Diet Quality as Assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and Health Outcomes: A Second Update of a Systematic Review and Meta-Analysis of Cohort Studies

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ABSTRACT

Background  Suboptimal diet quality has a large impact on noncommunicable disease burden.

Objective  This study aimed to update the body of evidence on the associations between diet quality, as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, and the Dietary Approaches to Stop Hypertension score, and health status. Moreover, results of the previous systematic reviews and meta-analyses were extended by evaluating the credibility of the evidence.

Methods  PubMed, Embase, and Scopus databases were searched to identify eligible studies published between May 15, 2017 and March 14, 2020. Pooled relative risk (RR) with 95% CI for highest vs lowest category of diet quality were estimated using a random-effects model. Heterogeneity was explored using Cochran’s Q test and I² statistic with 95% CI. Presence of publication bias was detected by using funnel plots and Egger’s regression test. The NutriGrade tool was used to assess the credibility of evidence.

Results  The current update identified 47 new reports, resulting in a total of 113 reports including data from 3,277,684 participants. Diets of the highest quality, as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, and Dietary Approaches to Stop Hypertension scores, were inversely associated with risk of all-cause mortality (RR 0.80, 95% CI 0.78 to 0.82, I² = 68%, n = 23), cardiovascular disease incidence or mortality (RR 0.80, 95% CI 0.78 to 0.82, I² = 59%, n = 45), cancer incidence or mortality (RR 0.86, 95% CI 0.84 to 0.89, I² = 73%, n = 45), incidence of type 2 diabetes (RR 0.81, 95% CI 0.78 to 0.85, I² = 76%, n = 16), and incidence of neurodegenerative diseases (RR 0.82, 95% CI 0.75 to 0.89, I² = 71%, n = 12). In cancer survivors, the highest diet quality was linked with lower risk of all-cause (RR 0.83, 95% CI 0.77 to 0.88, I² = 45%, n = 12) and cancer mortality (RR 0.82, 95% CI 0.75 to 0.89, I² = 44%, n = 12). The credibility of evidence for identified associations between overall healthy dietary patterns and included health outcomes was moderate.

Conclusion  This updated systematic review and meta-analysis suggests that high diet quality (assessed by the Healthy Eating Index, Alternate Healthy Eating Index, and Dietary Approaches to Stop Hypertension) is inversely associated with risk of all-cause mortality, cardiovascular disease incidence or mortality, cancer incidence or mortality, type 2 diabetes, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. Moderate credibility of evidence for identified associations complements the recent 2020 Dietary Guidelines Advisory Committee report recommending healthy dietary patterns for disease prevention.

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dietary patterns are considered crucial to disease prevention.

In 2015, we published a systematic review and meta-analysis on associations between diet quality, as assessed by the Healthy Eating Index (HEI), Alternate Healthy Eating Index (AHEI), and Dietary Approaches to Stop Hypertension (DASH) score, and risk of all-cause mortality, CVD mortality or events, cancer mortality or incidence, T2D, and neurodegenerative disease. Moreover, in an updated version of this systematic review, the associations of these diet quality indices with all-cause mortality and cancer mortality among cancer survivors were also investigated. Pooled data from 68 prospective cohort studies suggested that diets that scored highly on HEI, AHEI, and DASH were inversely associated with risk of all-cause mortality, CVD, cancer, T2D, and neurodegenerative disease by 22%, 22%, 16%, 18%, and 15%, respectively. Among cancer survivors, a high-quality diet was inversely associated with risk of all-cause mortality and cancer mortality.

Numerous new studies have appeared since this last publication that are eligible for inclusion in this systematic review. In addition, addressing the credibility of the evidence is crucial in health decision-making. Currently, there is heightened awareness of the need for an appropriate evaluation of the quality of evidence synthesis in nutrition research. For this reason, this update aimed to extend previous analysis by assessing the credibility of evidence using the NutriGrade tool, which was applied previously in a series of systematic reviews on food groups.

METHODS
A predefined protocol for previous versions of this systematic review and meta-analysis was registered in PROSPERO International Prospective Register of Systematic Reviews (https://www.crd.york.ac.uk/PROSPERO/; ID: CRD42013006561). Changes made to the protocol are annotated in the text. The present update of the review was conducted and reported according to the Meta-Analysis of Observational Studies in Epidemiology guidelines.

Data Sources and Searches
An updated literature search for studies published from May 15, 2017 through March 14, 2020 was conducted in electronic databases (PubMed, Embase, and Scopus) with no restrictions on the language of publication. The search strategy for the PubMed database was adopted as follows: (“healthy”[All fields] AND (“eating”[All fields] OR “eating”[MeSH Terms])) AND (“abstracting and indexing as topic”[MeSH Terms] OR (“abstracting”[All fields] AND “indexing”[All fields] AND “topic”[All fields]) OR “abstracting and indexing as topic”[All fields] OR “index”[All fields]) OR (“dah”[All fields] AND (“diet”[All fields] OR “diet”[MeSH Terms]). Reference lists from included articles were checked in order to identify additional eligible studies. One author (J.M.) performed the literature search and any uncertainties were resolved through discussion with another author (L.S.).

Study Selection
Studies were considered as eligible for inclusion if they met the following criteria: conducted on adult populations (aged 18 years or older); evaluated the association of diet quality as assessed by the HEI, AHEI, or DASH score on risk of all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease in the general population and on all-cause mortality or cancer mortality among cancer survivors; and had a prospective observational design. Studies performed exclusively in patients with chronic diseases (such as CVD, diabetes, chronic kidney disease, or frailty syndrome) were excluded. In the case of 2 reports based on the same study, the one with the longer follow-up or with a larger number of cases was included. Two authors (J.M. and A.D.) independently performed the title and abstract screening, as well as study selection, and any disagreements were resolved by discussion with the third author (L.S.).

Data Extraction
After selecting the studies, the following information was extracted from each report: name of the first author, year of publication, study location and name, sample size, age at entry to the study, sex, length of follow-up, outcome, number of cases, diet quality index, adjustment factors, risk estimate (multivariable-adjusted odds ratio [OR], risk ratio [RR], or hazard ratio [HR]), and study quality. In contrast to the previous version of this review, if a study provided separate estimates for men and women, they were pooled using the fixed-effects model before inclusion in the analysis (according to the methodological recommendations of the World Cancer Research Fund). When a study reported multiple risk estimates, the one adjusted for the highest number of confounders was selected. Study data were extracted by one author (J.M.) and verified by another (L.S.).

Study Quality and Credibility of Evidence Assessment
The methodological quality of studies was evaluated using the Newcastle Ottawa Assessment Scale for Cohort Studies, as in the previous versions. The NutriGrade tool was used to quantify the credibility of evidence for the association between diet quality and predefined outcomes. In brief, a summary score was calculated and interpreted as very low (0 to <4 points), low (4 to <6 points), moderate (6 to <8 points), or high (8 to 10 points) credibility of the evidence (details of the NutriGrade tool items are provided in the footnotes for Table 1). Separate judgments on credibility of evidence were made for overall high diet quality (all 3 indices), HEI, AHEI, and DASH score.
| Comparison | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 | Item 8 | Total score | Credibility of evidence |
|------------|-------|-------|-------|-------|-------|-------|-------|-------|-------------|-----------------------|
| Overall high diet quality |       |       |       |       |       |       |       |       |             |                       |
| All-cause mortality | 2 | 1 | 1 | 1 | 0.5 | 1 | 0 | 0 | 6.5 | Moderate |
| CVD mortality or incidence | 2 | 1 | 1 | 1 | 0.5 | 1 | 0 | 0 | 6.5 | Moderate |
| Cancer mortality or incidence | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 7 | Moderate |
| T2D | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 7 | Moderate |
| Neurodegenerative disease | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 6 | Moderate |
| All-cause mortality among cancer survivors | 2 | 1 | 1 | 1 | 0.5 | 1 | 0 | 0 | 6.5 | Moderate |
| Cancer mortality among cancer survivors | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 6 | Moderate |
| HEI |       |       |       |       |       |       |       |       |             |                       |
| All-cause mortality | 2 | 1 | 0.6 | 0 | 0.5 | 1 | 0 | 0 | 5.1 | Low |
| CVD mortality or incidence | 2 | 1 | 0.6 | 1 | 0.5 | 1 | 1 | 0 | 7.1 | Moderate |
| Cancer mortality or incidence | 2 | 1 | 0.6 | 0 | 0.5 | 1 | 0 | 0 | 5.1 | Low |
| T2D | 2 | 1 | 0.3 | 0 | 1 | 1 | 1 | 0 | 5.3 | Low |
| Neurodegenerative disease | NA | NA | NA | NA | NA | NA | NA | NA | Very low |                       |
| All-cause mortality among cancer survivors | 2 | 1 | 0.3 | 0 | 0 | 1 | 1 | 0 | 5.3 | Low |
| Cancer mortality among cancer survivors | 2 | 1 | 0.3 | 0 | 0 | 1 | 1 | 0 | 5.3 | Low |
| AHEI |       |       |       |       |       |       |       |       |             |                       |
| All-cause mortality | 2 | 1 | 0.6 | 1 | 0.5 | 1 | 0 | 0 | 6.1 | Moderate |
| CVD mortality or incidence | 2 | 1 | 0.6 | 1 | 1 | 1 | 1 | 0 | 7.6 | Moderate |
| Cancer mortality or incidence | 2 | 1 | 0.6 | 0 | 1 | 1 | 1 | 0 | 5.6 | Low |
| T2D | 2 | 1 | 0.6 | 1 | 1 | 1 | 1 | 0 | 6.6 | Moderate |
| Neurodegenerative disease | 2 | 1 | 0.4 | 1 | 1 | 1 | 0 | 0 | 6.4 | Moderate |
| All-cause mortality among cancer survivors | 2 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 5 | Low |
| Cancer mortality among cancer survivors | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | Low |
| DASH score |       |       |       |       |       |       |       |       |             |                       |
| All-cause mortality | 2 | 1 | 0.6 | 1 | 0.5 | 1 | 0 | 0 | 6.1 | Moderate |
| CVD mortality or incidence | 2 | 1 | 0.6 | 1 | 1 | 1 | 0 | 0 | 6.6 | Moderate |

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Table 1. Item-level scoring for NutriGrade tool and credibility of evidence for association between the diet quality (overall high diet quality, HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| Comparison                              | Item 1 | Item 2 | Item 3 | Item 4 | Item 5 | Item 6 | Item 7 | Item 8 | Total score | Credibility of evidence |
|-----------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------------|-------------------------|
| Cancer mortality or incidence          | 2      | 1      | 0.6    | 1      | 0.5    | 1      | 0      | 0      | 6.1         | Moderate                |
| T2D                                     | 2      | 1      | 0.3    | 1      | 1      | 1      | 1      | 0      | 7.3         | Moderate                |
| Neurodegenerative disease              | 2      | 1      | 0.3    | 0      | 1      | 1      | 0      | 0      | 5.3         | Low                     |
| All-cause mortality among cancer survivors | 2      | 1      | 0.3    | 0      | 0.5    | 1      | 0      | 0      | 4.8         | Low                     |
| Cancer mortality among cancer survivors | 2      | 0      | 0.4    | 1      | 0.5    | 1      | 0      | 0      | 4.9         | Low                     |

*HEI = Healthy Eating Index.
*AHEI = Alternate Healthy Eating Index.
*DASH = Dietary Approaches to Stop Hypertension.
*CVD = cardiovascular disease.
*T2D = type 2 diabetes.
*Item-level NutriGrade tool scoring (points).
*Item 1 = Risk of bias, study quality, and study limitations (0 to 2 points)—2 points if mean Newcastle-Ottawa Score for a comparison ≥7.
*Item 2 = Precision (0 to 1 point)—1 point if ≥500 events and 95% CI excluded null value or otherwise 95% CI overlaps null value but excludes important benefit or harm (relative risk [RR] <0.8 or >1.2).
*Item 3 = Heterogeneity (0 to 1 point)—1 point if ≥10 studies, heterogeneity measures adequately reported, no important heterogeneity found or otherwise subgroup/sensitivity analyses conducted.
*Item 4 = Directness (0 to 1 point)—1 point if no important differences in the population or intervention, hard clinical outcome.
*Item 5 = Publication bias (0 to 1 point)—1 point if no evidence for publication bias with test or plot (10 or more studies).
*Item 6 = Funding bias (0 to 1 point)—1 point if report from academic or research institution.
*Item 7 = Effect size (0 to 2 points)—1 point if RR <0.80 to 0.50 or >1.20 to 2 and corresponding test statistically significant, 2 points if RR <0.5 or >2.0 and corresponding test statistically significant (highest vs lowest category).
*Item 8 = Dose—response (0 to 1 point)—1 point if significant linear/nonlinear dose—response relation.
*NA = not applicable.
HEI, AHEI, and DASH Components and Scoring

Components and scoring of HEI14-18 (HEI-200510-30 and HEI-201011-45), AHEI14,22,25,48-58, and DASH score9,22,33-44,49,53,55-57,61,62,64-81 were described in detail previously.

The HEI-2015 (not identified in previous versions of this meta-analysis) is composed of 13 items (overall scoring range from 0 to 100 points): total fruits (5 points), whole fruits (5 points), total vegetables (5 points), greens and beans (5 points), total grains (10 points), dairy (10 points), total protein foods (5 points), fatty acids (polyunsaturated fatty acid plus monounsaturated fatty acid to saturated fatty acid ratio) (10 points), refined grains (10 points), sodium (10 points), added sugars (10 points), and saturated fats (10 points). Refined grains, sodium, added sugars, and saturated fats as components to be consumed in moderation have a reversed scoring.82

Statistical Analysis

In accordance with previous versions of this review, studies were grouped according to the different clinical outcomes (i.e., all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease and all-cause mortality, or cancer mortality among cancer survivors). Extracted risk estimates (OR, RR, and HR) comparing the highest and lowest category of dietary indices were interpreted as RR and were pooled using a random-effects model with the DerSimonian-Laird method.83 The weighting of each study was assigned by calculating the standard error of the log-transformed RR, interpreted as an estimated variance of the log-transformed RR.83

Between-study heterogeneity was explored using Cochran’s Q test and $I^2$ statistic. An $I^2$ statistic >50% was regarded as a substantial amount of heterogeneity. Moreover, 95% CI for $I^2$ was calculated with the heterogi command in STATA software.84 Subgroup analyses were performed for dietary indices (HEI, AHEI, and DASH score) and their versions valid for the corresponding time period (HEI, HEI-2005, HEI-2010, HEI-2015, AHEI, AHEI-2010, and DASH-Fung score).81 The DASH-Fung score is composed of 8 components (fruits, vegetables, low-fat dairy, whole grains, nuts/seeds/legumes, red and processed meat, sugar-sweetened beverages, and sodium) scored by quintiles of intake.81 For CVD and cancer, separate analyses were applied to compare mortality and incidence. Additional subgroup analyses were conducted for distinct CVD outcomes (nonfatal or fatal coronary heart disease, stroke, and heart failure), site-specific cancers, and neurodegenerative disease (cognitive impairment and Parkinson disease). To check the robustness of results, analyses were restricted separately to US studies, long-term follow-up (8 years or more), high-quality (Newcastle Ottawa Assessment Scale score 8 points or higher), and men or women. Moreover, pooled estimates were recalculated using the fixed-effect model.

For comparisons with more than 10 eligible studies available, the publication bias was explored with Egger’s regression test and funnel plots.83 All analyses were conducted in Review Manager (RevMan)86 and STATA software.84

RESULTS

Literature Search and Study Characteristics

Detailed steps of the database search and study selection are illustrated in Figure 1. The updated search revealed 50 new eligible reports,87-136 which were assessed for overlapping results from 68 reports14-81 included in 2 previous versions of this systematic review. Five reports66,70,134-136 were excluded at this step because they overlapped other included studies, resulting in a total of 113 reports included in the current update (47 additional reports not identified previously).14,65,67-69,71-81,87-133

Characteristics of the 47 studies identified in the current update are presented in Table 2. Including the previous reports, analyses pooled data from 3,277,684 participants. Considering different clinical outcomes, all-cause mortality risk was assessed in 23 reports, CVD incidence or mortality in 45 reports, cancer incidence or mortality in 45 reports, T2D in 16 reports, neurodegenerative diseases in 12 reports, and all-cause mortality and cancer mortality among cancer survivors in 12 reports (those included breast, colorectal, ovarian, and overall cancer, as well as multiple myeloma survivors).

Main Outcomes

Pooled estimates for highest vs lowest category of diet quality (assessed by HEI, AHEI, or DASH score) were inversely associated with risk of all-cause mortality (Figure 2) (RR 0.80, 95% CI 0.79 to 0.82, $I^2 = 68\%$, 95% CI 55% to 77%, n = 23 reports), CVD incidence or mortality (Figure 3) (RR 0.80, 95% CI 0.78 to 0.82, $I^2 = 59\%$, 95% CI 46% to 69%, n = 45 reports), cancer incidence or mortality (Figure 4; available at www.jandonline.org) (RR 0.86, 95% CI 0.84 to 0.89, $I^2 = 73\%$, 95% CI 67% to 79%, n = 45 reports), T2D (Figure 5; available at www.jandonline.org) (RR 0.81, 95% CI 0.78 to 0.85, $I^2 = 76\%$, 95% CI 65% to 83%, n = 16 reports), and neurodegenerative diseases (Figure 6; available at www.jandonline.org) (RR 0.82, 95% CI 0.75 to 0.89, $I^2 = 71\%$, 95% CI 51% to 82%, n = 12 reports). Among cancer survivors, an inverse association was found between diet quality and all-cause mortality (Figure 7; available at www.jandonline.org) (RR 0.83, 95% CI 0.77 to 0.88, $I^2 = 45\%$, 95% CI 5% to 69%, n = 12 reports), as well as cancer mortality (Figure 8; available at www.jandonline.org) (RR 0.82, 95% CI 0.75 to 0.89, $I^2 = 44\%$, 95% CI 7% to 69%, n = 12 reports). Corresponding enumerative data are summarized in Table 3.

Subgroup and Sensitivity Analysis

Stratification of analyses for dietary scores showed that all 3 scores were associated with a lower risk of all-cause mortality, CVD, cancer, and T2D in the general population, and all-cause mortality among cancer survivors. There was a trend towards ($P = 0.04$) a greater reduction in T2D risk using the DASH score (RR 0.78, 95% CI 0.72 to 0.83, $I^2 = 65\%$) compared with the HEI (RR 0.88, 95% CI 0.82 to 0.94, $I^2 = 64\%$). For neurodegenerative diseases, lower risk of incidence was linked with diets that scored highly on AHEI (RR 0.76, 95% CI 0.70 to 0.82, $I^2 = 25\%$) and DASH (RR 0.85, 95% CI 0.76 to 0.95, $I^2 = 73\%$), but not HEI (RR 1.12, 95% CI 0.87 to 1.44). AHEI showed no association for cancer mortality among cancer survivors (RR 0.87, 95% CI 0.73 to 1.03, $I^2 = 53\%$).
The original HEI, unlike the newer versions (HEI-2005 and 2010), was not found to be related to risk of all-cause mortality, T2D, and cancer. The HEI-2015 was inversely associated with all-cause mortality, CVD, and cancer, but not with T2D. The original version of AHEI was not associated with cancer, whereas its newer adaptation was associated with decreased risk. After limiting the analyses to studies using only the DASH-Fung score, the observed associations remained except for neurodegenerative diseases and all-cause mortality among survivors (Table 4; available at www.jandonline.org).

Due to the fact that analyses on CVD and cancer included both mortality and incidence of distinct diseases, separate analyses were run to compare the estimates for them. Highest category of diet quality (by combining all 3 indices) was found to decrease risk of CVD incidence (RR 0.81, 95% CI 0.78 to 0.85, $I^2 = 42\%$) and CVD mortality (RR 0.79, 95% CI 0.77 to 0.82, $I^2 = 65\%$) equally. Similarly, no difference was observed among estimates for coronary heart disease (RR 0.78, 95% CI 0.74 to 0.83, $I^2 = 37\%$), stroke (RR 0.82, 95% CI 0.78 to 0.87, $I^2 = 0\%$), and heart failure (RR 0.80, 95% CI 0.68 to 0.94, $I^2 = 69\%$) (Table 3). When focusing on site-specific cancers, high-quality diets were inversely associated with risk of colorectal (RR 0.83, 95% CI 0.75 to 0.90, $I^2 = 67\%$), hepatocellular (RR 0.82, 95% CI 0.72 to 0.93, $I^2 = 0\%$), and prostate cancer (RR 0.93, 95% CI 0.89 to 0.97, $I^2 = 0\%$). Single studies reported an inverse association between highest quality of diet and esophageal, gallbladder, head and neck, and pancreatic cancer risk (Table 3 and Figure 9; available at www.jandonline.org). After stratifying neurodegenerative diseases, an association with high-quality diets was identified for cognitive decline (RR 0.81, 95% CI 0.74 to 0.88, $I^2 = 52\%$), but not for Parkinson disease (RR 0.89, 95% CI 0.70 to 1.14, $I^2 = 70\%$) (Table 3).

Estimates for men and women did not differ except for all-cause mortality and cancer-specific mortality among cancer survivors, which were found to be nonsignificant in men (RR 0.95, 95% CI 0.86 to 1.04, $I^2 = 34\%$) and RR 0.91, 95% CI 0.82 to 1.01, $I^2 = 12\%$, respectively) (Tables 5 and 6; available at www.jandonline.org). Findings from analyses conducted in US-based cohorts remained significant except for neurodegenerative diseases (RR 0.90 95% CI 0.80 to 1.01, $I^2 = 47\%$) (Table 7; available at www.jandonline.org). Sensitivity analysis conducted by the inclusion of studies with long-term

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**Figure 1.** Flowchart presenting search and selection of studies in the current update of the systematic review and meta-analysis of the associations of diet quality, as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, and Dietary Approaches to Stop Hypertension score, and health outcomes.
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|-------------------|---------|--------|---------|---------------|---------------|----------------|------|-------------------------|------------|----------------------------------------|---------------------------------------------|
| Abu-Saad, 2017    | Israeli | Hadera District Study | CVD events; All-cause mortality | 883           | 11.0          | 25-64          | Both | DASH score             | NA         | CVD events HR 0.71 (0.56 to 0.89)            | Quality assessment not possible because only abstract was available |
| Agarwal, 2018     | US      | Rush Memory and Aging Project | Parkinsonism | 706           | 4.6           | 59-97          | Both | DASH score             | HR 0.95 (0.87 to 1.04) | Parkinsonism                                      |
| Akbaraly, 2019    | UK      | Whitehall II | Dementia | 8,225          | 24.8          | 35-55          | Both | AHEI (2010)             | HR 0.88 (0.73 to 1.06) | Dementia                                      |
| Bathrellou, 2019  | Greece  | ATTICA | CVD events | 669           | 10.0          | ≥18            | Both | DASH score             | HR 0.95 (0.71 to 1.28) | CVD events                                      |
| Bogumil, 2019     | US      | Multiethnic Cohort | Hepatocellular carcinoma | 169,806       | 17.0          | 45-75          | Both | HEI (2010) AHEI (2010) DASH score | Hepatocellular carcinoma HR 0.84 (0.64 to 1.12) AHEI (2010) HR 0.87 (0.66 to 1.14) DASH score HR 0.89 (0.68 to 1.16) |复发 to next page |
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------------------|----------------|-----|------------------------|------------|------------------------------------------|---------------------------------|
| Campos, 2019       | US      | Multi-Ethnic Study of Atherosclerosis | Heart failure | 4,478/13.0 | 45-84 | Both | DASH score | Age, sex, race, education, energy intake, tobacco, site, exercise, BMI, hypertension, diabetes, high-density lipoprotein cholesterol, ejection fraction, left ventricle mass | Heart failure HR 0.70 (0.40 to 1.20) | 7 |
| Chan, 2019         | China   | Hong Kong Osteoporosis Risk Factors Study | All-cause mortality; CVD mortality | 2,802/12.4 | ≥65 | Both | DASH score | Age, BMI, smoking, drinking, Physical Activity Scale for the Elderly score, daily energy intake, education level, medical history of hypertension, diabetes mellitus and heart disease, serum 25(OH)D level, season of blood taking, high-sensitivity C-reactive protein, marital status, living alone, Geriatric Depression Scale category, Community Screening Instrument for Dementia category | All-cause mortality HR 0.88 (0.76 to 1.01) | 8 |
| Chebet, 2020       | US      | Women's Health Initiative | Obesity-related cancer | 9,886/13.0 | 50-79 | W | HEI (2015) | Age, BMI, waist circumference, smoking, educational attainment, income, randomization Women's Health Initiative arm, participating in observation study, sedentary time | Obesity-related cancer HR 0.99 (0.92 to 1.08) | 7 |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|-------------------|---------|--------|---------|---------------|--------------|----------------|------|------------------------|-----------|--------------------------------------|--------------------------|
| Chen, 2018 | Singapore | Singapore Chinese Health Study | T2D | 45,411 | 11.1 | 45-74 | Both | AHEI (2010) DASH score | Age at baseline interview, sex, dialect group, year of baseline interview, energy intake, BMI, physical activity, education, smoking, self-reported history of physician-diagnosed hypertension, coffee consumption, alcohol consumption (for DASH) | T2D | 8 |
| Chou, 2019 | Taiwan | Taiwan Initiative for Geriatric Epidemiological Research | Cognitive decline | 436 | 2.0 | ≥65 | Both | mAHEI | Age, sex, years of education, apolipoprotein E ε4 status, cognitive status at baseline, total calories, depressive symptoms, quantity-adjusted vegetable variety score, annual disposable income | Cognitive decline | 6 |
| Conway, 2018 | US | Southern Community Cohort Study | T2D | 38,064 | 7.5 | 40-79 | Both | HEI (2010) | Age at cohort entry, sex, education, household income, recruitment source, and health insurance status | T2D | 4 |
| Deshmukh, 2018 | US | NHANES III | All-cause mortality among cancer survivors; cancer mortality among cancer survivors | 1,191 cancer survivors | 17.2 | ≥12 | Both | HEI | Age, sex, income, education, BMI, hypertension, hyperlipidemia, diabetes, CVD | All-cause mortality among cancer survivors | 5 |
| Djousse, 2018 | US | Million Veteran Program | Coronary artery disease | 153,802 | 2.8 | 50-69 | Both | DASH score | Age, sex, race, smoking, BMI, exercise, alcohol, statin use | Coronary artery disease | 6 |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|--------------|--------------|----------------|-----|-------------------------|------------|------------------------------------------|-----------------------------------------------|
| Frisby, 2018       | US      | Physicians’ Health Study | Abdominal aortic aneurysm | 18,854       | 9.5          | 66.1           | M  | AHEI, DASH score       | Age, smoking, exercise, alcohol use, BMI, hypertension, and high cholesterol | Abdominal aortic aneurysm AHEI HR 0.81 (0.58 to 1.14) DASH score HR 0.80 (0.59 to 1.10) | Quality assessment not possible because only abstract was available |
| Guinter, 2018      | US      | Cancer Prevention Study II—Nutrition Cohort | All-cause mortality among cancer survivors; colorectal cancer mortality among cancer survivors | 1,321 cancer survivors | 6.5 | 50-74 | Both | DASH score | Age at diagnosis, year of diagnosis, sex, tumor stage, total caloric intake, BMI, education, smoking status, change in weight, treatment | All-cause mortality among cancer survivors HR 0.79 (0.62 to 0.99) Cancer mortality among cancer survivors HR 0.56 (0.35 to 0.89) | Quality assessment not possible because only abstract was available |
| Hardy, 2017        | US      | Atherosclerosis Risk in Communities | T2D | 10,102 | NA | 49-73 | Both | DASH score | Total calories, age, sex, physical activity level | T2D RR 0.70 (0.60 to 0.81) | Quality assessment not possible because only abstract was available |
| Haridass, 2018     | US      | California Teachers Study | Breast cancer | 96,959 | 14.0 | 22-104 | W | AHEI (2010), DASH score | Age at baseline, race, breast cancer family history, age at menarche, oral contraceptive use, parity status, smoking status, socioeconomic status, physical activity, total energy intake, BMI, total alcohol intake (for DASH score) | Breast cancer AHEI (2010) HR 0.90 (0.82 to 0.99) DASH score HR 0.94 (0.86 to 1.03) | Quality assessment not possible because only abstract was available |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI\textsuperscript{a}, AHEI\textsuperscript{b}, or DASH\textsuperscript{c} score) and all-cause mortality, CVD\textsuperscript{d} incidence or mortality, cancer incidence or mortality, T2D\textsuperscript{e}, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, \( n \) | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR\textsuperscript{f}/RR\textsuperscript{g}/HR\textsuperscript{h} (95\% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------------|-------------|----------------|-----|----------------------|------------|-----------------------------------------------|-------------------|
| Hashemian, 2019 \textsuperscript{104} | Iran | Golestan Cohort Study | All-cause mortality; cardiovascular mortality; cancer mortality | 42,373 | 10.6 | 40-75 | Both | HEI (2015) AHEI (2010) DASH score | Age, sex, BMI, formal education, place of residence, smoking status, opium use, physical activity, wealth score, marital status, history of hypertension, total energy intake | All-cause mortality | HEI (2015) HR 0.92 (0.83 to 1.01) AHEI (2010) HR 0.88 (0.80 to 0.97) DASH score HR 0.77 (0.70 to 0.86) | 9 |
| Hoon Lee, 2019 \textsuperscript{105} | US | Nurses' Health Study; Health Professional Follow-up Study | Multiple myeloma | 116,983 | 23.9 | 30-75 | Both | AHEI (2010) DASH score | Age, cumulative averages of total energy intake, and BMI | Multiple myeloma | AHEI (2010) HR 0.79 (0.64 to 0.98) DASH score HR 0.75 (0.60 to 0.93) | 6 |

(continued on next page)
| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|-------------------|---------|--------|---------|---------------|--------------|----------------|-----|-------------------------|------------|-------------------------------------------|-----------------------------------------------|
| Hoon Lee, 2020    | US      | Nurses’ Health Study; Health Professional Follow-up Study | All-cause mortality among multiple myeloma survivors; multiple myeloma mortality among multiple myeloma survivors | 423 multiple myeloma survivors | 3.5           | 30-75          | Both | AHEI (2010); DASH score | Age at diagnosis, prediagnosis energy intake, prediagnosis BMI, time between food frequency questionnaire return date and multiple myeloma diagnosis, year of diagnosis, comorbidity score | All-cause mortality among multiple myeloma survivors; AHEI (2010); HR 0.80 (0.71 to 0.89); DASH score; HR 0.86 (0.77 to 0.96) |
| Hu, 2020          | US      | Atherosclerosis Risk in Communities | All-cause mortality; CVD incidence; CVD mortality | 12,431 | 24.0          | 45-64          | Both | HEI (2015); AHEI (2010); DASH score | Age, sex, race-center (interaction), total energy intake, education level, income level, physical activity, smoking status, alcohol status (HEI and DASH score) | All-cause mortality among multiple myeloma survivors; HEI (2015); HR 0.82 (0.75 to 0.89); AHEI (2010); HR 0.80 (0.73 to 0.87); DASH score; HR 0.88 (0.80 to 0.96) |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|---------------|----------------|-----|-------------------------|-----------------------------------------------|--------------------------------------------------|
| Jones, 2018 | UK | EPIC-Norfolk | CVD incidence | 23,655 | 12.4 | 39-79 | Both | DASH score | HR 0.68 (0.58 to 0.80) | AHEI (2010) HR 0.66 (0.57 to 0.77) DASH score HR 0.79 (0.68 to 0.93) |
| Larsson, 2018 | Sweden | Swedish Mammography Cohort; Cohort of Swedish Men | Alzheimer’s disease | 28,755 | 12.6 | 45-83 | Both | DASH score | Age, sex, education, BMI, history of hypertension, hypercholesterolemia and diabetes, coffee consumption, alcohol consumption, smoking, walking/bicycling, leisure-time exercise, sleep duration | Alzheimer’s disease HR 0.96 (0.87 to 1.05) |
| Larsson, 2019 | Sweden | Swedish Mammography Cohort; Cohort of Swedish Men | Aortic valve stenosis | 74,401 | 15.2 | 45-83 | Both | DASH score | Age, sex, education, total energy intake, alcohol consumption, smoking, BMI, history of diabetes, hypertension, hypercholesterolemia | Aortic valve stenosis HR 1.06 (0.89 to 1.27) |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|---------------|----------------|-----|------------------------|------------|------------------------------------------|-----------------------------------------------|
| Lavalette, 2018    | France  | NutriNet-Santé Study | Overall cancer; breast cancer; prostate cancer; colorectal cancer | 41,543 | 3.0 | ≥40 | Both | AHEI (2010) | Age, sex, educational level, smoking status, number of 24-hour dietary recalls, height, family history of cancer, BMI, physical activity, energy intake (for women for breast cancer: number of biological children, menopausal status, hormonal treatment for menopause, oral contraception use at baseline) | HR 0.87 (0.73 to 1.03) | 5 |
| Ma, 2019           | US      | Nurses' Health Study; Health Professional Follow-up Study | Hepatocellular cancer | 138,688 | 32.0 | 30-75 | Both | AHEI (2010), DASH score | Age, race, cohort, physical activity level, BMI, smoking, regular aspirin use, total calorie intake, T2D, alcohol intake (for DASH score) | HEI (2010) | HR 0.61 (0.39 to 0.95) | 7 |
| Myneni, 2018       | US      | Women's Health Initiative | Lung cancer | 86,090 | 17.0 | 50-79 | W | HEI (2010), AHEI (2010), DASH score | Age, race/ethnicity, education, body mass index, smoking, physical activity, energy intake | HEI (2010) | HR 0.56 (0.33 to 0.96) | Quality assessment not possible because only abstract was available |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|---------------|----------------|-----|-------------------------|------------|------------------------------------------|-----------------------------------------------|
| Neelakantan, 2018  | Singapore | Singapore Chinese Health Study | All-cause mortality; CVD mortality; cancer mortality | 57,078 | 17.0 | 45-74 | Both | AHEI (2010) DASH score | Age at interview, sex, total energy intake, dialect, level of education, smoking status, physical activity, sleep duration, BMI, history of diabetes mellitus, history of hypertension, alcohol consumption (for DASH score) | All-cause mortality AHEI (2010) HR 0.82 (0.78 to 0.86) DASH score HR 0.80 (0.75 to 0.84) CVD mortality AHEI (2010) HR 0.77 (0.70 to 0.85) DASH score HR 0.72 (0.65 to 0.80) Cancer mortality AHEI (2010) HR 0.95 (0.87 to 1.04) DASH score HR 0.89 (0.82 to 0.98) | 8 |
| Nguyen, 2020      | China   | Shanghai Men’s Health Study; Shanghai Women’s Health Study | Colorectal cancer | 132,606 | 11.0 | 40-74 | Both | AHEI (2010) DASH score | Age, sex, total energy, education level, income levels, lifetime smoking, use of multivitamins, family history of colorectal cancer, physical activity, BMI, metabolic conditions (alcohol consumption for DASH score) | Colorectal cancer AHEI (2010) HR 0.91 (0.79 to 1.05) DASH score HR 0.90 (0.78 to 1.03) | 7 |
| Panizza, 2018     | US      | Multiethnic Cohort | All-cause mortality; CVD mortality; cancer mortality | 156,804 | 19.5 | 45-75 | Both | HEI (2015) | Age at study entry, BMI, history of diabetes, energy, ethnicity, education, marital status, smoking, physical activity, alcohol intake, hormone replacement therapy (for women) | All-cause mortality HR 0.79 (0.77 to 0.81) CVD mortality HR 0.76 (0.72 to 0.80) Cancer mortality HR 0.82 (0.78 to 0.86) | 8 |

(continued on next page)
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|--------------|----------------|-----|--------------------------|------------|----------------------------------------|-----------------------------------------------|
| Petimar, 2018      | US      | Nurses’ Health Study; Health Professional Follow-up Study | Colorectal cancer | 124,707 | 22.3 | Both | DASH score | Age, total energy intake, alcohol intake, physical activity, nonsteroidal anti-inflammatory drug use, family history of colorectal cancer, previous colorectal cancer screening via colonoscopy or sigmoidoscopy, history of polyps, smoking, multivitamin use, supplemental calcium intake, young adult BMI (further for women menopausal status, postmenopausal hormone use) | Colorectal cancer HR 0.89 (0.74 to 1.08) | 8 |
| Petimar, 2019      | US      | Sisters’ Study | Breast cancer | 45,626 | 7.6 | W | AHEI (2010) DASH score | Age, total energy intake, race/ethnicity, income, smoking, BMI, physical activity, height, education, mother diagnosed with breast cancer, age at first live birth, parity, hormone replacement therapy, age at menopause, oral contraception use, age at menarche, lifetime duration of breastfeeding, time of last mammogram, alcohol intake (for DASH score) | Breast cancer HR 0.91 (0.79 to 1.05) DASH score HR 0.78 (0.67 to 0.90) | 6 |
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|---------------|----------------|------|--------------------------|------------|------------------------------------------|-----------------------------------------------|
| Rautiainen, 2017   | US      | The Physicians’ Health Study II | All-cause mortality; CVD incidence | 13,316        | 11.4          | ≥50            | M    | AHEI                     | All-cause mortality | HR 1.04 (0.86 to 1.25)                         | 6                                             |
|                    |         |        |         |               |               |                |      |                          | CVD incidence       | HR 0.96 (0.77 to 1.19)                         |                                               |
| Seon Kuan, 2019    | UK, US  | Million Women Study; NIH-AARP study; PLCO Cancer Screening Trial | Glioma       | 1,262,104     | 12.2          | 50-74          | Both | AHEI, DASH score          | All-cause mortality | HR 1.14 (1.01 to 1.28)                         | 6                                             |
|                    |         |        |         |               |               |                |      |                          | CVD mortality       | RR 1.19 (1.05 to 1.34)                         |                                               |
| Shah, 2018         | US      | Cooper Center Longitudinal Study | All-cause mortality; CVD mortality | 11,376        | 18.0          | ≥20            | Both | DASH score               | All-cause mortality | HR 0.78 (0.69 to 0.89)                         | 8                                             |
|                    |         |        |         |               |               |                |      |                          | CVD mortality       | HR 0.85 (0.55 to 1.32)                         |                                               |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|--------------|---------------|----------------|-----|-------------------------|------------|----------------------------------------|-----------------------------------------------|
| Shakarsain, 2018    | Sweden  | Swedish National Study on Aging and Care in Kungsholmen | Cognitive decline | 2,223 | 6.0 | ≥60 | Both | DASH score | Total calorie intake, age, sex, education, civil status, physical activity, smoking, BMI, vitamin/mineral supplement intake, vascular disorders, diabetes, cancer, depression, apolipoprotein E, dietary components other than those included in each dietary index | Cognitive decline | HR 0.92 (0.54 to 1.55) | 7 |
| Shivappa, 2017      | UK      | Whitehall II | All-cause mortality; CVD mortality; Cancer mortality | 7,627 | 22.0 | 35-55 | Both | AHEI (2010) | Age, sex, ethnicity, occupational grade, marital status, smoking habits, physical activity, total energy intake, BMI, antecedent of CVD, use of lipid-lowering drugs, high-density lipoprotein cholesterol, hypertension, T2D, longstanding illness | All-cause mortality | HR 0.73 (0.61 to 0.87) | 8 |
| Solbak, 2017        | Canada  | Alberta’s Tomorrow Project | Cancer incidence | 25,169 | 10.4 | 35-69 | Both | HEI (2005) | Age, sex, BMI, current smoking status, marital status, household income, education, employment status, general health, family history of cancer, personal history of chronic disease | Cancer incidence | HR 0.78 (0.68 to 0.91) | 9 |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|--------------|----------------|-----|------------------------|------------|---------------------------------------|-----------------------------------------------|
| Sotos-Prieto, 2017 | US      | Nurses’ Health Study; Health Professional Follow-up Study | All-cause mortality; CVD mortality; cancer mortality | 73,739        | 12.0         | 30-75          | Both | AHEI (2010) DASH score | Age, initial dietary score, race, family history of myocardial infarction, diabetes or cancer, use or nonuse of aspirin or multivitamins, initial BMI, menopausal status, use or nonuse of hormone-replacement therapy (for women), initial smoking status and changes in smoking status (pack-years in people with smoking history), initial levels of physical activity, initial total energy intake and changes in these levels, history of hypertension, hypercholesterolemia, or T2D, change in weight, use or nonuse of cholesterol-lowering, antihypertensive medications, initial alcohol intake and changes in alcohol (for DASH score) | AHEI (2010) HR 0.83 (0.78 to 0.88) DASH score HR 0.90 (0.86 to 0.94) CVD mortality AHEI (2010) HR 0.85 (0.76 to 0.96) DASH score HR 0.96 (0.88 to 1.05) Cancer mortality AHEI (2010) HR 0.94 (0.85 to 1.04) DASH score HR 0.91 (0.84 to 0.98) | 8 |
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|---------|--------|---------|---------------|---------------|----------------|-----|------------------------|------------|--------------------------------------|-----------------------------------------------|
| Sun, 2018 | US | Women's Health Initiative | All-cause mortality among cancer survivors; breast cancer mortality among cancer survivors | 2,295 cancer survivors | 12.0 | 50-79 | W | HEI (2010) | Age at diagnosis, prediagnosis HEI-2010 score, prediagnosis total energy intake, change in total energy intake, race or ethnicity, education, income, breast cancer stage, estrogen receptor status, progesterone receptor status, time from diagnosis to dietary intake assessment, prediagnosis smoking status, postdiagnosis smoking status, prediagnosis physical activity, physical activity change, prediagnosis alcohol intake, prediagnosis BMI, cohort, use of postmenopausal hormone therapy, alcohol intake change, prediagnosis BMI, BMI change | All-cause mortality among cancer survivors | HR 0.79 (0.62 to 1.02) |
| Tait, 2020 | Canada | Canadian Community Health Survey | T2D | 4,755 | 12.1 | ≥18 | Both | HEI | Age, sex, income, race, physical activity, smoking, alcohol, BMI | HR 1.13 (0.73 to 1.76) |

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| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI, multivariate adjusted) | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|-------------------|---------|--------|---------|---------------|--------------|----------------|-----|------------------------|------------|------------------------------------------|---------------------------------|
| Trébuchet, 2019   | France  | NutriNet-Santé Cohort | CVD incidence | 94,113 | 5.4 | 18-74 | Both | AHEI (2010) | Age, sex, BMI, physical activity, smoking status, numbers of dietary records, alcohol intake, energy intake, family history of CVD, educational level, occupation, monthly household income, cohabiting status, season of recruitment | CVD incidence HR 0.75 (0.63 to 0.89) | 8 |
| Wang, 2018        | China   | China Health and Nutrition Survey | T2D | 4,440 | 3.0 | 18-65 | Both | AHEI (2010) | Age, individual income, education, urbanicity index, geographic region, smoking status, hypertension history, total energy intake | T2D OR 0.70 (0.45 to 1.09) | 5 |
| Wang, 2020        | China   | Shanghai Breast Cancer Survival Study | All-cause mortality among cancer survivors; breast cancer mortality among cancer survivors | 3,450 breast cancer survivors | 5.0 | 20-75 | W | HEI (2015) | Age at 60-mo survey, intervals between diagnosis and 60-mo survey, total energy intake, income, education, marriage, menopausal status at diagnosis, BMI at 60-mo survey, physical activity at 60-mo survey, estrogen receptor, progesterone receptor, human epidermal growth factor receptor 2, TNM stages, comorbidity, chemotherapy, radiotherapy, immunotherapy | All-cause mortality among cancer survivors HEI (2015) HR 0.79 (0.57 to 1.10) DASH score HR 0.66 (0.49 to 0.91) Breast cancer mortality among cancer survivors HEI (2015) HR 0.86 (0.58 to 1.27) DASH score HR 0.63 (0.44 to 0.92) | (continued on next page)
Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n Follow-up, y | Age at entry, y | Sex | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|-----------------------------|----------------|-----|-------------------------|------------|----------------------------------------|-----------------------------------------------|
| Wu, 2019131        | Singapore | Singapore Chinese Health Study | Cognitive impairment | 16,948 19.7 | 45-74 | Both | AHEI (2010) DASH score | Age at cognitive status measurement, year of baseline interview, sex, dialect group, marital status, education level, smoking status, physical activity, sleep duration, BMI, total energy intake, tea and coffee intake, baseline history of hypertension, diabetes, CVD, cancer, alcohol consumption (for DASH score) | Cognitive impairment AHEI (2010) OR 0.75 (0.66 to 0.85) DASH score OR 0.71 (0.62 to 0.81) | 8 |
| Xu, 2020132        | US | Atherosclerosis Risk in Communities | T2D | 10,808 22.0 | 45-64 | Both | HEI (2015) AHEI (2010) | Age, sex, race-center, education, family history of diabetes, family history of coronary heart disease/stroke, smoking status, physical activity, total energy intake, hypertension status, hypercholesterolemia status, estimated glomerular filtration rate, BMI category, alcohol intake (only for HEI) | T2D HEI (2015) HR 0.98 (0.87 to 1.11) AHEI (2010) HR 0.96 (0.85 to 1.08) | 8 |

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Table 2. Summary characteristics of 47 prospective studies (identified in the current update of review) evaluating association between diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| First author, year | Country | Cohort | Outcome | Population, n | Follow-up, y | Age at entry, y | Diet quality index/score | Adjustment | OR/RR/HR (95% CI), multivariate adjusted | Newcastle Ottawa Quality Assessment Scale (maximum 9) |
|--------------------|---------|--------|---------|---------------|--------------|-----------------|--------------------------|------------|------------------------------------------|-----------------------------------------------|
| Zhu, 2018<sup>133</sup> | China | Shanghai Women’s Health Study; Shanghai Men’s Health Study | Serious memory problem | 30,484 | 14.4 | 40-74 | Both AHEI DASH score | Total energy intake, sex, age, marital status, occupation, annual income, education, comorbidity, alcohol use, smoking status, exercise, BMI, waist-to-hip ratio, supplement intake, ginseng consumption | Serious memory decline | 6 |

<sup>1</sup>HEI = Healthy Eating Index.
<sup>2</sup>AHEI = Alternate Healthy Eating Index.
<sup>3</sup>DASH = Dietary Approaches to Stop Hypertension.
<sup>4</sup>CVD = cardiovascular disease.
<sup>5</sup>T2D = type 2 diabetes.
<sup>6</sup>OR = odds ratio.
<sup>7</sup>R = risk ratio.
<sup>8</sup>RR = hazard ratio.
<sup>9</sup>Higher score indicate high quality of studies.
<sup>10</sup>NA = not applicable.
<sup>11</sup>US = United States.
<sup>12</sup>UK = United Kingdom.
<sup>13</sup>W = women.
<sup>14</sup>mAHEI = modified Alternate Healthy Eating Index.
<sup>15</sup>NHANES = National Health and Nutrition Survey.
<sup>16</sup>M = men.
<sup>17</sup>EPIC = European Prospective Investigation into Cancer and Nutrition.
<sup>18</sup>NH-AARP = National Institutes of Health-American Association of Retired Persons (Study).
<sup>19</sup>PLCO = Prostate, Lung, Colorectal, and Ovarian (Cancer Screening Trial).
Table 2. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of all-cause mortality in prospective cohort studies. \(^a\)HEI = Healthy Eating Index. \(^b\)AHEI = Alternate Healthy Eating Index. \(^c\)DASH = Dietary Approaches to Stop Hypertension.
Figure 3. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of cardiovascular disease incidence or mortality in prospective cohort studies. **HEI** = Healthy Eating Index. **AHEI** = Alternate Healthy Eating Index. **DASH** = Dietary Approaches to Stop Hypertension.
## Table 3. Main and subgroup analyses for association between diet quality (assessed by HEI\(^a\), AHEI\(^b\) or DASH\(^c\) score) and all-cause mortality, CVD\(^d\) incidence or mortality, cancer incidence or mortality, T2D\(^e\), neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of reports | Diet Quality Index/Score | Relative risk | 95% CI | I\(^2\), % (95% CI) | P for subgroup differences\(^g\) |
|----------------------------------------------|----------------|--------------------------|---------------|--------|---------------------|-------------------------------|
| All-cause mortality                          | 23             | All indices combined     | 0.80          | 0.79, 0.82 | 68 (55, 77)        |                               |
|                                              |                | HEI                      | 0.80          | 0.78, 0.82 | 52                 | 0.32                          |
|                                              |                | AHEI                     | 0.79          | 0.76, 0.82 | 77                 |                               |
|                                              |                | DASH score               | 0.82          | 0.79, 0.84 | 50                 |                               |
| Cardiovascular disease incidence or mortality| 45             | All indices combined     | 0.80          | 0.78, 0.82 | 59 (46, 69)        |                               |
|                                              |                | HEI                      | 0.81          | 0.77, 0.84 | 47                 | 0.11                          |
|                                              |                | AHEI                     | 0.77          | 0.74, 0.80 | 45                 |                               |
|                                              |                | DASH score               | 0.81          | 0.78, 0.85 | 60                 |                               |
| Cardiovascular disease mortality             | 24             | All indices combined     | 0.79          | 0.77, 0.82 | 65                 | 0.34\(^h\)                    |
| Coronary heart disease                       | 23             | All indices combined     | 0.81          | 0.78, 0.85 | 42                 |                               |
| Stroke                                       | 9              | All indices combined     | 0.78          | 0.74, 0.83 | 37                 | 0.45\(^i\)                    |
| Heart failure                                | 5              | All indices combined     | 0.80          | 0.68, 0.94 | 69                 |                               |
| Cancer incidence or mortality                | 45             | All indices combined     | 0.86          | 0.84, 0.89 | 73 (67, 79)        |                               |
|                                              |                | HEI                      | 0.84          | 0.80, 0.88 | 77                 | 0.12                          |
|                                              |                | AHEI                     | 0.89          | 0.86, 0.92 | 64                 |                               |
|                                              |                | DASH score               | 0.86          | 0.82, 0.90 | 73                 |                               |
| Cancer mortality                             | 16             | All indices combined     | 0.85          | 0.83, 0.87 | 48                 | 0.26\(^k\)                    |
| Cancer incidence                             | 29             | All indices combined     | 0.87          | 0.84, 0.91 | 76                 |                               |
| Breast cancer\(^j\)                         | 5              | All indices combined     | 0.94          | 0.88, 1.00 | 42                 | 0.03\(^m\)                    |
| Colorectal cancer                            | 6              | All indices combined     | 0.83          | 0.75, 0.90 | 67                 |                               |
| Hepatocellular cancer                        | 3              | All indices combined     | 0.82          | 0.72, 0.93 | 0                  |                               |
| Lung cancer                                  | 2              | All indices combined     | 0.68          | 0.42, 1.08 | 90                 |                               |
| Prostate cancer                              | 2              | All indices combined     | 0.93          | 0.89, 0.97 | 0                  |                               |
| Type 2 diabetes                              | 16             | All indices combined     | 0.81          | 0.78, 0.85 | 76 (65, 83)        |                               |
|                                              |                | HEI                      | 0.88          | 0.82, 0.94 | 64                 | 0.04                          |
|                                              |                | AHEI                     | 0.80          | 0.75, 0.86 | 77                 |                               |
|                                              |                | DASH score               | 0.78          | 0.72, 0.83 | 65                 |                               |
| Neurodegenerative diseases                   | 12             | All indices combined     | 0.82          | 0.75, 0.89 | 71 (51, 82)        |                               |

(continued on next page)
Table 3. Main and subgroup analyses for association between diet quality (assessed by HEI\textsuperscript{a}, AHEI\textsuperscript{b} or DASH\textsuperscript{c} score) and all-cause mortality, CVD\textsuperscript{d} incidence or mortality, cancer incidence or mortality, T2D\textsuperscript{e}, neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| Outcome                                      | No. of reports | Diet Quality Index/Score | Relative risk | 95% CI         | I\textsuperscript{2}, % | (95% CI) | P for subgroup differences\textsuperscript{g} |
|----------------------------------------------|----------------|--------------------------|---------------|-----------------|-------------------------|----------|------------------------------------------|
|                                              |                | HEI                      | 1.12          | 0.87, 1.44      | NA\textsuperscript{n}   | 0.008    |                                          |
|                                              |                | AHEI                     | 0.76          | 0.70, 0.82      | 25                      |          |                                          |
|                                              |                | DASH score               | 0.85          | 0.76, 0.95      | 73                      |          |                                          |
| Parkinson’s disease                          | 3              | All indices combined     | 0.89          | 0.70, 1.14      | 70                      | 0.84\textsuperscript{o} |                                          |
| Cognitive impairment                         | 9              | All indices combined     | 0.81          | 0.74, 0.88      | 52                      |          |                                          |
| All-cause mortality among cancer survivors   | 12             | All indices combined     | 0.83          | 0.77, 0.88      | 45 (5, 69)              |          |                                          |
|                                              |                | HEI                      | 0.78          | 0.69, 0.89      | 49                      | 0.59     |                                          |
|                                              |                | AHEI                     | 0.83          | 0.73, 0.94      | 54                      |          |                                          |
|                                              |                | DASH score               | 0.86          | 0.77, 0.96      | 48                      |          |                                          |
| Cancer mortality among cancer survivors      | 12             | All indices combined     | 0.82          | 0.75, 0.89      | 44 (7, 69)              |          |                                          |
|                                              |                | HEI                      | 0.75          | 0.62, 0.92      | 56                      | 0.58     |                                          |
|                                              |                | AHEI                     | 0.87          | 0.73, 1.03      | 53                      |          |                                          |
|                                              |                | DASH score               | 0.83          | 0.72, 0.95      | 33                      |          |                                          |

\textsuperscript{a}HEI=Healthy Eating Index.  
\textsuperscript{b}AHEI=Alternate Healthy Eating Index.  
\textsuperscript{c}DASH=Dietary Approaches to Stop Hypertension score.  
\textsuperscript{d}CVD=cardiovascular diseases.  
\textsuperscript{e}T2D=type 2 diabetes.  
\textsuperscript{f}I\textsuperscript{2}=inconsistency.  
\textsuperscript{g}P for differences between HEI, AHEI and DASH score, unless other indicated.  
\textsuperscript{h}P for differences between cardiovascular disease incidence and mortality.  
\textsuperscript{i}Coronary heart disease, stroke and heart failure estimates included both fatal and non-fatal cases.  
\textsuperscript{j}P for differences between coronary heart disease, stroke, and heart failure.  
\textsuperscript{k}P for differences between cancer incidence and mortality.  
\textsuperscript{l}Presented are only site-specific cancer with at least two studies per comparison.  
\textsuperscript{m}P for differences between site-specific cancers.  
\textsuperscript{n}NA=not applicable.  
\textsuperscript{o}P for differences between Parkinson’s disease and cognitive impairment.
follow-up (median ≥8 years) or high-quality studies (Newcastle Ottawa Assessment Scale ≥8 points) did not change results from the main analyses (Tables 8 and 9; available at www.jandonline.org). Furthermore, the fixed-effect model suggested robustness of findings from primary analysis (Table 10; available at www.jandonline.org).

**Publication Bias**

Results of Egger’s regression test indicated no evidence of publication bias for all-cause mortality \( (P = 0.16) \), CVD incidence or mortality \( (P = 0.72) \), cancer incidence or mortality \( (P = 0.97) \), T2D \( (P = 0.87) \), neurodegenerative diseases \( (P = 0.34) \), and all-cause mortality among cancer survivors \( (P = 0.13) \). However, some indication for publication bias was found for cancer mortality among cancer survivors \( (P = 0.02) \).

Visual inspection of funnel plots revealed general symmetry for CVD incidence or mortality (Figure 10; available at www.jandonline.org), cancer incidence and mortality (Figure 11; available at www.jandonline.org), T2D (Figure 12; available at www.jandonline.org), and neurodegenerative diseases (Figure 13; available at www.jandonline.org). However, small asymmetry could be observed for all-cause mortality (Figure 14; available at www.jandonline.org), all-cause mortality among cancer survivors (Figure 15; available at www.jandonline.org), as well as cancer mortality among cancer survivors (Figure 16; available at www.jandonline.org), indicating that risk of publication bias cannot be excluded.

**Credibility of the Evidence**

Considering overall high adherence to healthy dietary patterns (assessed by HEI, AHEI, and DASH score), the credibility of evidence for all 7 included outcomes was moderate according to the NutriGrade tool (Table 1). Judgments for HEI ranged from very low (neurodegenerative diseases) and low (all-cause mortality, cancer incidence or mortality, T2D, all-cause and cancer mortality among cancer survivors) to moderate (CVD incidence or mortality). Regarding AHEI, the credibility of evidence was moderate, except for overall cancer and cancer survivor outcomes. Similar judgments were made for DASH score, except for cancer (moderate credibility of evidence) and neurodegenerative diseases (low credibility of evidence).

**DISCUSSION**

The current update of this systematic review and meta-analysis summarized data from 113 reports, including more than 3.2 million participants, on associations between diet quality assessed by HEI, AHEI, and DASH, and multiple chronic diseases outcomes. The highest vs lowest quality of diet described by all 3 dietary scores combined was associated with lower risk of all-cause mortality (20%), CVD incidence or mortality (20%), cancer incidence or mortality (14%), T2D (19%), and neurodegenerative diseases (18%) in the general population, as well as all-cause mortality (17%) and cancer mortality (18%) among cancer survivors.

In general, the results from the present update correspond with the main findings in the first update of this review published in 2018. However, the updated literature search added new substantial evidence to prior analyses by identifying 47 prospective cohort studies that have not yet been considered. For the first time it was possible to observe an inverse association of all-cause mortality among cancer survivors for the AHEI and DASH scores, as well as cancer mortality among cancer survivors for the DASH score. Moreover, it was possible to meta-analyze incidence of cancer subtypes represented only by single studies in the previous review, such as hepatocellular, lung, and prostate cancers.4

Analysis of dietary patterns is recognized as a more comprehensive approach compared with focusing on single nutrients or food.137 As distinct dietary patterns show differences in their composition, it is important to clarify that meta-analysis compares similar constructs. The dietary indices included in this systematic review share common characteristics—high intake of food and nutrients considered as beneficial with simultaneous low intake of those detrimental for health.137 Thus, HEI, AHEI, and DASH scores promote high consumption of fruits, vegetables, whole grains, and healthy fats with simultaneous low intake of solid fats, added sugar, and sodium. With respect to T2D, the trend toward a greater benefit from adhering to DASH score compared with HEI might be attributed to the fact that DASH, unlike HEI, penalizes intake of red and processed meat, which is linked with a higher risk of T2D.8,138 Both the HEI and AHEI scores are updated regularly, considering the latest available evidence. The benefit of adhering to a diet might depend on chronological development of scores.4 Thus, the original HEI was not associated with risk of all-cause mortality and cancer, probably due to lack of distinction between refined and unrefined grains. Considering the explicit statement of the 2015-2020 Dietary Guidelines for Americans to cut the intake of saturated fat and added sugar, the developers of the HEI-2015 included them as separate moderation components.82

Advantages of adhering to high-quality diets can also vary depending on disease etiology. Analyses stratified for specific CVD outcomes suggested an inverse association of high diet quality with coronary heart disease, stroke, and heart failure. These findings are in line with recent meta-analyses, which identified healthy/prudent dietary patterns as beneficial in the prevention of stroke and heart failure.139,140 Consistent with results from the 2018 update, there was an inverse association between highest diet quality adherence and colorectal cancer risk. Comparable associations for healthy dietary patterns were reported by the recent 2020 scientific report from the 2020 Dietary Guidelines Advisory Committee (DGAC) and a meta-analysis of cohort studies by Feng and colleagues.141,142 Reduced risks of hepatocellular and prostate cancers in the highest diet quality category were also reported by another systematic review.143 For neurodegenerative diseases, high diet quality was linked with a lower chance for cognitive decline, but not Parkinson disease. Whereas current findings for cognitive impairment correspond with a previous meta-analysis by Solfrizzi and colleagues,144 a relationship between the quality of dietary patterns and Parkinson disease has not been established.

Addressing the credibility of the evidence is a crucial aspect of delivering evidence-based nutrition recommendations. Despite the clear advantage in inferring causality, the use of randomized trials in studying diet–disease relationships is limited by a lack of blinding, as well as difficulty ensuring proper adherence in a long-term follow-up. Therefore, prospective cohort studies remain an essential source of evidence in nutritional epidemiology.1 The NutriGrade tool used in the current update

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was previously implemented to evaluate the credibility of evidence from diet–disease associations.7–10 The judgments of this study suggested moderate credibility of evidence for the association between healthy dietary patterns reflected by the HEI, AHEI, and DASH score and multiple health outcomes (Table 1). Moreover, considering specific indices, moderate credibility of evidence was identified for associations between HEI, AHEI, and DASH for CVD, AHEI and DASH for all-cause mortality and T2D, and DASH for cancer, as well as AHEI for neurodegenerative diseases. The main reasons that credibility could not be judged as high include small effect sizes, low number of studies, indirectness caused by differences in specific scores estimates, and evidence for the presence of publication bias for some outcomes. In contrast to current findings, the DGAC in its 2020 scientific report suggested the presence of strong evidence for a relationship between dietary patterns and all cause-mortality, as well as confirmed findings from its previous 2015 report suggesting the presence of strong evidence for a relationship between dietary patterns and CVD.141 Difference in judgment can be explained by the application of a different framework to assess the credibility of evidence. In that context, an advantage of the NutriGrade tool is the application of clear and transparent guidance on scoring. Furthermore, the DGAC statement pertaining to CVD involved supportive evidence from randomized controlled trials focusing on surrogate outcomes, such as blood pressure or blood lipids, whereas our judgment focused only on prospective studies with hard clinical end points. Moderate credibility of the evidence for cancer and T2D corresponded with findings from the 2020 DGAC scientific report.142 In addition, moderate credibility for T2D corresponded with judgments from a recent umbrella review.158

Moderate to high credibility of evidence is considered plausible to make a strong recommendation on particular health interventions.145 In particular, consistent moderate credibility of evidence for both specific scores and overall high diet quality in the context of CVD suggests promotion of healthy diet as a part of disease prevention. Therefore, findings from this systematic review complement the recent 2020 DGAC report.141

Strengths and Limitations
A major limitation of the current findings is the substantial amount of heterogeneity.7 Potential sources of this heterogeneity include varying characteristics of cohorts as well as heterogeneous dietary scoring systems. All 3 dietary indices/scores were developed on the basis of data from the US population. More than one-third of the reports included in the current update of the systematic review provided data from European and Asian cohort studies. Both food availability and culinary tradition can vary greatly across countries and continents.146 Thus, the use of predefined dietary patterns in their original form may not be appropriate in other cultural settings. Several studies had to redefine food classification and components of indices due to lack of intake data or food items infrequently consumed in specific communities. For example, one of the Chinese modifications of AHEI did not include intake of whole grains, sugar-sweetened beverages, and trans-fatty acids,144 and the Swedish adaption of the DASH score did not include sodium restriction.27 Therefore, participants categorized in 2 different studies as adhering to high-quality diets could potentially differ in the intake of healthful and less healthful foods and nutrients. Likewise, the majority of studies included in the present meta-analysis adopted the DASH score created by Fung,81 which uses scoring based on the quantile distribution of intake. This could lead to differences in cutoff points for components between studies. This approach was previously recognized as a potential disadvantage of other a priori–defined diet quality indices, such as the Mediterranean diet score.147 In addition to being an important source of heterogeneity, different scoring did not allow for conducting a dose–response meta-analysis, which downgraded the credibility of evidence for identified associations. Another limitation is the fact that the majority of included cohort studies used food frequency questionnaires as a dietary assessment method. The semi-quantitative nature of these data limits the ability to obtain an accurate estimate of intake.145 Future studies should consider focusing on new assessment methods, such as multiple source method and biomarkers of intake.146,150 A strength of multiple-source method is the ability to provide an unbiased estimate of individual usual intake by combining data from 24-hour dietary recalls and food frequency questionnaires. However, validated biomarkers of intake could provide an additional objective measure of long-term exposure to a specific food or nutrient.

Only a few studies included in this review collected longitudinal data on dietary intake. Individual food consumption can change substantially during long-term follow-up, leading to misclassification if only baseline data are available.125 Future updates of this systematic review should address differences in the evidence generated from baseline and repeated measures to assess changes in intake. Finally, for the analyses of cancer survivor data, different cancer subtypes were pooled, which might be a limitation because of different responsiveness of distinct tumors to the diet. However, in a previous meta-analysis, scores from a priori–determined diet quality indices showed a consistent inverse association for different tumor subtypes.151 A particular strength of this analysis is the large number of included studies (113 reports pooling data from 3,277,684 participants). The majority of included studies were high-quality prospective cohort studies. The current update was conducted and reported according to a predefined protocol. Furthermore, the credibility of evidence was assessed using the NutriGrade tool, which has already been adopted in previous systematic reviews.

CONCLUSIONS
This updated systematic review and meta-analysis suggests that high diet quality (as assessed by HEI, AHEI, and DASH) is inversely associated with risk of all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative diseases, as well as all-cause mortality and cancer mortality among cancer survivors. Moderate credibility of evidence for identified associations...
complements the recent 2020 DGAC report recommending healthy dietary patterns for disease prevention.

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AUTHORS CONTRIBUTIONS
J. Morze, A. Danielewicz, and L. Schwingshackl collected the data. J. Morze and L. Schwingshackl wrote the first draft with contributions from G. Hoffmann. All authors reviewed and commented on subsequent drafts of the manuscript.
Figure 4. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of cancer incidence or mortality in prospective cohort studies. aHEI = Healthy Eating Index. bAHEI = Alternate Healthy Eating Index. cDASH = Dietary Approaches to Stop Hypertension.
| Study or Subgroup                          | log(Risk Ratio) | SE  | Weight | Risk Ratio IV, Random, 95% CI   | Risk Ratio IV, Random, 95% CI |
|------------------------------------------|-----------------|-----|--------|--------------------------------|--------------------------------|
| HEI                                      |                 |     |        |                                |                                |
| Cespedes and colleagues 2016              | -0.1863         | 0.0317 | 5.4%   | 0.83 [0.78, 0.88]             |                               |
| Chiuye and colleagues 2012                | -0.1985         | 0.0388 | 5.1%   | 0.82 [0.76, 0.88]             |                               |
| Conway and colleagues 2018                | -0.1985         | 0.0881 | 3.1%   | 0.82 [0.69, 0.97]             |                               |
| Jacobs and colleagues 2015                | -0.0726         | 0.034 | 5.3%   | 0.93 [0.87, 0.99]             |                               |
| Tait and colleagues 2020                  | 0.1222          | 0.2245 | 0.8%   | 1.13 [0.73, 1.75]             |                               |
| Xu and colleagues 2020                    | -0.0202         | 0.0631 | 4.1%   | 0.98 [0.87, 1.11]             |                               |
| Subtotal (95% CI)                         |                 |     |        |                                |                               |
|                                           | 23.8%           |     |        | 0.88 [0.82, 0.94]             |                               |

Heterogeneity: Tau² = 0.00; Chi² = 13.75, df = 5 (P = 0.02); I² = 64%
Test for overall effect: Z = 3.66 (P = 0.0002)

AHEI

| Study or Subgroup                          | log(Risk Ratio) | SE  | Weight | Risk Ratio IV, Random, 95% CI   | Risk Ratio IV, Random, 95% CI |
|------------------------------------------|-----------------|-----|--------|--------------------------------|--------------------------------|
| Cespedes and colleagues 2016              | -0.2485         | 0.0338 | 5.3%   | 0.78 [0.73, 0.83]             |                               |
| Chen and colleagues 2016                  | -0.2319         | 0.0457 | 4.8%   | 0.79 [0.73, 0.87]             |                               |
| Chiuye and colleagues 2012                | -0.4005         | 0.0479 | 4.7%   | 0.67 [0.61, 0.74]             |                               |
| de Koning and colleagues 2014             | -0.2614         | 0.071 | 3.7%   | 0.77 [0.67, 0.88]             |                               |
| Fung and colleagues 2007                  | -0.2744         | 0.072 | 3.7%   | 0.76 [0.66, 0.86]             |                               |
| Interact 2014                             | -0.0408         | 0.0561 | 4.4%   | 0.96 [0.86, 1.07]             |                               |
| Jacobs and colleagues 2015                | -0.1278         | 0.0298 | 5.5%   | 0.88 [0.83, 0.93]             |                               |
| Otto and colleagues 2015                  | -0.2107         | 0.1099 | 2.4%   | 0.81 [0.65, 1.00]             |                               |
| Qiao and colleagues 2014                  | -0.2744         | 0.042 | 5.0%   | 0.76 [0.70, 0.83]             |                               |
| Tobias and colleagues 2012                | -0.4308         | 0.1764 | 1.2%   | 0.65 [0.46, 0.92]             |                               |
| Wang and colleagues 2018                  | -0.3567         | 0.2254 | 0.8%   | 0.70 [0.45, 1.09]             |                               |
| Xu and colleagues 2020                    | -0.0408         | 0.0621 | 4.1%   | 0.96 [0.85, 1.08]             |                               |
| Subtotal (95% CI)                         |                 |     |        |                                |                               |
|                                           | 45.6%           |     |        | 0.80 [0.75, 0.86]             |                               |

Heterogeneity: Tau² = 0.01; Chi² = 47.13, df = 11 (P < 0.00001); I² = 77%
Test for overall effect: Z = 6.44 (P < 0.00001)

DASH score

| Study or Subgroup                          | log(Risk Ratio) | SE  | Weight | Risk Ratio IV, Random, 95% CI   | Risk Ratio IV, Random, 95% CI |
|------------------------------------------|-----------------|-----|--------|--------------------------------|--------------------------------|
| Cespedes and colleagues 2016              | -0.3011         | 0.0357 | 5.2%   | 0.74 [0.69, 0.79]             |                               |
| Chen and colleagues 2018                  | -0.3383         | 0.0496 | 4.6%   | 0.71 [0.65, 0.79]             |                               |
| de Koning and colleagues 2011             | -0.2877         | 0.073 | 3.6%   | 0.75 [0.65, 0.87]             |                               |
| Hardy and colleagues 2017                 | -0.3567         | 0.0766 | 3.5%   | 0.70 [0.60, 0.81]             |                               |
| Interact 2014                             | -0.0513         | 0.0628 | 4.1%   | 0.95 [0.84, 1.07]             |                               |
| Jacobs and colleagues 2015                | -0.2485         | 0.0269 | 5.6%   | 0.78 [0.74, 0.82]             |                               |
| Liese and colleagues 2009                 | -0.4463         | 0.2796 | 0.6%   | 0.64 [0.37, 1.11]             |                               |
| Otto and colleagues 2015                  | 0.0183          | 0.1264 | 2.0%   | 1.02 [0.79, 1.30]             |                               |
| Tobias and colleagues 2012                | -0.3857         | 0.1672 | 1.4%   | 0.68 [0.49, 0.94]             |                               |
| Subtotal (95% CI)                         |                 |     |        |                                |                               |
|                                           | 30.6%           |     |        | 0.78 [0.72, 0.83]             |                               |

Heterogeneity: Tau² = 0.01; Chi² = 22.63, df = 8 (P = 0.004); I² = 65%
Test for overall effect: Z = 7.05 (P < 0.00001)
Test for subgroup differences: Chi² = 6.58, df = 2 (P = 0.04), I² = 69.6%

| Total (95% CI)                            | 100.0%          |     |        | 0.81 [0.78, 0.85]             |                               |

Heterogeneity: Tau² = 0.01; Chi² = 106.81, df = 26 (P < 0.00001); I² = 76%
Test for overall effect: Z = 9.43 (P < 0.00001)
Test for subgroup differences: Chi² = 6.58, df = 2 (P = 0.04), I² = 69.6%

**Figure 5.** Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of type 2 diabetes in prospective cohort studies. 4HEI = Healthy Eating Index. 5AHEI = Alternate Healthy Eating Index. 6DASH = Dietary Approaches to Stop Hypertension.
| Study or Subgroup               | log[Risk Ratio] | SE    | Weight | RR (95% CI)          | RR (95% CI)          |
|--------------------------------|----------------|-------|--------|---------------------|---------------------|
| **HEI**<sup>a</sup>            |                |       |        |                     |                     |
| Haring and colleagues 2016    | 0.1133         | 0.1289| 5.5%   | 1.12 [0.87, 1.44]   | 1.12 [0.87, 1.44]   |
| Subtotal (95% CI)              |                |       | 5.5%   |                     |                     |
| Heterogeneity: Not applicable  |                |       |        |                     |                     |
| Test for overall effect: Z = 0.88 (P = 0.38) |   |   |        |                     |                     |
| **AHEI**<sup>b</sup>           |                |       |        |                     |                     |
| Akbaraly and colleagues 2019  | -0.1278        | 0.0953| 7.1%   | 0.88 [0.73, 1.06]   | 0.88 [0.73, 1.06]   |
| Chou and colleagues 2019      | -0.6162        | 0.2881| 1.8%   | 0.54 [0.31, 0.95]   | 0.54 [0.31, 0.95]   |
| Gao and colleagues 2007       | -0.3567        | 0.1616| 4.3%   | 0.70 [0.51, 0.96]   | 0.70 [0.51, 0.96]   |
| Haring and colleagues 2018    | -0.1985        | 0.1264| 5.6%   | 0.82 [0.64, 1.05]   | 0.82 [0.64, 1.05]   |
| Smyth and colleagues 2015     | -0.2744        | 0.072 | 8.4%   | 0.76 [0.66, 0.88]   | 0.76 [0.66, 0.88]   |
| Sääksjärvi and colleagues 2013| 0.2546         | 0.3576| 1.3%   | 1.29 [0.64, 2.60]   | 1.29 [0.64, 2.60]   |
| Wu and colleagues 2019        | -0.2877        | 0.0645| 8.8%   | 0.75 [0.66, 0.85]   | 0.75 [0.66, 0.85]   |
| Zhu and colleagues 2018        | -0.4005        | 0.0756| 8.2%   | 0.67 [0.58, 0.78]   | 0.67 [0.58, 0.78]   |
| Subtotal (95% CI)              |                |       | 45.4%  | 0.76 [0.70, 0.82]   | 0.76 [0.70, 0.82]   |
| Heterogeneity: Tau² = 0.00; Chi² = 9.34, df = 7 (P = 0.23); P = 25% |   |   |        |                     |                     |
| Test for overall effect: Z = 6.48 (P < 0.00001) |   |   |        |                     |                     |
| **DASH score**<sup>c</sup>    |                |       |        |                     |                     |
| Agarwal and colleagues 2018   | -0.0513        | 0.0449| 9.8%   | 0.95 [0.87, 1.04]   | 0.95 [0.87, 1.04]   |
| Haring and colleagues 2016    | -0.0726        | 0.0705| 8.5%   | 0.93 [0.81, 1.07]   | 0.93 [0.81, 1.07]   |
| Larsson and colleagues 2018   | -0.0408        | 0.0479| 9.7%   | 0.96 [0.87, 1.05]   | 0.96 [0.87, 1.05]   |
| Morris and colleagues 2015    | -0.5108        | 0.2467| 2.4%   | 0.60 [0.37, 0.97]   | 0.60 [0.37, 0.97]   |
| Shakerian and colleagues 2018 | -0.0866        | 0.2674| 2.1%   | 0.92 [0.54, 1.55]   | 0.92 [0.54, 1.55]   |
| Wu and colleagues 2019        | -0.3425        | 0.0682| 8.6%   | 0.71 [0.62, 0.81]   | 0.71 [0.62, 0.81]   |
| Zhu and colleagues 2018        | -0.2614        | 0.0763| 8.1%   | 0.77 [0.66, 0.89]   | 0.77 [0.66, 0.89]   |
| Subtotal (95% CI)              |                |       | 49.1%  | 0.85 [0.76, 0.95]   | 0.85 [0.76, 0.95]   |
| Heterogeneity: Tau² = 0.01; Chi² = 22.13, df = 6 (P = 0.001); P = 73% |   |   |        |                     |                     |
| Test for overall effect: Z = 2.83 (P = 0.005) |   |   |        |                     |                     |
| **Total (95% CI)**             | 100.0%         | 0.82  | [0.75, 0.89] |                     |
| Heterogeneity: Tau² = 0.02; Chi² = 50.96, df = 15 (P < 0.00001); P = 71% |   |   |        |                     |
| Test for overall effect: Z = 4.63 (P < 0.00001) |   |   |        |                     |
| Test for subgroup differences: Chi² = 9.86, df = 2 (P = 0.008); P = 79.3% |   |   |        |                     |

**Figure 6.** Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of neurodegenerative diseases in prospective cohort studies. <sup>a</sup>HEI = Healthy Eating Index. <sup>b</sup>AHEI = Alternate Healthy Eating Index. <sup>c</sup>DASH = Dietary Approaches to Stop Hypertension.
Figure 7. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of all-cause mortality among cancer survivors. aHEI = Healthy Eating Index. bAHEI = Alternate Healthy Eating Index. cDASH = Dietary Approaches to Stop Hypertension.
Figure 8. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of cancer mortality among cancer survivors in prospective cohort studies. aHEI = Healthy Eating Index. bAHEI = Alternate Healthy Eating Index. cDASH = Dietary Approaches to Stop Hypertension.
Table 4. Subgroup analyses for associations between different versions of HEI\(^a\) (HEI, HEI-2005, HEI-2010, and HEI-2015), AHEI\(^b\) (AHEI and AHEI-2010), or DASH\(^c\) score (DASH-Fung) and all-cause mortality, CVD\(^d\) incidence or mortality, cancer incidence or mortality, T2D\(^e\) and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                  | Dietary index       | No. of studies | Relative risk | 95% CI       | \(I^2,\)% |
|--------------------------|---------------------|----------------|--------------|--------------|-----------|
| All-cause mortality      | HEI (original)      | 2              | 1.05         | 0.45 to 2.45 | 67        |
|                          | HEI-2010            | 5              | 0.78         | 0.77 to 0.80 | 16        |
|                          | HEI-2015            | 3              | 0.83         | 0.77 to 0.91 | 78        |
|                          | AHEI                | 4              | 0.76         | 0.63 to 0.93 | 88        |
|                          | AHEI-2010           | 9              | 0.80         | 0.78 to 0.83 | 62        |
|                          | DASH-Fung           | 11             | 0.82         | 0.79 to 0.85 | 62        |
| CVD incidence and mortality | HEI (original)    | 3              | 0.80         | 0.71 to 0.90 | 0         |
|                          | HEI-2005            | 2              | 0.80         | 0.72 to 0.88 | 0         |
|                          | HEI-2010            | 5              | 0.80         | 0.76 to 0.84 | 49        |
|                          | HEI-2015            | 3              | 0.85         | 0.74 to 0.97 | 84        |
|                          | AHEI                | 7              | 0.76         | 0.68 to 0.86 | 58        |
|                          | AHEI-2010           | 14             | 0.77         | 0.74 to 0.80 | 41        |
|                          | DASH-Fung           | 19             | 0.83         | 0.79 to 0.87 | 61        |
| Cancer incidence and mortality | HEI (original)  | 3              | 1.02         | 0.89 to 1.17 | 46        |
|                          | HEI-2005            | 6              | 0.81         | 0.74 to 0.89 | 72        |
|                          | HEI-2010            | 14             | 0.83         | 0.78 to 0.88 | 76        |
|                          | HEI-2015            | 2              | 0.82         | 0.78 to 0.86 | 0         |
|                          | AHEI                | 4              | 0.91         | 0.76 to 1.10 | 83        |
|                          | AHEI-2010           | 23             | 0.88         | 0.86 to 0.91 | 50        |
|                          | DASH-Fung           | 21             | 0.86         | 0.82 to 0.90 | 76        |
| T2D                      | HEI (original)      | 1              | 1.13         | 0.73 to 1.75 | NA\(^g\) |
|                          | HEI-2005            | 1              | 0.82         | 0.76 to 0.88 | NA        |
|                          | HEI-2010            | 3              | 0.87         | 0.79 to 0.95 | 69        |
|                          | HEI-2015            | 1              | 0.98         | 0.87 to 1.11 | NA        |
|                          | AHEI                | 6              | 0.80         | 0.72 to 0.88 | 65        |
|                          | AHEI-2010           | 6              | 0.80         | 0.73 to 0.89 | 85        |
|                          | DASH-Fung           | 5              | 0.76         | 0.70 to 0.82 | 56        |
| Neurodegenerative diseases | HEI-2010           | 1              | 1.12         | 0.87 to 1.44 | NA        |
|                          | AHEI                | 5              | 0.72         | 0.63 to 0.81 | 22        |

(continued on next page)
Table 4. Subgroup analyses for associations between different versions of HEI (HEI, HEI-2005, HEI-2010, and HEI-2015), AHEI (AHEI and AHEI-2010), or DASH score (DASH-Fung) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors. (continued)

| Outcome                                      | Dietary index | No. of studies | Relative risk | 95% CI       | $I^2, \%$ |
|----------------------------------------------|---------------|----------------|---------------|--------------|-----------|
| All-cause mortality among cancer survivors   | AHEI-2010     | 3              | 0.79          | 0.72 to 0.87 | 1         |
|                                              | DASH-Fung     | 2              | 0.81          | 0.62 to 1.06 | 87        |
|                                              | HEI (original)| 1              | 0.59          | 0.45 to 0.77 | NA        |
|                                              | HEI-2005      | 4              | 0.78          | 0.63 to 0.97 | 50        |
|                                              | HEI-2010      | 2              | 0.88          | 0.78 to 0.98 | 0         |
|                                              | HEI-2015      | 1              | 0.79          | 0.57 to 1.10 | NA        |
|                                              | AHEI-2010     | 4              | 0.83          | 0.73 to 0.94 | 54        |
|                                              | DASH-Fung     | 4              | 0.90          | 0.80 to 1.02 | 42        |
| Cancer mortality among cancer survivors      | HEI (original)| 1              | 0.35          | 0.19 to 0.63 | NA        |
|                                              | HEI-2005      | 4              | 0.85          | 0.65 to 1.12 | 44        |
|                                              | HEI-2010      | 2              | 0.74          | 0.56 to 0.97 | 40        |
|                                              | HEI-2015      | 1              | 0.86          | 0.58 to 1.27 | NA        |
|                                              | AHEI-2010     | 4              | 0.87          | 0.73 to 1.03 | 53        |
|                                              | DASH-Fung     | 4              | 0.88          | 0.80 to 0.96 | 0         |

*HEI = Healthy Eating Index.
*AHEI = Alternate Healthy Eating Index.
*DASH = Dietary Approaches to Stop Hypertension.
*CVD = cardiovascular disease.
*T2D = type 2 diabetes.
$I^2$ = inconsistency.
*NA = not applicable.
Figure 9. Forest plot showing pooled relative risks with 95% CI for association between highest vs lowest diet quality (assessed by HEI, AHEI, and DASH score) and risk of site-specific cancers in prospective cohort studies. HEI = Healthy Eating Index. AHEI = Alternate Healthy Eating Index. DASH = Dietary Approaches to Stop Hypertension.
Table 5. Men: Pooled relative risk (with 95% CIs) for the association between the diet quality (assessed by the HEI,\textsuperscript{a} AHEI,\textsuperscript{b} or DASH\textsuperscript{c} score) and all-cause mortality, CVD\textsuperscript{d} incidence or mortality, cancer incidence or mortality, T2D,\textsuperscript{e} and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of studies | Index                     | Relative risk | 95% CI     | $I^2,\%$ |
|----------------------------------------------|----------------|---------------------------|---------------|------------|----------|
| All-cause mortality                          | 10             | All indexes combined      | 0.79          | 0.76 to 0.81| 79       |
| CVD incidence or mortality                   | 15             | All indexes combined      | 0.79          | 0.76 to 0.83| 68       |
| Cancer incidence or mortality                | 23             | All indexes combined      | 0.83          | 0.80 to 0.86| 69       |
| T2D                                          | 6              | All indexes combined      | 0.82          | 0.77 to 0.86| 49       |
| Neurodegenerative disease                    | 6              | All indexes combined      | 0.79          | 0.68 to 0.91| 52       |
| All-cause mortality among cancer survivors   | 2              | All indexes combined      | 0.95          | 0.86 to 1.04| 34       |
| Cancer mortality among cancer survivors      | 2              | All indexes combined      | 0.91          | 0.82 to 1.01| 12       |

\textsuperscript{a}HEI = Healthy Eating Index.
\textsuperscript{b}AHEI = Alternate Healthy Eating Index.
\textsuperscript{c}DASH = Dietary Approaches to Stop Hypertension.
\textsuperscript{d}CVD = cardiovascular disease.
\textsuperscript{e}T2D = type 2 diabetes.
\textsuperscript{f}$I^2$ = inconsistency.

Table 6. Women: Pooled relative risk (with 95% CIs) for the association between the diet quality (assessed by the HEI,\textsuperscript{a} AHEI,\textsuperscript{b} or DASH\textsuperscript{c} score) and all-cause mortality, CVD\textsuperscript{d} incidence or mortality, cancer incidence or mortality, T2D,\textsuperscript{e} and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of studies | Index                     | Relative risk | 95% CI     | $I^2,\%$ |
|----------------------------------------------|----------------|---------------------------|---------------|------------|----------|
| All-cause mortality                          | 11             | All indexes combined      | 0.80          | 0.78 to 0.82| 54       |
| CVD incidence or mortality                   | 20             | All indexes combined      | 0.77          | 0.75 to 0.79| 32       |
| Cancer incidence or mortality                | 29             | All indexes combined      | 0.89          | 0.86 to 0.91| 55       |
| T2D                                          | 9              | All indexes combined      | 0.77          | 0.72 to 0.81| 70       |
| Neurodegenerative disease                    | 7              | All indexes combined      | 0.81          | 0.73 to 0.90| 59       |
| All-cause mortality among cancer survivors   | 9              | All indexes combined      | 0.79          | 0.73 to 0.85| 19       |
| Cancer mortality among cancer survivors      | 9              | All indexes combined      | 0.79          | 0.73 to 0.85| 0        |

\textsuperscript{a}HEI = Healthy Eating Index.
\textsuperscript{b}AHEI = Alternate Healthy Eating Index.
\textsuperscript{c}DASH = Dietary Approaches to Stop Hypertension.
\textsuperscript{d}CVD = cardiovascular disease.
\textsuperscript{e}T2D = type 2 diabetes.
\textsuperscript{f}$I^2$ = inconsistency.
### Table 7. US-based studies: Pooled relative risk (with 95% CIs) for the association between the diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of Studies | Index                     | Relative risk | 95% CI       | $I^2$ | % |
|----------------------------------------------|---------------|---------------------------|---------------|--------------|------|---|
| All-cause mortality                          | 15            | All indexes combined      | 0.80          | 0.78 to 0.82 | 74   |   |
| CVD incidence or mortality                   | 27            | All indexes combined      | 0.81          | 0.79 to 0.83 | 57   |   |
| Cancer incidence or mortality                | 35            | All indexes combined      | 0.87          | 0.84 to 0.89 | 76   |   |
| T2D                                          | 12            | All indexes combined      | 0.80          | 0.77 to 0.84 | 76   |   |
| Neurodegenerative disease                    | 4             | All indexes combined      | 0.90          | 0.80 to 1.01 | 47   |   |
| All-cause mortality among cancer survivors   | 11            | All indexes combined      | 0.83          | 0.78 to 0.89 | 47   |   |
| Cancer mortality among cancer survivors      | 11            | All indexes combined      | 0.82          | 0.75 to 0.91 | 47   |   |

aHEI = Healthy Eating Index.
bAHEI = Alternate Healthy Eating Index.
cDASH = Dietary Approaches to Stop Hypertension.
dCVD = cardiovascular disease.
eT2D = type 2 diabetes.

### Table 8. Studies with long-term follow-up (≥8 years): Pooled relative risk (with 95% CIs) for the association between the diet quality (assessed by HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of Studies | Index                     | Relative risk | 95% CI       | $I^2$ | % |
|----------------------------------------------|---------------|---------------------------|---------------|--------------|------|---|
| All-cause mortality                          | 22            | All indexes combined      | 0.80          | 0.79 to 0.82 | 69   |   |
| CVD incidence or mortality                   | 38            | All indexes combined      | 0.81          | 0.79 to 0.83 | 61   |   |
| Cancer incidence or mortality                | 40            | All indexes combined      | 0.87          | 0.85 to 0.89 | 75   |   |
| T2D                                          | 10            | All indexes combined      | 0.81          | 0.77 to 0.86 | 75   |   |
| Neurodegenerative disease                    | 7             | All indexes combined      | 0.83          | 0.75 to 0.91 | 73   |   |
| All-cause mortality among cancer survivors   | 6             | All indexes combined      | 0.74          | 0.66 to 0.82 | 0    |   |
| Cancer mortality among cancer survivors      | 6             | All indexes combined      | 0.71          | 0.59 to 0.84 | 27   |   |

aHEI = Healthy Eating Index.
bAHEI = Alternate Healthy Eating Index.
cDASH = Dietary Approaches to Stop Hypertension.
dCVD = cardiovascular disease.
eT2D = type 2 diabetes.

$I^2$ = inconsistency.
Table 9. High-quality studies (Newcastle-Ottawa Assessment Scale ≥8 points): Pooled relative risk (with 95% CIs) for the
association between the diet quality (HEI, AHEI, or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of studies | Index                  | Relative risk | 95% CI     | \(I^2\) |
|----------------------------------------------|---------------|------------------------|---------------|------------|---------|
| All-cause mortality                           | 16            | All indexes combined   | 0.80          | 0.79 to 0.82 | 64      |
| CVD incidence or mortality                    | 33            | All indexes combined   | 0.80          | 0.78 to 0.82 | 61      |
| Cancer incidence or mortality                 | 34            | All indexes combined   | 0.86          | 0.84 to 0.88 | 70      |
| T2D                                          | 9             | All indexes combined   | 0.82          | 0.78 to 0.86 | 82      |
| Neurodegenerative disease                    | 4             | All indexes combined   | 0.80          | 0.70 to 0.93 | 78      |
| All-cause mortality among cancer survivors    | 9             | All indexes combined   | 0.84          | 0.78 to 0.92 | 41      |
| Cancer mortality among cancer survivors       | 9             | All indexes combined   | 0.86          | 0.79 to 0.95 | 19      |

*HEI = Healthy Eating Index.
*AHEI = Alternate Healthy Eating Index.
*DASH = Dietary Approaches to Stop Hypertension.
*CVD = cardiovascular disease.
*T2D = type 2 diabetes.
\(I^2\) = inconsistency.

Table 10. Fixed-effects models: Pooled relative risk (with 95% CIs) for the association between the diet quality (assessed by the HEI, AHEI or DASH score) and all-cause mortality, CVD incidence or mortality, cancer incidence or mortality, T2D, and neurodegenerative disease, as well as all-cause mortality and cancer mortality among cancer survivors.

| Outcome                                      | No. of studies | Index                  | Relative risk | 95% CI     |
|----------------------------------------------|---------------|------------------------|---------------|------------|
| All-cause mortality                           | 23            | All indexes combined   | 0.80          | 0.79 to 0.80 |
| CVD incidence or mortality                    | 45            | All indexes combined   | 0.79          | 0.78 to 0.80 |
| Cancer incidence or mortality                 | 45            | All indexes combined   | 0.86          | 0.85 to 0.87 |
| T2D                                          | 16            | All indexes combined   | 0.81          | 0.80 to 0.83 |
| Neurodegenerative disease                    | 12            | All indexes combined   | 0.84          | 0.81 to 0.88 |
| All-cause mortality among cancer survivors    | 12            | All indexes combined   | 0.85          | 0.81 to 0.88 |
| Cancer mortality among cancer survivors       | 12            | All indexes combined   | 0.83          | 0.78 to 0.88 |

*HEI = Healthy Eating Index.
*AHEI = Alternate Healthy Eating Index.
*DASH = Dietary Approaches to Stop Hypertension.
*CVD = cardiovascular disease.
*T2D = type 2 diabetes.
**Figure 10.** Funnel plot showing study precision against the relative risk with 95% CIs for cardiovascular disease incidence and mortality. \(^a\)SE = standard error, \(^b\)HEI = Healthy Eating Index. \(^c\)AHEI = Alternate Healthy Eating Index. \(^d\)DASH = Dietary Approaches to Stop Hypertension. \(^e\)P for Egger’s regression test.

**Figure 11.** Funnel plot showing study precision against the relative risk with 95% CIs for cancer incidence and mortality. \(^a\)SE = standard error, \(^b\)HEI = Healthy Eating Index. \(^c\)AHEI = Alternate Healthy Eating Index. \(^d\)DASH = Dietary Approaches to Stop Hypertension. \(^e\)P for Egger’s regression test.
Figure 12. Funnel plot showing study precision against the relative risk with 95% CIs for type 2 diabetes. aSE = standard error. bHEI = Healthy Eating Index. cAHEI = Alternate Healthy Eating Index. dDASH = Dietary Approaches to Stop Hypertension. eP for Egger’s regression test.

Figure 13. Funnel plot showing study precision against the relative risk with 95% CIs for neurodegenerative diseases. aSE = standard error. bHEI = Healthy Eating Index. cAHEI = Alternate Healthy Eating Index. dDASH = Dietary Approaches to Stop Hypertension. eP for Egger’s regression test.
**Figure 14.** Funnel plot showing study precision against the relative risk with 95% CIs for all-cause mortality. \(^a\)SE = standard error. \(^b\)HEI = Healthy Eating Index. \(^c\)AHEI = Alternate Healthy Eating Index. \(^d\)DASH = Dietary Approaches to Stop Hypertension. \(^e\)P for Egger’s regression test.

**Figure 15.** Funnel plot showing study precision against the relative risk with 95% CIs for all-cause mortality among cancer survivors. \(^a\)SE = standard error. \(^b\)HEI = Healthy Eating Index. \(^c\)AHEI = Alternate Healthy Eating Index. \(^d\)DASH = Dietary Approaches to Stop Hypertension. \(^e\)P for Egger’s regression test.
Figure 16. Funnel plot showing study precision against the relative risk with 95% CIs for cancer mortality among cancer survivors. \(^a\)SE = standard error. \(^b\)HEI = Healthy Eating Index. \(^c\)AHEI = Alternate Healthy Eating Index. \(^d\)DASH = Dietary Approaches to Stop Hypertension. \(^e\)P for Egger’s regression test.