the GRADE framework revealed the following levels of certainty (Figure 7 and Supplementary Table S13). Of the 74 meta-analyses assessed overall, 4 (5.4%) were rated as high quality, including adherence to the 2007 WCRF/AICR dietary recommendations and decreased risks of 4 outcomes (all cancers, BC, CRC, and prostate cancer). In addition, 8 (10.8%), 26 (35.1%), and 36 (48.6%) meta-analyses were rated as moderate, low, and very low quality, respectively. The most common reasons for downgrading were inconsistency (26 meta-analyses), publication bias (12 meta-analyses), and imprecision (1 meta-analysis).

Outcomes/ Exposure	Author, year reference	Comparison	Random effects (95% CI)	AMSTAR	GRADE	Evidence class
Breast cancer						
2007 WCRF/AICR dietary	Jankovic et al., 2017 [26]	Per 1 - score increase	0.93 (0.87 - 0.99)	2	High	IV
DASH diet	Shu et al., 2023 [45]	Highest vs. Lowest	0.92 (0.86 - 0.98)	6	Low	IV
Dietary Inflammatory Index	Jayedi et al., 2018 [46]	Highest vs. Lowest	1.07 (1.00 - 1.14)	7	Moderate	IV
Dietary Inflammatory Index	Hayati et al., 2022 [47]	Per 1 - unit increase	1.01 (0.99 - 1.02)	9	Very low	NS
Healthy diet	Shin et al., 2023 [48]	Highest vs. Lowest	0.89 (0.75 - 1.06)	6	Low	NS
High-fat diet	Uhomoibhi et al., 2022 [49]	NA	1.31 (0.72 - 2.37)	3	Very low	NS
Mediterranean diet	Morze et al., 2021 [50]	Highest vs. Lowest	0.97 (0.94 - 1.00)	8	Low	NS
Pesco-vegetarian diet	Godos et al., 2016 [51]	Pesco vs. Non-vegetarian	0.98 (0.82 - 1.16)	6	Low	NS
Prudent diet	Xiao et al., 2019 [52]	Highest vs. Lowest	0.89 (0.85 - 0.93)	7	Very low	I
Prudent/healthy diet	Brennan et al., 2010 [12]	Highest vs. Lowest	0.93 (0.87 - 0.98)	5	Moderate	IV
Unhealthy diet	Shin et al., 2023 [48]	Highest vs. Lowest	1.04 (0.74 - 1.48)	6	Very low	NS
Vegetable-fruit-soybean diet	Zhang et al., 2019 [53]	Highest vs. Lowest	0.87 (0.83 - 0.92)	5	Low	I
Vegetarian diet	Godos et al., 2016 [51]	Vegetarian vs. Non-vegetarian	0.96 (0.88 - 1.05)	6	Low	NS
Western diet	Xiao et al., 2019 [52]	Highest vs. Lowest	1.02 (0.96 - 1.09)	7	Low	NS
Western/unhealthy diet	Brennan et al., 2010 [12]	Highest vs. Lowest	0.99 (0.90 - 1.08)	5	Moderate	NS
Endometrial cancer						
Alcohol-drinking diet	Si et al., 2016 [59]	Highest vs. Lowest	0.91 (0.64 - 1.29)	6	Very low	NS
Healthy diet	Si et al., 2016 [59]	Highest vs. Lowest	0.66 (0.46 - 0.94)	6	Very low	IV
Western diet	Si et al., 2016 [59]	Highest vs. Lowest	1.56 (1.04 - 2.34)	6	Very low	IV
Gynecological cancers						
Dietary Inflammatory Index	Liu et al., 2019 [61]	Highest vs. Lowest	1.08 (1.01 - 1.16)	7	Very low	IV
Ovarian cancer						
Healthy diet	Wang et al., 2018 [67]	Highest vs. Lowest	0.95 (0.85 - 1.06)	6	Very low	NS
Western diet	Wang et al., 2018 [67]	Highest vs. Lowest	1.09 (0.93 - 1.28)	6	Very low	NS
Prostate cancer						
2007 WCRF/AICR dietary	Jankovic et al., 2017 [26]	Per 1 - score increase	0.94 (0.92 - 0.97)	2	High	III
Healthy diet	Fabiani et al., 2016 [65]	Highest vs. Lowest	0.97 (0.88 - 1.08)	6	Very low	NS
Mediterranean diet	Morze et al., 2021 [50]	Highest vs. Lowest	0.98 (0.94 - 1.02)	8	Low	NS
Pesco-vegetarian diet	Godos et al., 2016 [51]	Pesco vs. Non-vegetarian	1.00 (0.75 - 1.34)	6	Very low	NS
Vegetarian diet	Godos et al., 2016 [51]	Vegetarian vs. Non-vegetarian	0.83 (0.63 - 1.10)	6	Very low	NS
Western diet	Fabiani et al., 2016 [65]	Highest vs. Lowest	0.97 (0.87 - 1.08)	6	Moderate	NS

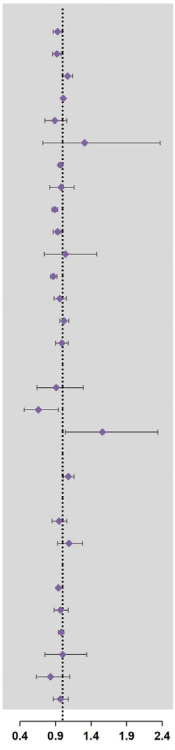

FIGURE 2. Summary random-effects estimate with 95% confidence intervals from 27 meta-analyses of dietary patterns and reproductive system cancer risks. AMSTAR, a measurement tool to assess systematic reviews; CI, confidence interval; Credibility assessment, class I: convincing, class II: highly suggestive, class III: suggestive, class IV: weak; DASH, Dietary Approaches to Stop Hypertension; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NA, Not Applicable; NS, nonsignificant; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research.

Discussion

The results of this UR provide a comprehensive overview of re-ported associations between different dietary patterns and risks of multiple cancers by incorporating evidence from 30 studies with 74 eligible meta-analyses of prospective cohort studies. We found that dietary patterns are significantly associated with various cancer risks across different measurements of exposure, including highest compared with lowest, any compared with none or a perunit increment in dietary pattern score.

The WCRF/AICR issued 5 recommendations related to dietary intake (Supplemental Table 4) [26,71]. The present UR found a favorable association between adhering to the 2007 WCRF/AICR di-etary recommendations and the risk of all cancers. One of the 2007 WCRF/AICR dietary recommendations is to incorporate plant-original foods into the daily diet (Supplemental Table 4) [72]. Strong evidence from the WCRF suggests that eating whole grains and foods containing dietary fibers protects against CRC. Current evidence has also shown that high consumption of foods of plant origin is linked to lower risks of cancers [73,74]. A recent UR of 20 meta-analyses of observational and interventional studies reported a significant reduction in all cancer incidence by 18% among vegetarians compared with omnivores [75]. Meanwhile, the strong evidence supported by the WCRF indicates that diets that increase blood glucose and insulin after eating might be a potential cause of endometrial cancer [72]. A summary meta-analysis of 93 original studies focused on the combination of diet and life-style with the incidence of cancers revealed that low-fiber, high-fat, and high-sugar diets are associated with a higher BMI [76], leading to increased body fat accumulation and impaired glucose and insulin regulation, which alter physiological hormonal homeostasis and ulti-mately increased cancer risk [76,77]. Notably, the present UR showed adherence to recommendations associated with a reduced risk of prostate cancer. However, this association was only supported by Class III in terms of the evidence classification when a lower P value threshold ($P < 10^{-6}$) was used. Further, research of larger scale is needed to confirm this association.

Our UR suggested adherence to prudent diet pattern associated with decreased risk of BC. A prudent diet is characterized by high con-sumption of vegetables, fruits, legumes, cereals, and seafood [78,79]. According to the WCRF, the consumption of prudent diet rich in ca-rotenoids could decrease the risk of BC [80,81]. Furthermore, sub-stantial consumption of fish ($\geq$ 1 serving/d), a principal constituent of the prudent diet, might interact with the fatty acid desaturases gene [82] and attenuate the detrimental genetic association with long-term weight gain [83] and further potentially reduce the occurrence and develop-ment of BC [84,85] Notably, a meta-analysis of 93 studies supports the prudent dietary pattern negatively associated with BC among pre-menopausal women [76] because the adverse effects of high estrogen concentrations were greatly diminished by potentially stronger pro-tective effects of various nutrient-rich fruits and vegetables, further promoting estrogen excretion. Overall, a prudent diet should be adopted, particularly among young premenopausal women, to protect against the development of BC.

The present UR also found a harmful association between the DII score and the risk of CRC comparing the highest score to the lowest, as well as a 1-unit increment in the score. A recent UR of 11

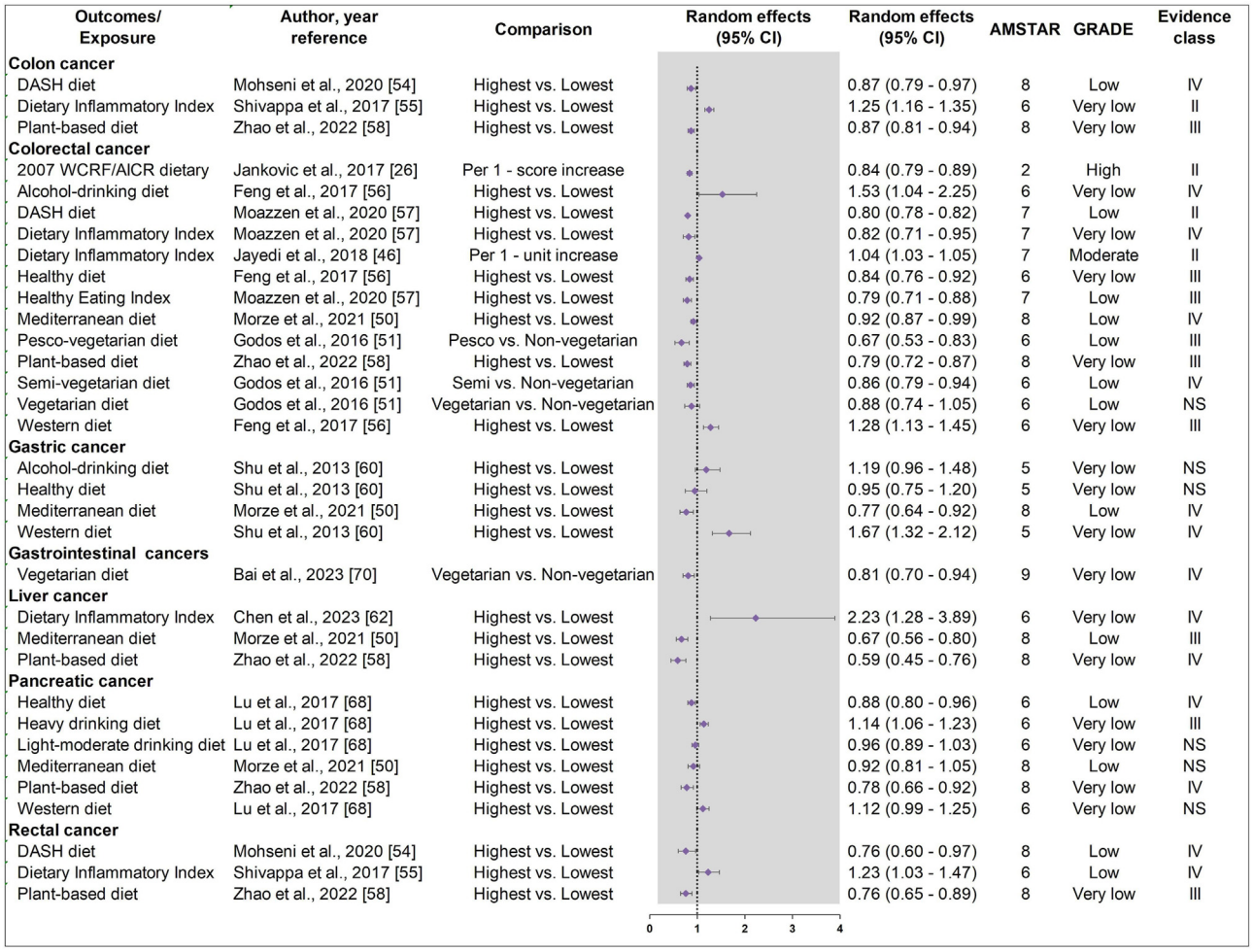

FIGURE 3. Summary random-effects estimate with 95% confidence intervals from 33 meta-analyses of dietary patterns and digestive system cancer risks. AMSTAR, a measurement tool to assess systematic reviews; CI, confidence interval; Credibility assessment, class I: convincing, class II: highly suggestive, class III: suggestive, class IV: weak; DASH, Dietary Approaches to Stop Hypertension; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NS, nonsignificant; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research.

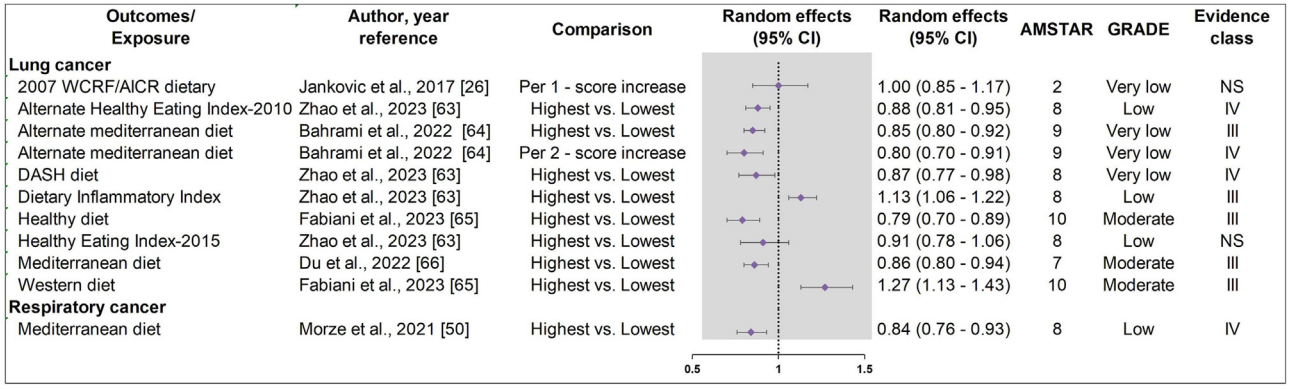

FIGURE 4. Summary random-effects estimate with 95% confidence intervals from 11 meta-analyses of dietary patterns and respiratory cancer risks. AMSTAR, a measurement tool to assess systematic reviews; CI, confidence interval; Credibility assessment, class I: convincing, class II: highly suggestive, class III: suggestive, class IV: weak; DASH, Dietary Approaches to Stop Hypertension; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NS, nonsignificant; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research.

meta-analyses of observational studies demonstrated the association between the DII score (each 1-unit increase) and the risk of CRC [86]. Meanwhile, another UR further demonstrated this association [87]. Although the DII represents the inflammatory properties of diets, the benefits of a low-inflammatory diet might be partly mediated by antioxidants, fiber, and blood-glucose-lowering components [88,89]. Thus, additional in vitro and in vivo experiments are needed to verify this causal association. Interestingly, our UR also identified the association

Outcomes/ Exposure	Author, year reference	Comparison	Random effects (95% CI)	Random effects (95% CI)	AMSTAR	GRADE	Evidence class
All cancers							
2007 WCRF/AICR dietary	Jankovic et al., 2017 [26]	Per 1 - score increase		0.93 (0.92 - 0.95)	2	High	I
Vegetarian diet	Huang et al., 2012 [43]	Vegetarian vs. Non-vegetarian		0.82 (0.67 - 1.00)	6	Low	NS
Bladder cancer							
Mediterranean diet	Dianatinasab et al., 2022 [44]	Highest vs. Lowest		0.92 (0.85 - 1.01)	8	Very low	NS

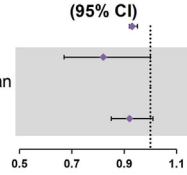

FIGURE 5. Summary random-effects estimate with 95% confidence intervals from 3 meta-analyses of dietary patterns and other systemic cancer risks. AMSTAR, a measurement tool to assess systematic reviews; CI: confidence interval; Credibility assessment: class I: convincing, class II: highly suggestive, class III: suggestive, class IV: weak; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NS, nonsignificant; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research.

Author, year reference	AMSTAR											
	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Item 11	Quality
Bai et al., 2023 [70]	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	High
Chen et al., 2023 [62]	Can't answer	N	Y	N	N	Y	Y	Y	Y	N	Y	Moderate
Fabiani et al., 2023 [65]	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	High
Shin et al., 2023 [48]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Shu et al., 2023 [45]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Zhao et al., 2023 [63]	Y	N	Y	N	Y	Y	Y	Y	Y	N	Y	High
Bahrami et al., 2022 [64]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	High
Dianatinasab et al., 2022 [44]	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	High
Du et al., 2022 [66]	Can't answer	Y	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Hayati et al., 2022 [47]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	High
Uhomoibhi et al., 2022 [49]	Can't answer	N	N	N	N	Y	N	Y	N	N	Y	Low
Zhao et al., 2022 [58]	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	High
Morze et al., 2021 [50]	Y	N	Y	N	N	Y	Y	N	Y	Y	Y	High
Moazzen et al., 2020 [57]	Can't answer	Y	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Mohseni et al., 2020 [54]	Can't answer	Y	Y	N	N	Y	Y	Y	Y	Y	Y	High
Liu et al., 2019 [61]	Can't answer	Y	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Xiao et al., 2019 [52]	Can't answer	Y	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Zhang et al., 2019 [53]	Can't answer	N	Y	N	N	Y	Y	N	Y	N	Y	Moderate
Jayedi et al., 2018 [46]	Can't answer	Y	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Wang et al., 2018 [67]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Feng et al., 2017 [56]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Jankovic et al., 2017 [26]	Can't answer	N	N	N	N	N	N	N	Y	N	Y	Low
Lu et al., 2017 [68]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Shivappa et al., 2017 [55]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Fabiani et al., 2016 [69]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Godos et al., 2016 [51]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Si et al., 2016 [59]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	Y	Moderate
Shu et al., 2013 [60]	Can't answer	N	Y	N	N	Y	Y	N	Y	Y	N	Moderate
Huang et al., 2012 [43]	Can't answer	Y	Y	N	N	Y	N	N	Y	Y	Y	Moderate
Brennan et al., 2010 [12]	Can't answer	N	Y	N	N	Y	N	N	Y	Y	Y	Moderate

FIGURE 6. Methodological quality assessment of the included articles with assessment of multiple systematic reviews (AMSTAR). Item 1: Was an "a priori" design provided? Item 2: Was there duplicate study selection and data extraction? Item 3: Was a comprehensive literature search performed? Item 4: Was the status of publication (i.e., grey literature) used as an inclusion criterion? Item 5: Was a list of studies (included and excluded) provided? Item 6: Were the characteristics of the included studies provided? Item 7: Was the scientific quality of the included studies assessed and documented? Item 8: Was the scientific quality of the included studies used appropriately in formulating conclusions? Item 9: Were the methods used to combine the findings of studies appropriate? Item 10: Was the likelihood of publication bias assessed? Item 11: Was the conflict of interest stated? Each question can be answered with "Yes," "No," "Can't answer," and "Not applicable." Only "Yes" scores 1 point, with a maximum score of 11. N, no; Y, yes.

FIGURE 7. GRADE classification of quality of evidence. The size of the circle reflects the magnitude of the random effect sizes. Rating down for inconsistency by 1 and 2 levels based on serious and very serious concerns. Upgrade for magnitude of effect by 1 and 2 levels based on risk ratio. Cohort studies start with a "low quality" rating. DASH, Dietary Approaches to Stop Hypertension; DII, Dietary Inflammatory Index; GRADE, Grading of Recommendations Assessment, Development, and Evaluation; HEI, Healthy Eating Index; MD, Mediterranean diet; WCRF/AICR, World Cancer Research Fund/American Institute for Cancer Research. [a]Downgraded by 1 level for inconsistency: substantial heterogeneity is seen between studies (I^2 > 50%). [b]Downgraded by 2 levels for inconsistency: substantial heterogeneity is seen between studies (I^2 > 75%), whereas heterogeneity was unexplained. [c]Downgraded by only one level for inconsistency: substantial heterogeneity is seen between studies (I^2 > 75%), whereas heterogeneity was mainly explained. [d]Downgraded by one level for imprecision: sub-stantial imprecision is seen in studies (events <300). [e]Downgraded by 1 level for publication bias: asymmetry on funnel plot, the P of Egger's test or Begg's test < 0.05. [f]Upgraded by only 1 level for dose-response because of the existence of dose-response. [g]Upgraded by only 1 level for plausible confounding because the plausible confounding would reduce effect.

between a high DII score and an increased risk of colon cancer. Similarly, a previous UR of 35 meta-analyses indicated this positive association [90]. However, the above associations were classified as very low quality in terms of GRADE, mainly owing to the presence of heterogeneity and publication bias. The findings should be cautiously interpreted.

To our knowledge, this UR is the first to map and evaluate existing evidence of the associations between dietary patterns and risks of various cancers based on prospective cohort studies both systematically and comprehensively. Rigorous criteria were used to evaluate the quality of the included studies and evidence level of the reported as-sociations. In addition, this UR revealed some limitations and gaps in the current evidence, which may facilitate improvement of future studies. Furthermore, sensitivity analyses found that most hierarchies of evidence remained unchanged.

Possible limitations in this UR should be considered. First, this UR only included meta-analyses of observational studies, which have po-tential selection and confounding biases, such as not fully ruling out residual confounder of overall energy intake [91,92]. Nevertheless, observational studies are more suitable for our UR [9]. The identified RCTs included original studies <3, and the assessed interventions were usually irrelevant to specific dietary patterns and, thus, were excluded [93 94]. Notably, the findings of the RCTs were generally consistent with the observational studies [95,96]. Second, deficiencies in UR methodology led us to include only quantitatively analyzed systematic reviews [97,98], thereby potentially ignoring other cancers. However, the findings of such cancers were further summarized (Supplemental Table S14). Third, dietary patterns are dependent on the number of items included in the self-reported food frequency questionnaires; [99] thus, misclassification due to recall and reporting biases cannot be avoided.

Besides, participants might change dietary habits during the follow-up period, resulting in misclassification bias and underestimation of the role of dietary patterns. Additionally, geographical area as a potential source of heterogeneity should be assessed in future studies, as versions of food frequency questionnaires vary by region, and dietary patterns are strongly related to cultural habits and country-specific factors.

In conclusion, the present UR found adherence to a prudent diet, vegetable-fruit-soybean diet, and the 2007 dietary WCRF/AICR recommendations associated with a decreased risk of certain cancers. These findings for dietary guidelines and policy development are ex-pected to benefit public health policies. Future prospective studies and large consortiums with better assessment of foods and interactions to identify dietary patterns and biological mechanisms are needed to draw firmer conclusions. It might be meaningful to explore how dietary guidelines can prevent the onset of cancers.

Author contributions

J-LY, Y-ZL, RW, X-JS, T-TG, and Q-JW contributed to the study design. J-LY, Y-ZL, RW, X-JS, D-DW, J-CL, P-CL, J-YW, Y-CS, and Y-XM collection of data. F-HL, XC, M-HS, JX, and YQ analysis of data. J-LY, Y-ZL, RW, X-JS, L-GZ, SG, Y-HZ, XG, LQ, X-HZ, T-TG, and Q-JW wrote the first draft of the manuscript and edited the manuscript. All authors read and approved the final manuscript. J-LY, Y-ZL, RW, and X-JS contributed equally to this work.

Conflict of interest

Xue-Hong Zhang is an Editor for The American Journal of Clinical Nutrition.

The authors declare no competing interests.

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Data sharing

All the data supporting the conclusions of this article are included within the article and its supplementary files.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajcnut.2024.11.020.

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