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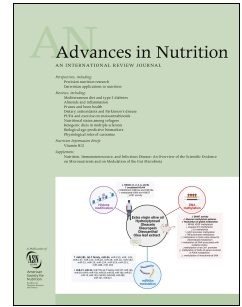
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Plant-based diets and cognitive outcomes: a systematic review and meta-analysis

Catherine Bigras, Riccardo Mazzoli, Danielle Laurin, Marcella Malavolti, Giulia Barbolini, Marco Vinceti, Jean-Philippe Drouin-Chartier, Tommaso Filippini



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27 **Abstract**

28 **Introduction:** While plant-rich dietary patterns like the Mediterranean and MIND diets have
29 been linked to cognitive benefits, the role of predominantly plant-based diets is less understood.
30 This systematic review aimed to evaluate the association between plant-based diets and
31 cognitive outcomes.

32 **Methods:** A literature search was conducted in Medline and Embase using keywords related to
33 plant-based diets (e.g. “vegetarian diet”) and cognitive outcomes (e.g. “dementia”). Studies of
34 any design were eligible. Reviewers independently screened studies, extracted data, and
35 assessed quality using the Newcastle-Ottawa Scale. Meta-analyses were conducted on
36 prospective studies that examined the same dietary exposure and cognitive outcome, using
37 fixed-effects regression models.

38 **Results:** Twenty-two studies were included, with considerable variability in methodologies and
39 outcomes. Plant-based diets were defined either categorically (e.g., vegetarian vs. non-
40 vegetarian), or using indices of adherence, such as the healthful plant-based diet index (hPDI),
41 with higher scores reflecting higher adherence. Two meta-analyses, each based on two high-
42 quality prospective cohort studies, examined associations between plant-based diet indices and
43 cognitive outcomes. For cognitive impairment, pooled ORs (95% CI) for highest vs. lowest
44 quartiles were 0.61 (0.55, 0.68; $I^2=97.1%$) for PDI and 0.68 (0.62, 0.75; $I^2=84.3%$) for hPDI.
45 For dementia, pooled HRs were 1.03 (0.91, 1.17; $I^2=0%$) for PDI, 0.85 (0.75, 0.97; $I^2=0%$) for
46 hPDI, and 1.17 (1.03, 1.33; $I^2=60.3%$) for unhealthful PDI (uPDI).

47 **Conclusions:** These findings suggest that dietary patterns emphasizing healthful plant-based
48 foods and limiting less healthful plant foods and animal products are associated with lower odds
49 of cognitive impairment and risk of dementia. However, findings across individual studies were
50 inconsistent, highlighting the need for further high-quality research.

51 This review was registered on PROSPERO (registration no. CRD42022380055).

52 **Keywords:** cognitive decline; cognitive impairment, dementia; vegetarian diet; plant-based
53 diet.

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54 **Statement of significance**

55 This systematic-review and meta-analysis suggests that dietary patterns emphasizing healthful
56 plant-based foods and limiting less healthful plant foods and animal products are associated
57 with lower odds of cognitive impairment and risk of dementia. However, findings across
58 individual studies were inconsistent, highlighting the need for further high-quality research.

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59 **Introduction**

60 Dementia is a neurocognitive disorder that represents the advanced stage of a disease process
61 that began 10 to 20 years before clinical manifestations (1). Along the continuum, subtle
62 cognitive changes can be detected using validated screening tools (2, 3), neuropsychological
63 test batteries (4) or medical examination. Cognitive impairment is an umbrella term referring
64 to any unspecified impairment in cognitive function, whereas mild cognitive impairment (MCI)
65 is a clinically defined condition in which deficits exceed those of normal ageing but do not yet
66 disrupt daily functioning (5). With dementia now ranking as the 7th leading cause of death
67 worldwide (6), its rising prevalence underscores the need for effective prevention strategies
68 given the long latency period of the disease (7, 8).

69 Diet is increasingly recognized as a modifiable lifestyle factor that may play a role in
70 cognitive ageing. The Mediterranean, DASH (Dietary Approaches to Stop Hypertension) and
71 MIND (Mediterranean-DASH Intervention for Neurodegenerative Delay) diets are among the
72 most studied dietary patterns in relation to cognitive health. All have been associated with
73 slower rates of cognitive decline and a lower risk of dementia, supported by observational
74 studies (9-13) and, in the case of the Mediterranean diet, interventional studies (14, 15). These
75 diets emphasize the consumption of plant-based foods, such as fruits, vegetables, whole grains,
76 legumes, nuts, and olive oil, while incorporating moderate amounts of animal products,
77 particularly fish, and limiting red meat and saturated fat (16). Despite being largely plant-
78 forward, these dietary patterns are not primarily defined as plant-based. In contrast,
79 predominantly plant-based diets, which include limited to no animal-derived foods, are less
80 well studied in relation to cognitive outcomes (17).

81 Studying the impact of strict vegetarian or vegan diets on long-term health may be
82 challenging in populations where the prevalence of these diets is low. The plant-based diet
83 indices created by Satija et al. (18), offer a convenient way of studying the impact of increasing

84 levels of adherence to a plant-based diet that can be applied to any population. The overall
85 plant-based index (PDI) is derived by assigning positive scores to plant-foods and reverse
86 scores to animal foods. A healthful and unhealthful version of the PDI can be obtained by
87 assigning positive scores to healthy plant foods and negative scores to unhealthy plant foods
88 (hPDI) and conversely by assigning positive scores to unhealthy plant foods and negative scores
89 to healthy plant foods (uPDI). The PDI indices have been studied in the context of various
90 health outcomes (19-22), but their association with the cognitive function is not yet understood.

91 Previous systematic reviews on plant-based diets and cognition have been limited in
92 scope, with one identifying no eligible studies related to cognitive function (23), and another
93 including only two studies on the topic (24). Both reviews predate the emerging use of the PDI
94 indices. We therefore conducted a systematic review and meta-analysis to address these gaps
95 by providing a comprehensive up-to-date evaluation of the evidence on the relationship
96 between plant-based diets and cognitive outcomes namely cognitive performance, cognitive
97 decline, MCI, non-specified cognitive impairment, or dementia.

98 **Methods**

99 This systematic review and meta-analysis was conducted in accordance with the Preferred
100 Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (25). The
101 protocol was *a priori* registered on the international systematic review registry (PROSPERO
102 registration no. CRD42022380055).

103 *Eligibility criteria*

104 Due to the scarcity of existing systematic reviews on the topic of plant-based diets and cognitive
105 function, we employed relatively broad selection criteria to capture as much relevant studies as
106 possible. The current review included studies based on the following PECOS criteria:

107 Population (P): adults in any geographic location;

108 Exposure (E): adherence to a vegetarian, vegan or plant-based diet;

109 Comparator (C): compared to non-vegetarian diets or lower levels of adherence;

110 Outcome (O): cognitive outcomes (i.e., cognitive performance, cognitive decline, mild
111 cognitive impairment, or a non-specified cognitive impairment, dementia). These were defined
112 as follows:

113 - Cognitive performance: cognitive functioning measured using standardized tests such
114 as the MMSE, MoCA, or other cognitive test batteries.

115 - Cognitive decline: a measurable change in cognitive performance over time.

116 - Mild cognitive impairment (MCI): based on study-reported clinical diagnosis.

117 - Non-specified cognitive impairment: study-defined cognitive dysfunction identified
118 through cognitive testing but not formally classified as MCI or dementia.

119 - Dementia: clinical diagnosis according to standard criteria or medical records;

120 Study design (S): observational cohort, cross-sectional and case control studies, interventional
121 studies, were all considered for inclusion.

122 The detailed PECOS criteria are presented in **Supplementary Table S1**.

123 Although dietary patterns such as the Mediterranean, DASH and MIND diets are often
124 considered plant-based, we excluded studies focusing on these patterns, as our focus was
125 specifically on diets that emphasize plant-based/vegetarian/vegan eating as a primary
126 characteristic. Studies that assessed the exposure according to *a posteriori* dietary patterns
127 derived from factor analysis were also excluded, as these patterns are arbitrarily labeled and
128 often lack consistency across studies, making them difficult to compare meaningfully. We also
129 did not include studies that involved plant-based diet interventions as part of multi-domain
130 interventions. We excluded studies that assessed subjective cognitive complaints or mortality
131 due to dementia. Studies that did not report effect estimates were also excluded.

132 Studies derived from the same cohorts were included. Although these studies used
133 overlapping participant samples, they reported varying results due to differences in participant
134 selection criteria, dietary pattern classification methods, and adjustment factors. To maintain
135 transparency and capture the full range of findings, each study was included in the qualitative
136 synthesis with clear identification of the cohort source.

137 *Literature search and study selection*

138 We performed a literature search in Embase and MEDLINE from inception up to March 23rd,
139 2025, using keywords related to a plant-based diet and cognitive outcomes, e.g., ((vegetarian
140 or vegan OR plant-based, etc.) AND (cognitive function OR cognitive decline OR dementia,
141 etc.)). The detailed search strategy used for each database can be found in **Supplementary**
142 **Table S2**. No time limitation, language restrictions, or any other filters were set. An additional
143 manual search was conducted by screening the references of the articles found. Titles and
144 abstracts were independently screened for eligibility by two authors and validated by a third
145 author. Disagreements were solved with the help of other reviewers.

146 *Data extraction*

147 Data extraction was performed by two authors, with independent validation by a third author.
148 The following data were extracted and organized into summary tables: name of author, year of
149 publication, study design, location, sample size, age and biological sex of participants, follow-
150 up if applicable, method to assess plant-based diet exposure, method to assess cognitive
151 outcome, measures of association (beta-coefficients, Hazard Ratios (HRs), Odds Ratios (ORs),
152 Relative Risks (RRs) with their 95% confidence intervals (CI) or standard error (SE)), and
153 adjustment factors. In case of missing information, the corresponding author of the paper was
154 contacted for clarification.

155 *Quality assessment*

156 Study quality was assessed using the Newcastle-Ottawa Scale (NOS) (26) by two independent
157 authors, with disagreements resolved by consensus following review by three other authors.
158 The NOS includes evaluation of selection, comparability (including control for confounding),
159 and outcome assessment. We adapted the scale for cross-sectional studies by attributing a score
160 of zero to the three questions that were not applicable (outcome not present at baseline, follow-
161 up duration, and follow-up rate), thereby accounting for the inherent biases associated with this
162 study design. Studies could receive a maximum of 9 points: scores of ≥ 7 to 9 were considered
163 as “good”, 4 to 6 as “fair” and ≤ 3 as “poor”. The detailed description of the criteria used to
164 score the included studies is presented in **Supplementary Table S3**.

165 *Data analysis*

166 We conducted the meta-analyses in accordance with the Cochrane Handbook, using R software
167 (version 4.4.2) and the “meta” package (27). Only prospective studies were included. Meta-
168 analyses were performed when at least two studies included evaluated the same dietary
169 exposure to the same cognitive outcome. When multiple studies were based on the same cohort,
170 we included only one in the main meta-analysis—selecting the study with the largest sample
171 size, most comparable outcomes, and similar categorization of PDI scores (e.g., into quartiles

172 or tertiles)—to respect the principle of independence between studies. When possible, sensitivity
173 analyses were conducted by replacing the selected study with each of the other studies from the
174 same cohort in separate meta-analyses. We used effect estimates obtained from fully adjusted
175 models, as reported by the original studies.

176 When meta-analysis was feasible, forest plots were used to display the pooled risk
177 estimates for cognitive outcomes, comparing the highest versus lowest quantiles of adherence
178 to a plant-based diet. When possible, we also conducted sensitivity meta-analyses using
179 continuous estimates (e.g., risk per 10-point increment in hPDI). Given the limited number of
180 studies in each analysis, we used fixed-effects models. Standard random-effects models
181 perform poorly with few studies, as the between-study variance cannot be reliably estimated
182 (28). The difference between studies was evaluated with the I^2 statistic. Given the small number
183 of studies, I^2 was used as an exploratory tool rather than a definitive indicator of heterogeneity.
184 Assessment of publication bias was not possible due to the small number of studies, which
185 limits the reliability of standard tests.

186 **Results**

187 *Study selection*

188 A total of 2,819 records were identified through database searches. One article was found
189 outside the formal search strategy during the review process and included based on eligibility.
190 After removal of duplicates, 2,520 records were screened, of which 22 met the inclusion criteria
191 and were selected for further analysis. Detailed information on the selection process is presented
192 in **Figure 1**.

193 *Study characteristics*

194 Descriptive characteristics of the studies included are presented in **Tables 1** and **2**. With one
195 exception (29), all studies were published in the past 6 years. Of the 22 included studies, a total
196 of 17 unique cohorts were represented in the review, as some studies were based on overlapping
197 cohort data. All studies were observational: 15 were prospective cohort studies (29-43) (from
198 10 unique cohorts), 6 were cross-sectional (44-49) and one included both prospective and cross-
199 sectional analyses (50). No interventional studies were identified. Among the prospective
200 cohort studies, age at baseline ranged from 53.3 to 83.8 years and follow-up ranged from 2 to
201 19.7 years. Most cohorts were from Asian countries (n = 9) followed by Europe (n = 4), and
202 North America (n = 4). Dietary assessment varied among the studies, ranging from simple
203 questionnaires (e.g. unspecified lifestyle questionnaires with few questions on diet) to 24h diet
204 recalls or food frequency questionnaires (FFQ). Classification of plant-based diet exposure also
205 differed, with 7 studies comparing a vegetarian diet to a non-vegetarian diet in a dichotomous
206 fashion (29-32, 44-46), while 15 calculated increasing levels of plant-based diet adherence
207 using indices such as the PDI, hPDI and uPDI (from 10 unique cohorts) (33-43, 47-50). The
208 outcomes analyzed included incidence of dementia (n = 7), prevalence of MCI or a non-
209 specified cognitive impairment (n = 12), and cognitive decline (n = 3). Cognitive impairment
210 was assessed with the Mini Mental State Exam (MMSE) in 6 studies (3 unique cohorts), and

211 MCI with the Montreal Cognitive Assessment (MoCA) in 2 studies, whereas 4 studies relied
212 on neuropsychological tests to assess cognitive impairment or decline. **Table 3** presents the
213 count of studies for each exposure-to-outcome combination.

214 Among the prospective cohort studies, 10 received good quality ratings and 6 were rated
215 fair. The 6 cross-sectional studies received fair scores apart from one that was rated as poor
216 (**Table 4**).

217 *Summary of study findings*

218 Overall, findings related to the association between plant-based diets and cognitive outcomes
219 were inconsistent, with some studies reporting protective associations, while others found no
220 evidence of association or even harmful associations (Table 1).

221 *Strict vegetarian diets and cognitive outcomes*

222 The association between strict vegetarian diets and cognitive outcomes was examined in 4
223 prospective cohort studies (29-32) and 3 cross-sectional studies (44-46) (Table 1). The study
224 populations varied widely, and the results were inconsistent across study designs and outcomes.

225 Among the 4 prospective studies, one reported a beneficial association (32), 2 reported no
226 association (29, 30) and one suggested a detrimental association (31). Similarly, among the 3
227 cross-sectional studies, one reported a beneficial association (44), one found no association
228 (45), and one suggested a detrimental association (46). All prospective and cross-sectional
229 studies received low to fair quality ratings. It was not possible to conduct a meta-analysis
230 because of the variability in the study populations, exposures and cognitive outcomes.

231 *Adherence to a plant-based dietary pattern and cognitive outcomes*

232 A total of 12 prospective cohort studies (33-43, 50) and 3 cross-sectional studies (47-49)
233 examined the association between adherence to a plant-based dietary pattern and cognitive
234 outcomes (Table 2). Among the 12 prospective cohort studies, adherence to a plant-based diet
235 was assessed using the plant-based diet indices (PDI, hPDI, uPDI) in 7 unique cohorts. One

236 study used the provegetarian diet score (PVD) (38), which is similar to the PDI. Three cohort
237 studies with follow-up duration ranging from 2 to 10 years measured cognitive change over
238 time and reported no evidence of association (33, 38, 50), except for Liu et al. (33) who reported
239 an inverse association between higher hPDI adherence and cognitive decline among African
240 American participants but not white participants. Five studies, all conducted within two Asian
241 cohorts with 10 and 19.7 years of follow-up, measured the association between the plant-based
242 diet indices and cognitive impairment and suggested a beneficial association for highest
243 adherence to the PDI and hPDI (34-36, 39, 40). Risk of dementia was assessed in 4 studies
244 conducted within two European cohorts (37, 41-43), with mixed results. While no association
245 was found between the plant-based diet indices and risk of dementia in the Rotterdam Study
246 (37), results were mixed among the 3 studies based on UK Biobank cohort, with 2 studies
247 reporting no significant association between the plant-based diet indices and risk of dementia
248 (41, 43), and one reporting a beneficial association for hPDI and a detrimental association for
249 uPDI (42). Ten out of the 12 prospective cohort studies received good quality ratings and 2
250 were rated fair.

251 Among the 3 cross-sectional studies that measured the association between the plant-
252 based diet indices and MCI, beneficial results were reported for the hPDI in one of the two
253 studies that measured it (49), while detrimental results were found for the uPDI in the two
254 studies that measured it (47, 48). The 3 cross-sectional studies received low to fair quality
255 ratings.

256 *Meta-analyses results*

257 Prospective studies with similar dietary exposures and outcomes were selected for meta-
258 analysis. For duplicate cohorts, only one study was included in the main meta-analysis. Reasons
259 for selecting and excluding duplicate cohorts for the meta-analyses are presented in
260 **Supplementary Table S4.**

261 *Adherence to a plant-based diet and odds of cognitive impairment*

262 The meta-analysis comparing the association between highest vs. lowest adherence to the PDI
263 and hPDI and the odds of cognitive impairment included two Asian cohorts (36, 39) and totaled
264 23,084 participants (**Figure 2**). Both studies received good quality ratings. The pooled ORs
265 (95% confidence interval (CI)) for highest vs lowest quartiles were 0.61 (0.55, 0.68; $I^2=97.1\%$)
266 for PDI and 0.68 (0.62, 0.75; $I^2 = 84.3\%$) for hPDI. The uPDI was not calculated in one of the
267 studies and could not therefore be included in the meta-analysis.

268 *Adherence to a plant-based diet and risk of dementia*

269 The meta-analysis comparing the association between highest vs. lowest adherence to the PDI,
270 hPDI and uPDI and the risk of dementia included two European cohorts (37, 42) and totaled
271 190,075 participants (**Figure 3**). Both studies were rated as good quality. The pooled HRs (95%
272 CI) for highest vs lowest quintile were 1.03 (0.91, 1.17; $I^2 = 0\%$) for PDI, 0.85 (0.75, 0.97; $I^2 =$
273 0%) for hPDI, and 1.17 (1.03, 1.33; $I^2 = 60.3\%$) for uPDI. A sensitivity analysis using the plant-
274 based dietary indices continuously (per 10-point increment) rather than categorically yielded
275 similar results (**Supplementary Figure S1**). Another sensitivity analysis was conducted by
276 replacing the UK Biobank sample with an alternative study sample based on the same cohort
277 (43). In this study, participants were divided into tertiles of adherence rather than quintiles, and
278 the HRs from the meta-analysis were no longer significant (**Supplementary Figure S2**).

279 Discussion

280 This systematic review of 22 prospective and cross-sectional studies suggests a favorable
281 association between adherence to plant-based diets and cognitive outcomes. While variability
282 in study populations, follow-up duration, dietary assessments and outcomes may explain some
283 inconsistencies, in the two meta-analyses each including two good quality prospective cohort
284 studies on the association between adherence to a plant-based diet and cognitive outcomes,
285 pooled results revealed that when compared to the lowest levels of adherence, highest hPDI
286 adherence was associated with a modestly lower risk of both cognitive impairment and
287 dementia. The results were mixed when adherence to a plant-based diet was considered without
288 accounting for the quality of the plant foods (i.e., when the exposure was the PDI). Higher
289 adherence to the PDI was associated with a lower risk of cognitive impairment, but no
290 association was observed for dementia. On the other hand, highest uPDI adherence was
291 associated with a higher risk of dementia. While these results are based on a limited number of
292 studies, they provide initial evidence that a dietary pattern emphasizing healthy plant-based
293 foods while limiting the consumption of unhealthy plant foods and animal is associated with a
294 reduced risk of cognitive impairment and dementia.

295 The present study is an important addition to the body of meta-evidence on plant-based
296 diets and cognitive outcomes. A 2021 systematic review and meta-analysis by Iguacel et al.
297 (24) included only two studies on vegetarian diets and cognitive outcomes. The meta-analysis
298 combined unadjusted data from two studies with different populations and outcomes and did
299 not yield any significant effect. In contrast, our review includes a larger number of studies and
300 provides initial estimates regarding the PDI indices based on large, good quality cohort studies
301 with extended follow-up periods.

302 The present review found inconsistent results across 7 prospective and cross-sectional
303 studies examining the association between strict vegetarian and vegan diets and cognitive

304 outcomes. While some studies reported beneficial effects, others found no association or even
305 suggested potential detrimental effects. However, all studies were given low or fair quality
306 ratings and variability in study populations and methods likely contributed to the inconsistency
307 in findings. One important limitation of a dichotomous classification of individuals as
308 vegetarians or non-vegetarians is that it may not accurately reflect the complexity of dietary
309 patterns. Vegetarian diets can vary widely in their inclusion of animal-derived foods, and do
310 not necessarily reflect the healthfulness or overall quality of the dietary pattern, which could
311 partly explain some of the inconsistent findings observed in this review.

312 The PDI scores provide a more comprehensive graded assessment of adherence to plant-
313 based diets. Notably, findings on their association with cognitive outcomes were generally more
314 consistent across studies employing similar measures, particularly among the 12 prospective
315 studies. The meta-analyses included good quality cohort studies and provided evidence for a
316 beneficial association between increasing levels of adherence to a plant-based diet and cognitive
317 outcomes. The hPDI, which emphasizes the consumption of healthy plant-based foods, was
318 associated with a lower risk of both dementia and cognitive impairment. Conversely, the uPDI,
319 which reflects a diet rich in unhealthy plant foods such as added sugars and refined grains, was
320 associated with a higher risk of dementia. High uPDI scores could reflect high intakes of ultra-
321 processed foods, which has been linked to adverse cognitive outcomes in previous research (51,
322 52). Although the meta-analyses revealed promising results, they should be considered in light
323 of the characteristics of the included studies. In the meta-analysis on the association between
324 PDI/hPDI/uPDI scores and the risk of dementia, both studies were conducted in European
325 countries in populations of relatively similar ages (64.1y; 57y) and follow-up duration (14.5y;
326 10y), using detailed dietary assessments. I^2 values were low for PDI and hPDI, and higher for
327 uPDI. However, given the inclusion of only two studies, the I^2 statistic may not reliably estimate
328 between-study variability and should be considered as an exploratory indicator of heterogeneity

329 (53). Conversely, in the meta-analysis on the association between PDI/hPDI and cognitive
330 impairment, while both studies were from Asian countries, the participants from Zhu et al. (36)
331 were of advanced age at baseline (mean: 80y) compared to the participants from Wu et al. (39)
332 (mean: 53.5y). The use of a brief 16-item FFQ in Zhu et al. (36) combined with differences in
333 participant age, may explain the considerable between-study variability reflected in the I^2
334 statistic for PDI and hPDI that could limit the interpretation of the odds ratio estimate for
335 cognitive impairment. Nonetheless, the direction of the estimates was consistent across all
336 meta-analyses, supporting the beneficial association of hPDI and detrimental association of
337 uPDI with cognitive outcomes.

338 The results of the present systematic review fit in the larger body of literature supporting
339 the cognitive health benefits of plant-rich dietary patterns such as the Mediterranean, DASH,
340 and MIND diets (9, 11, 13). Despite shared characteristics, the effectiveness of the hPDI relative
341 to these other dietary patterns is unclear. A large-scale study using data from the Nurses' Health
342 Study and the Health Professionals Follow-Up Study comparing eight different dietary patterns
343 and their association with healthy aging found that, while the hPDI was significantly associated
344 with increased odds of reaching the age of 70 years old without impairments in cognitive,
345 physical and mental health, it was the least strongly associated when compared to other dietary
346 patterns (54). Other dietary patterns that included small amounts of animal foods, such as the
347 Planetary Health Diet Index (PHDI), were more strongly associated with maintaining subjective
348 intact cognitive health than the hPDI. Some studies included in the present review also
349 compared the PDI and hPDI with different dietary patterns and their association with cognitive
350 outcomes. Using data from the UK Biobank, Shang et al. (41) compared the association
351 between the aMED, AHEI-2010, hPDI and AEDII dietary patterns and chronic diseases, and
352 found that the aMED and AHEI-2010—but not the hPDI and AEDII—were significantly
353 associated with a reduced risk of dementia. Wu et al. (39) used data from the Singapore Chinese

354 Health Study and prospectively assessed the association between 5 dietary patterns and the odds
355 of cognitive impairment. While all dietary patterns were significantly associated with a reduced
356 risk, the PDI, followed by the hPDI were the least strongly associated. These findings suggest
357 that the hPDI may be less effective in reducing the risk of cognitive impairment and dementia
358 compared to other healthy dietary patterns. Current literature on the association between animal
359 food groups and brain health is mixed. While red meat appears to be associated with negative
360 outcomes(55), dairy products may have protective effects (56), and fish has been more
361 consistently linked to cognitive benefits (57, 58). The hPDI might therefore not fully reflect an
362 ideal dietary pattern for cognitive health and could explain some of the null associations
363 observed in this review. For example, van Soest et al. (50) found that a higher hPDI was
364 associated with slower rates of cognitive decline only in individuals who consumed more than
365 0.93 servings of fish per week. More research is needed to understand the effectiveness of the
366 hPDI relative to other dietary patterns in the context of cognitive health.

367 Although the meta-analyses suggested beneficial associations, varying results were
368 observed among other individual studies, sometimes across different subgroups. For example,
369 in a prospective cohort study, Liu et al. (33) reported a significant inverse association between
370 higher hPDI adherence and cognitive decline among African American participants but not
371 white participants. Although De Crom et al. (37) reported no association between the PDI scores
372 and dementia in the overall prospective cohort, significant inverse associations between higher
373 hPDI scores and dementia were observed in subgroup analyses among men and APOE e4
374 carriers. While it was not possible to conduct subgroup analyses in this review, these findings
375 suggest that plant-based diets may be more beneficial in some subgroups than others and should
376 be explored further in future studies.

377 Study methodology may also account for some of the inconsistent findings. Dietary
378 assessment methods ranged from brief, unvalidated questionnaires to comprehensive FFQs with

379 hundreds of items. Simpler tools may lack the sensitivity to capture dietary patterns accurately,
380 while detailed FFQs, though more informative, still rely on self-report dietary and are subject
381 to recall bias, particularly in older populations. This can potentially attenuate or distort the
382 association between diet and cognitive outcomes. Additionally, assessment of cognitive
383 function varied widely, ranging from brief but validated screening tests to detailed
384 neuropsychological test batteries, clinical evaluations or medical records. These measures
385 capture different stages along the continuum and differ in their validity and reliability. In
386 particular, screening tools such as the MoCA and MMSE are not diagnostic measures and may
387 lead to misclassification (59). These methodological issues limit outcome comparability and
388 may potentially explain the inconsistent findings across studies. Additionally, as is common in
389 longitudinal studies of aging populations, selection bias is possible, particularly due to self-
390 selection or exclusion of more vulnerable individuals in older cohorts. This could explain
391 some of the inconsistent findings in this review.

392 Strengths of this systematic review include its comprehensive scope and detailed search
393 strategy. Although the meta-analyses were limited by the small number of eligible studies, the
394 included studies were of good quality and featured large sample sizes, which supports the
395 overall robustness of the findings. However, there are several limitations that should be
396 acknowledged. The restricted number of studies combined with the substantial variability in
397 dietary assessment methods and cognitive outcomes made quantitative synthesis challenging.
398 It was not possible to assess publication bias, and assessment of heterogeneity was limited and
399 unreliable due to the small number of studies included. Additionally, the meta-analyses relied
400 on a fixed effects model, which does not account for potential between-study variability and
401 may constrain the generalizability of the findings. Moreover, all included studies were
402 observational, which further limits the conclusions that can be drawn on the causal nature of
403 the relationship between plant-based diets and cognitive health.

404 To the best of our knowledge, this is the first comprehensive systematic review and
405 meta-analysis on the relationship between plant-based diets and cognitive outcomes, which
406 included both strict vegetarian diets as well as assessment of graded adherence to plant-based
407 diets. Specifically, it is the first to include the recently developed plant-based diet indices and
408 offer initial estimates. While current evidence is still limited, nearly all included studies were
409 published in the past 6 years, suggesting that literature on this topic will likely continue to
410 expand. This systematic review and meta-analysis provides a baseline for future investigations
411 in this emerging research area.

412 **Conclusion**

413 While overall evidence was inconsistent, meta-analyses based on a subset of high-quality cohort
414 studies suggest that a dietary pattern emphasizing healthy plant-based foods while limiting the
415 consumption of unhealthy plant foods and animal foods is associated with a modestly lower
416 risk of dementia and cognitive impairment. However, these results should be interpreted with
417 caution, as they are based on a limited number of studies. Current evidence remains limited due
418 to methodological variability across studies. More well-designed large-scale prospective
419 studies with long follow-up durations are needed to clarify the relationship between plant-based
420 diets and cognitive ageing.

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423

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References

1. Sperling RA, Aisen PS, Beckett LA, Bennett DA, Craft S, Fagan AM et al. Toward defining the preclinical stages of Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimers Dement*. 2011 May;7(3):280-92.
2. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I et al. The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For Mild Cognitive Impairment. *Journal of the American Geriatrics Society*. 2005;53(4):695-9.
3. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. *Journal of psychiatric research*. 1975;12(3):189-98.
4. Jacova C, Kertesz A, Blair M, Fisk JD, Feldman HH. Neuropsychological testing and assessment for dementia. *Alzheimer's & Dementia*. 2007 2007/10/01/;3(4):299-317.
5. Petersen RC, Caracciolo B, Brayne C, Gauthier S, Jelic V, Fratiglioni L. Mild cognitive impairment: a concept in evolution. *Journal of Internal Medicine*. 2014;275(3):214-28.
6. World Health Organization. Global status report on the public health response to dementia. 2021.
7. Nichols E, Steinmetz JD, Vollset SE, Fukutaki K, Chalek J, Abd-Allah F et al. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *The Lancet Public Health*. 2022;7(2):e105-e25.
8. Livingston G, Huntley J, Liu KY, Costafreda SG, Selbæk G, Alladi S et al. Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. *The Lancet*. 2024;404(10452):572-628.
9. Fu J, Tan L-J, Lee JE, Shin S. Association between the mediterranean diet and cognitive health among healthy adults: A systematic review and meta-analysis. *Frontiers in Nutrition*. 2022 2022-July-28;Volume 9 - 2022.
10. Morris MC, Tangney CC, Wang Y, Sacks FM, Barnes LL, Bennett DA et al. MIND diet slows cognitive decline with aging. *Alzheimer's & Dementia*. 2015 2015/09/01/;11(9):1015-22.
11. van Soest APM, Beers S, van de Rest O, de Groot LC. The Mediterranean-Dietary Approaches to Stop Hypertension Intervention for Neurodegenerative Delay (MIND) Diet for the Aging Brain: A Systematic Review. *Advances in Nutrition*. 2024 2024/03/01/;15(3):100184.
12. van den Brink AC, Brouwer-Brolsma EM, Berendsen AAM, van de Rest O. The Mediterranean, Dietary Approaches to Stop Hypertension (DASH), and Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND) Diets Are Associated with Less Cognitive Decline and a Lower Risk of Alzheimer's Disease—A Review. *Advances in Nutrition*. 2019 2019/11/01/;10(6):1040-65.
13. Chen X, Maguire B, Brodaty H, O'Leary F. Dietary Patterns and Cognitive Health in Older Adults: A Systematic Review. *Journal of Alzheimer's Disease*. 2019;67(2):583-619.
14. Valls-Pedret C, Sala-Vila A, Serra-Mir M, Corella D, de la Torre R, Martínez-González MÁ et al. Mediterranean Diet and Age-Related Cognitive Decline: A Randomized Clinical Trial. *JAMA Internal Medicine*. 2015;175(7):1094-103.
15. Martínez-Lapiscina EH, Clavero P, Toledo E, Estruch R, Salas-Salvadó J, San Julián B et al. Mediterranean diet improves cognition: the PREDIMED-NAVARRA randomised trial. *Journal of Neurology, Neurosurgery & Psychiatry*. 2013;84(12):1318.

16. Scarmeas N, Anastasiou CA, Yannakoulia M. Nutrition and prevention of cognitive impairment. *The Lancet Neurology*. 2018;17(11):1006-15.
17. Wang T, Masedunskas A, Willett WC, Fontana L. Vegetarian and vegan diets: benefits and drawbacks. *European Heart Journal*. 2023;44(36):3423-39.
18. Satija A, Bhupathiraju SN, Rimm EB, Spiegelman D, Chiuve SE, Borgi L et al. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLOS Medicine*. 2016;13(6):e1002039.
19. Satija A, Bhupathiraju Shilpa N, Spiegelman D, Chiuve Stephanie E, Manson JoAnn E, Willett W et al. Healthful and Unhealthful Plant-Based Diets and the Risk of Coronary Heart Disease in U.S. Adults. *JACC*. 2017 2017/07/25;70(4):411-22.
20. Chen Z, Drouin-Chartier J-P, Li Y, Baden MY, Manson JE, Willett WC et al. Changes in Plant-Based Diet Indices and Subsequent Risk of Type 2 Diabetes in Women and Men: Three U.S. Prospective Cohorts. *Diabetes Care*. 2021;44(3):663-71.
21. Li H, Zeng X, Wang Y, Zhang Z, Zhu Y, Li X et al. A prospective study of healthful and unhealthful plant-based diet and risk of overall and cause-specific mortality. *European Journal of Nutrition*. 2022 2022/02/01;61(1):387-98.
22. Thompson AS, Tresserra-Rimbau A, Karavasiloglou N, Jennings A, Cantwell M, Hill C et al. Association of Healthful Plant-based Diet Adherence With Risk of Mortality and Major Chronic Diseases Among Adults in the UK. *JAMA Network Open*. 2023;6(3):e234714-e.
23. Medawar E, Huhn S, Villringer A, Veronica Witte A. The effects of plant-based diets on the body and the brain: a systematic review. *Translational Psychiatry*. 2019 2019/09/12;9(1):226.
24. Iguacel I, Huybrechts I, Moreno LA, Michels N. Vegetarianism and veganism compared with mental health and cognitive outcomes: a systematic review and meta-analysis. *Nutrition Reviews*. 2020;79(4):361-81.
25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
26. Wells GA, Shea B, O'Connell D, Peterson J, Welch V, Losos M et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. 2000.
27. Balduzzi S, Rücker G, Schwarzer G. How to perform a meta-analysis with R: a practical tutorial. *BMJ Mental Health*. 2019;22(4):null.
28. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods*. 2010;1(2):97-111.
29. Giem P, Beeson WL, Fraser GE. The Incidence of Dementia and Intake of Animal Products: Preliminary Findings from the Adventist Health Study. *Neuroepidemiology*. 1993;12(1):28-36.
30. Gatto NM, Garcia-Cano J, Irani C, Jaceldo-Siegl K, Liu T, Chen Z et al. Vegetarian Dietary Patterns and Cognitive Function among Older Adults: The Adventist Health Study-2. *J Nutr Gerontol Geriatr*. 2021 2021;40(4):197-214.
31. Fan S-M, Chiu P-Y, Liu C-H, Liao Y-C, Chang H-T. Predictive value of hypercholesterolemia, vegetarian diet, and hypertension for incident dementia among elderly Taiwanese individuals with low educational levels. *Ther Adv Chronic Dis*. 2023 2023;14.
32. Tsai J-H, Huang C-F, Lin M-N, Chang C-E, Chang C-C, Lin C-L. Taiwanese Vegetarians Are Associated with Lower Dementia Risk: A Prospective Cohort Study. *Nutrients*. 2022 2022;14(3).

33. Liu X, Dhana K, Barnes LL, Tangney CC, Agarwal P, Aggarwal N et al. A healthy plant-based diet was associated with slower cognitive decline in African American older adults: a biracial community-based cohort. *Am J Clin Nutr.* 2022 2022;116(4):875-86.
34. Chen Y, Cao Y, Fang W, Sannoh M, Zhang H, Ni R et al. Leisure activity engagement attenuates the risks of cognitive impairment induced by unhealthy plant-based diets: a nationwide cohort study. *Eur J Clin Nutr.* 2025 2025;79(1):15-23.
35. Liang F, Fu J, Turner-McGrievy G, Wang Y, Qiu N, Ding K et al. Association of Body Mass Index and Plant-Based Diet with Cognitive Impairment among Older Chinese Adults: A Prospective, Nationwide Cohort Study. *Nutrients.* 2022 2022;14(15).
36. Zhu A, Yuan C, Pretty J, Ji JS. Plant-based dietary patterns and cognitive function: A prospective cohort analysis of elderly individuals in China (2008–2018). *Brain Behav.* 2022 2022;12(8).
37. de Crom TOE, Steur M, Ikram MK, Ikram MA, Voortman T. Plant-based dietary patterns and the risk of dementia: a population-based study. *Age Ageing.* 2023 2023;52(9).
38. Munoz-Garcia Mariana I, Toledo E, Razquin C, Dominguez Ligia J, Maragarone D, Martinez-Gonzalez J et al. “A priori” Dietary Patterns and Cognitive Function in the SUN Project. *Neuroepidemiology.* 2019;54(1):45-57.
39. Wu J, Song X, Chen G-C, Neelakantan N, Van Dam RM, Feng L et al. Dietary pattern in midlife and cognitive impairment in late life: A prospective study in Chinese adults. *Am J Clin Nutr.* 2019 2019;110(4):912-20.
40. Zhou Y-F, Song X-Y, Wu J, Chen G-C, Neelakantan N, van Dam RM et al. Association Between Dietary Patterns in Midlife and Healthy Ageing in Chinese Adults: The Singapore Chinese Health Study. *J Am Med Dir Assoc.* 2021 2021;22(6):1279-86.
41. Shang X, Liu J, Zhu Z, Zhang X, Huang Y, Liu S et al. Healthy dietary patterns and the risk of individual chronic diseases in community-dwelling adults. *Nat Commun.* 2023 2023;14(1).
42. Wu H, Gu Y, Meng G, Wu H, Zhang S, Wang X et al. Quality of plant-based diet and the risk of dementia and depression among middle-aged and older population. *Age Ageing.* 2023 2023;52(5).
43. Zhang J, Cao X, Li X, Li X, Hao M, Xia Y et al. Associations of Midlife Dietary Patterns with Incident Dementia and Brain Structure: Findings from the UK Biobank Study. *Am J Clin Nutr.* 2023 2023;118(1):218-27.
44. Singh DR, Parajuli P, Hug J, Nath D, Koirala R, Mandal R. Dementia symptoms among senior citizens living in geriatric homes of kathmandu valley. *Kathmandu Univ Med J.* 2021 2021;19(74):195-9.
45. Gazbare P, Palekar DTJ. Identifying mild cognitive impairment and its predictors among normal middle adulthood in Pune, Maharashtra: A community-based cross-sectional survey. *Clin Epidemiol Global Health.* 2024 2024;25.
46. Kaur M, Kaur M. Cognitive performance of women at various stages of reproductive aging and associated risk factors. *Climacteric.* 2022 2022;25(3):278-85.
47. He M, Su D, Zhang R, Xu P, Han D, Huang L et al. Sex Disparity in the Nutrition-Related Determinants of Mild Cognitive Impairment: A Case–Control Study. *Nutrients.* 2025 2025;17(2).
48. Peng J, Li X, Wang J, Li F, Gao J, Deng Y et al. Association between plant-based dietary patterns and cognitive function in middle-aged and older residents of China. *Journal of Alzheimer's Disease.* 2025;103(1):282-92.
49. Gong Y, Chen H, Gu Y, Shen J, Shen T, Ding Y et al. Healthy dietary patterns in relation to cognitive performance and Alzheimer's disease mortality. *J Prev Alzheimers Dis.* 2025 2025:100100.

50. van Soest APM, van de Rest O, Witkamp RF, van der Velde N, de Groot LCPGM. The association between adherence to a plant-based diet and cognitive ageing. *European Journal of Nutrition*. 2023 2023/08/01;62(5):2053-62.
51. Henney AE, Gillespie CS, Alam U, Hydes TJ, Mackay CE, Cuthbertson DJ. High intake of ultra-processed food is associated with dementia in adults: a systematic review and meta-analysis of observational studies. *Journal of Neurology*. 2024 2024/01/01;271(1):198-210.
52. Gomes Gonçalves N, Vidal Ferreira N, Khandpur N, Martinez Steele E, Bertazzi Levy R, Andrade Lotufo P et al. Association Between Consumption of Ultraprocessed Foods and Cognitive Decline. *JAMA Neurology*. 2023;80(2):142-50.
53. von Hippel PT. The heterogeneity statistic I2 can be biased in small meta-analyses. *BMC Medical Research Methodology*. 2015 2015/04/14;15(1):35.
54. Tessier A-J, Wang F, Korat AA, Eliassen AH, Chavarro J, Grodstein F et al. Optimal dietary patterns for healthy aging. *Nature Medicine*. 2025 2025/03/24.
55. Li Y, Li Y, Gu X, Liu Y, Dong D, Kang JH et al. Long-Term Intake of Red Meat in Relation to Dementia Risk and Cognitive Function in US Adults. *Neurology*. 2025;104(3):e210286.
56. Viloz F, Filippini T, Ortega N, Kopp-Heim D, Voortman T, Blum MR et al. Dairy Intake and Risk of Cognitive Decline and Dementia: A Systematic Review and Dose-Response Meta-Analysis of Prospective Studies. *Advances in Nutrition*. 2024 2024/01/01;15(1):100160.
57. Samieri C, Morris M-C, Bennett DA, Berr C, Amouyel P, Dartigues J-F et al. Fish Intake, Genetic Predisposition to Alzheimer Disease, and Decline in Global Cognition and Memory in 5 Cohorts of Older Persons. *American Journal of Epidemiology*. 2017;187(5):933-40.
58. Zhang Y, Chen J, Qiu J, Li Y, Wang J, Jiao J. Intakes of fish and polyunsaturated fatty acids and mild-to-severe cognitive impairment risks: a dose-response meta-analysis of 21 cohort studies. *The American Journal of Clinical Nutrition*. 2016 2016/02/01;103(2):330-40.
59. Devenney E, Hodges JR. The Mini-Mental State Examination: pitfalls and limitations. *Practical Neurology*. 2017;17(1):79-80.

Table 1. Characteristics of included studies that evaluated the association between strict vegetarian diets and cognitive outcomes (n=7).

Cohort/study/ population (Country)	Author (year)	Design	Sample size (n)	Age at baseline ¹ (y)	Follow- up	Dietary assessment method	Exposure	Cognitive outcome	Adjusted for	Results
Adventist Health Study-1 (USA)	Giem et al. (1993)	Prospective - unmatched substudy	2984	> 65	Study duration: 5y	Lifestyle questionnaire including questions on past and current dietary habits	Meat > 4x/week vs. vegetarian diet (no meat in 30 years) (ref.)	Probable dementia from hospital records	Age, sex, education	RR (95% CI) = 0.86 (0.25, 2.94).
		Prospective - matched substudy	272	> 65	Study duration: 5y	Lifestyle questionnaire including questions on past and current dietary habits	Meat > 4x/week vs.vegan and lacto-ovo- vegetarian diet (ref.)	Probable dementia from hospital records	Age, sex, education	RR = 2.18, p = 0.065.
Adventist Health Study-2 (US + Canada)	Gatto et al. (2021)	Prospective	132 (57.6% F)	75.1 ± 8.1 ²	Study duration: 10y	>200-item quantitative FFQ	Vegetarian (vegan, lacto- ovo, pesco) vs. non-vegetarian diet (reference)	Mild memory impairment (MMI) based on comprehensive neuropsychological battery.	Age, education, ApoE genotype	OR (95% CI) = 1.46 (0.51, 4.21).
Community- based sample among adults living in Pune (India)	Gazbare & Palekar (2024)	Cross- sectional	605 (46.78% F)	49.21 ± 6.53	N/A	Lifestyle questionnaire (3 questions on diet- past 6mo)	Vegetarian (only vegetables) vs. non-vegetarian diet (ref.)	MCI (based on ACE- III).	Age, gender, education, marital status, family type, BMI, sleep duration, stress, physical activity, lifestyle	OR (95% CI) = 0.84 (0.52, 1.32).
HAICDDS Project (Taiwan)	Fan et al. (2023)	Prospective	1285 (53% F)	72.4	2.58y (mean)	Interview or review of medical chart to assess lifestyle factors including whether participants followed a vegetarian diet	Vegetarian vs. non vegetarian diet (ref.)	Dementia (based on NIA-AA criteria and consensus meetings)	Age, gender, education, vascular risk factors (hypertension, diabetes, coronary artery disease, hypercholesterolemia, myocardial infarction), drugs (anti- hypertensives, anti- diabetics, anti-lipid agents), and lifestyle factors (smoking, alcohol).	HR (95% CI) = 1.68 (1.03, 2.75)
Senior citizens in Kathmandu valley (Nepal)	Singh et al. (2021)	Cross- sectional	304 (75.3% F)	≥ 60	N/A	Interview, no details on dietary assessment method	Non-vegetarian vs. lifetime vegetarian diet (ref.)	Dementia symptoms (based on 6-CIT).	Age, gender, education, past occupation, geriatric allowance, history of alcohol consumption, physical activity.	OR (95% CI) = 2.31 (1.12, 4.76)
Tzu Chi Vegetarian Study (Taiwan)	Tsai et al. (2022)	Prospective	4891 (73.5% F- veg group; 57.4% F- non veg- group)	58 ± 6.5 (veg group) 57.8 ± 6.3 (non-veg group)	9.2y (mean)	Questionnaire, no details on dietary assessment method	Vegetarian (no meat, fish or poultry for ≥1y) vs. non- vegetarian diet (ref.)	Dementia or mild cognitive impairment (based on ICD codes from death register data and medical claims records)	Age, sex, education, marital status, physical activity, smoking, alcohol, baseline medical comorbidities.	HR (95% CI) = 0.671 (0.452, 0.996).

Women living in rural areas of Punjab (India)	Kaur & Kaur (2022)	Cross-sectional	404 (100% F)	50.78 ± 8.1	N/A	Interview-based questionnaire, no details on dietary assessment method	Vegetarian vs. non-vegetarian diet (ref.)	Cognitive impairment (based on MMSE).	Study conducted among women only. Adjusted for age, education, age at menarche, marital status, physical activity, number of children, menopausal status.	OR (95% CI) = 1.77 (1.02, 3.08) .
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Abbreviations: FFQ: Food frequency questionnaire, PDI, hPDI and uPDI: overall, healthful and unhealthful plant-based diet indices, APOE ε 4: ε4 allele of the Apolipoprotein E gene, HR: Hazard ratio, OR: Odds ratio: RR: Relative risk, BMI: Body mass index, RAVLT: Rey Auditory Verbal Learning Test, SDMT: Symbol Digit Modalities Test, CERAD: Consortium to Establish a Registry for Alzheimer's Disease, AFT: Animal Fluency Test, DSST: Digit Symbol Substitution Test, MMSE: Mini-Mental State Evaluation, MoCA: Montreal Cognitive Assessment, AA: African American, STICS-m: Spanish version of the modified Telephone Interview for Cognitive Status, 6-CIT: Six-item Cognitive Impairment Test, MCI: Mild cognitive impairment, MMI: Mild Memory Impairment, GRS: Genetic risk score, TDI: Townsend deprivation index. ACE-III: Addenbrooke's cognitive examination III.

¹Data presented as mean (mean ± SD) unless otherwise specified.

²Age at cognitive testing.

Table 2. Characteristics of included studies that evaluated the association between plant-based diet adherence and cognitive outcomes (n=15).

Cohort/study/ population (Country)	Author (year)	Design	Sample size (n)	Age at baseline ¹ (y)	Follow- up	Dietary assessment method	Exposure	Cognitive outcome	Adjusted for	Results
B-vitamins for the Prevention of Osteoporotic Fractures (B-proof) trial (Netherlands)	van Soest et al. (2023)	Cross-sectional	658 (41% F)	72.1 ± 5.4	N/A	190-item FFQ	PDI, hPDI, uPDI	<u>Primary outcome:</u> Global cognitive function (Z-scores), assessed using cognitive test battery (RAVLT, Digit Span task, Trail making test, Stroop test, SDMT, Letter fluency tests). <u>Secondary outcome:</u> Domain-specific cognitive function (Z-scores) (episodic memory, attention & working memory, information processing speed, executive functioning).	Age, gender, education, BMI, physical activity, smoking, alcohol, margarine consumption.	βs (95% CI) per 10-point increment: <u>Global cognitive function:</u> PDI: 0.04 (-0.02, 0.10); hPDI: -0.02 (-0.08, 0.03); uPDI: -0.02 (-0.06, 0.05). <u>Episodic memory</u> PDI: 0.07 (-0.01, 0.16); hPDI: 0.00 (-0.08, 0.07); uPDI: 0.03 (-0.05, 0.11). <u>Attention & working memory:</u> PDI: -0.02 (-0.12, 0.08); hPDI: -0.06 (-0.15, 0.03); uPDI: 0.01 (-0.09, 0.10). <u>Information processing speed</u> PDI: 0.04 (-0.05, 0.13); hPDI: -0.03 (-0.11, 0.06); uPDI: 0.00 (-0.09, 0.09). <u>Executive functioning</u> PDI: 0.06 (-0.02, 0.15); hPDI: 0.01 (-0.07, 0.08); uPDI: -0.03 (-0.12, 0.05).
Prospective	314		72.1 ± 5.4 ²	Study duration: 2y	190-item FFQ	PDI, hPDI, uPDI	<u>Primary outcome:</u> Change in global cognitive function (Z-scores), assessed using cognitive test battery (RAVLT, Digit Span task, Trail making test, Stroop test, SDMT, Letter fluency tests). <u>Secondary outcome:</u> Change in Z-scores of domain-specific cognitive function (episodic memory, attention & working memory, information processing speed, executive functioning).	Age, gender, education, BMI, physical activity, smoking, alcohol, margarine consumption, baseline cognition score.	βs (95% CI) per 10-point increment: <u>Change in global cognitive function:</u> PDI : -0.03 (-0.08, 0.02); hPDI : 0.03 (-0.01, 0.08); uPDI : -0.05 (-0.09, 0.00). <u>Change in episodic memory</u> PDI : -0.06 (-0.17, 0.05); hPDI : 0.00 (-0.10, 0.10); uPDI : -0.04 (-0.14, -0.06). <u>Change in attention & working memory:</u> PDI : 0.04 (-0.08, 0.16); hPDI : 0.14 (0.03, 0.25); uPDI : -0.16 (-0.27, -0.05). <u>Change in information processing speed:</u> PDI : -0.07 (-0.16, 0.01); hPDI : 0.01 (-0.07, 0.09); uPDI : -0.07 (-0.16, 0.01).	

										<u>Change in executive functioning:</u> PDI : -0.03 (-0.06, 0.11); hPDI : -0.01 (-0.09, 0.07); uPDI : 0.03 (-0.05, 0.12).
Chicago Health and Aging Study (USA)	Liu et al. (2022)	Prospective	3337 (64% F)	73.7 ± 5.7	Study duration: 10y	144-item semi-quantitative FFQ	PDI, hPDI, uPDI	<u>Primary outcome:</u> Cognitive decline (annual rate of decline in global cognition: composite score of immediate and delayed recall of East Boston Story (2 tests of episodic memory), SDMT (perceptual speed), and MMSE). <u>Secondary outcomes:</u> Rate of decline in perceptual speed and episodic memory.	Results stratified by race: “White and African American”. Adjusted for age, sex, apoE e4 allele, education, calories, cognitive activities, smoking status, comorbidities (history of hypertension, diabetes, myocardial infarction, stroke), time, and their respective interactions with time.	β s ± SE, Q5 vs Q1: <i>African American participants:</i> <u>Global cognition</u> PDI: 0.0072 ± 0.0073, p = 0.51 hPDI: 0.0183 ± 0.0086, p = 0.04 uPDI: -0.0137 ± 0.0086, p=0.21 <u>Perceptual speed</u> PDI: 0.0113 ± 0.0075, p = 0.10 hPDI: 0.0179 ± 0.0088, p = 0.03 uPDI: -0.0083 ± 0.0088, p = 0.48 <u>Episodic memory</u> PDI: 0.0072 ± 0.0073, p = 0.51 hPDI: 0.0163 ± 0.0118, p = 0.04 uPDI: -0.0137 ± 0.0086, p = 0.21 <i>White participants:</i> <u>Global cognition</u> PDI: 0.0010 ± 0.0095, p = 0.24 hPDI: -0.0047 ± 0.0098, p = 0.65 uPDI: -0.0091 ± 0.0096, p = 0.44 <u>Perceptual speed</u> PDI: 0.0054 ± 0.0113, p = 0.80 hPDI: 0.0049 ± 0.0117, p = 0.67 uPDI: 0.0056 ± 0.0114, p = 0.66 <u>Episodic memory</u> PDI: 0.0010 ± 0.0095, p = 0.24 hPDI: -0.0047 ± 0.0098, p = 0.66 uPDI: -0.0091 ± 0.0096, p = 0.44
Chinese Longitudinal Healthy Longevity Survey (China)	Chen et al. (2025)	Prospective	10 617 (50.7% F)	83.8 ± 10.8	4.9y (mean)	15-item non-quantitative FFQ	uPDI	Cognitive impairment (based on MMSE)	Age, sex, education, married status, living pattern, exercise, smoking, drinking, household income, and BMI.	HRs (95% CI): Per 1-unit increment: 1.02 (1.01, 1.03) T3 vs. T1 : 1.38 (1.18, 1.62) .
	Liang et al. (2022)	Prospective	4792 (49.4% F)	80.7 ± 9.58	24156 person-years (~5.04y /person)	16-item non-quantitative FFQ	PDI, hPDI, uPDI	Cognitive impairment (based on MMSE).	Sex, age, residence, education, occupation, smoking, alcohol consumption, physical activity, financial independence, health conditions.	HRs (95% CI): PDI < vs. > median: 1.32 (1.16, 1.50); hPDI < vs. > median: 1.46 (1.29, 1.66); uPDI > vs. < median: 1.21(1.06–1.38).

	Zhu et al. (2022)	Prospective	6136 (46.33% F)	80 ± 9.83	Study duration: 10y	16-item non-quantitative FFQ	PDI, hPDI, uPDI	Cognitive impairment (based on MMSE).	Age, sex, marital status, urban/rural residence, education, occupation before age 60, financial status, social and leisure activity, smoking and drinking status, physical activity, geographic regions, BMI, vitamin A/C/E intake, hypertension, diabetes, heart disease, cerebrovascular disease, and dyslipidemia.	ORs (95% CI), Q4 vs. Q1: PDI: 0.45 (0.39, 0.52); hPDI: 0.61 (0.54, 0.70); uPDI: 2.03 (1.79, 2.31).
Community-based Cohort Study on Nervous System Diseases (China)	He et al. (2025)	Cross-sectional	1086 (52.7 % F)	≥ 55	N/A	81-item FFQ	PDI, hPDI, uPDI	MCI based on MoCA.	Results stratified by sex. For women: Marital status, cereal and depression. For men: Age, vegetable intake, vegetable oil intake and cereal.	OR (95% CI) for MCI among women: uPDI: 1.06 (1.02, 1.09). Men: NS, no result shown.
Middle-aged and elderly participants from Xiangyang city (China)	Peng et al. (2025)	Cross-sectional	937 (66.9% F)	62.2 ± 9.2	N/A	Simplified FFQ	PDI, hPDI, uPDI	MCI based on MoCA test.	Age, sex, education, average annual income, marital status, alcohol intake, smoking status, physical activity, BMI, heart disease, cerebrovascular disease, diabetes, hyperlipidemia, hypertension.	ORs (95% CI) for MCI, Q4 vs. Q1 : PDI: 0.82 (0.50, 1.35); hPDI: 0.80 (0.49, 1.30); uPDI: 2.21 (1.35, 3.60). ORs (95% CI) for MCI, per 10-point increase : PDI: 0.91 (0.66, 1.26); hPDI: 0.93 (0.66, 1.31); uPDI: 1.50 (1.15, 1.96).
National Health and Nutrition Examination Survey (NHANES-2011-14) (USA)	Gong et al. (2025)	Cross-sectional	2713 (51.4% F) ³	59.8 ± 12.6	N/A	24h recalls (≥ 1)	hPDI	Psychometric MCI (p-MCI) based on a neuropsychological test battery (CERAD World Learning Test, AFT, and DSST).	Age, sex, total energy intake, race, education, poverty-income ratio, smoking status, metabolic equivalent score, BMI, hypertension, diabetes and cardiovascular diseases.	ORs (95% CI) for p-MCI : T3 vs. T1 : 0.73 (0.54, 0.98). Per SD increment: 0.89 (0.78, 01.00).
Rotterdam Study (RS) (Netherlands)	de Crom et al. (2023)	Prospective	9543 (58% F)	64.1 ± 8.6	14.5y (mean)	170-item FFQ (sub-cohorts RS-I and RS-11) and 389-item FFQ (sub-cohort RS-III)	PDI, hPDI, uPDI	Dementia (final diagnosis established by consensus panel according to DSM-III-R and NINCDS-ADRDA criteria).	Sub-cohort, age, sex, energy intake, education, alcohol, miscellaneous food intake, smoking, physical activity, APOE ε4 status, BMI, diabetes, total cholesterol, high-density lipoprotein cholesterol, use of lipid lowering medication, systolic blood pressure, diastolic blood pressure, and use of blood-pressure lowering medication	HR (95% CI) for dementia, per 10-point increase: PDI: 0.99 (0.91, 1.08); hPDI: 0.93 (0.75, 1.01); uPDI: 1.02 (0.94, 1.10). HR (95% CI) for dementia, Q5 vs. Q1 : PDI: 1.04 (0.87, 1.24); hPDI: 0.89 (0.74, 1.06); uPDI: 1.05 (0.87, 1.26).
Seguimiento Universidad de	Munoz-Garcia et	Prospective	806 (30.3% F)	61 ± 6	6y (mean)	136-item semi-	Pro-vegetarian	Cognitive decline: mean 6-y change in STICS-m	Age at baseline STICS, sex, follow-up time until baseline STICS-m,	β (95% CI) for 6-year change in STICS-m score per 6-point increase in PVD score = 0.19 (-0.03, 0.40).

Navarra (SUN) cohort (Spain)	al. (2020)					quantitative FFQ	diet (PVD) score	score (telephone adaptation of MMSE).	education, and APOE 4, smoking, package-years, total energy intake, physical activity, BMI, alcohol intake, depression, hypertension, high cholesterol, low HDL cholesterol, cardiovascular disease, type 2 diabetes.	
Singapore Chinese Health Study (Singapore)	Wu et al. (2019)	Prospective	16948 (59.2% F)	53.5 ± 6.2	19.7y (mean)	165-item semi-quantitative FFQ	PDI, hPDI	Cognitive impairment (based on MMSE).	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, alcohol consumption, baseline history of hypertension, diabetes, cardiovascular disease, and cancer.	ORs (95% CI) for cognitive impairment, Q4 vs. Q1: PDI: 0.82 (0.71, 0.94); hDPI: 0.78 (0.68, 0.90). ORs (95% CI) for cognitive impairment, per SD increment: PDI: 0.93 (0.88, 0.97); hDPI: 0.92 (0.88, 0.97).
	Zhou et al. (2021)	Prospective	14159 (59% F)	53.3 ± 6.1	~20y	165-item semi-quantitative FFQ	PDI, hPDI	No cognitive impairment (based on MMSE).	Age at baseline, year of baseline interview, sex, dialect group, marital status, education, smoking status, physical activity, sleep duration, BMI, alcohol, and total energy intake.	ORs (95% CI) for no cognitive impairment, Q4 vs. Q1: PDI: 1.15 (0.99, 1.33); hDPI: 1.23 (1.06, 1.43). ORs (95%CI) for no cognitive impairment, per SD increment: PDI: 1.06 (1.00, 1.12); hDPI: 1.07 (1.02, 1.13).
UK Biobank (UK)	Shang et al. (2023)	Prospective	115093 (55.9% F)	59.0 ± 7.9	8.4-8.6y (range)	24h recalls (≥ 2)	hPDI	Dementia (based on ICD codes from hospital records and death register data).	Age, sex, and total energy intake, ethnicity, education, income, BMI, smoking, sleep, physical activity, and GRS for longevity.	HR (95% CI) for dementia, per quintile increment = 0.97 (0.92, 1.02).
	Wu et al. (2023)	Prospective	180532 (55% F)	Q3: 57 (median)	10y (median)	24h recalls (≥ 1)	PDI, hPDI and uPDI	Dementia (based on ICD codes from hospital records and death register data).	Age, sex, BMI, ethnicity, smoking status, alcohol, education, visiting friends, living alone, physical activity, total energy intake, medication history (use of antihypertensive, lipid-lowering and hypoglycaemic medication), TDI, family history disease (dementia and depression), hypertension and diabetes.	HRs (95% CI) for dementia, per 10-point increase: PDI: 0.99 (0.90, 1.11); hPDI: 0.87 (0.79, 0.96); uPDI: 1.18 (1.07, 1.29). HRs (95% CI) for dementia, Q5 vs. Q1 : PDI: 1.03 (0.87, 1.23); hPDI: 0.82 (0.68, 0.98); uPDI: 1.29 (1.08, 1.53).
	Zhang et al. (2023)	Prospective	114684 (55.5% F)	56.8 ± 7.77	1077621 person-years (9.4y /person)	24h recalls (≥ 2)	PDI, hPDI, uPDI	Dementia (based on ICD codes from hospital records and death register data).	Age, sex, education, TDI, BMI, smoking status, alcohol consumption, regular physical activity, sleep duration, time on watching TV, family	HR (95% CI) for dementia, T3 vs. T1 : PDI : 1.12 (0.90, 1.41). hPDI : 0.97 (0.77, 1.22). uPDI : 1.03 (0.82, 1.29).

history of Alzheimer's disease, apolipoprotein E genotypes, cancer, cardiovascular disease, diabetes.

Abbreviations: FFQ: Food frequency questionnaire, PDI, hPDI and uPDI: overall, healthful and unhealthful plant-based diet indices, APOE ϵ 4: ϵ 4 allele of the Apolipoprotein E gene, HR: Hazard ratio, OR: Odds ratio, RR: Relative risk, BMI: Body mass index, RAVLT: Rey Auditory Verbal Learning Test, SDMT: Symbol Digit Modalities Test, CERAD: Consortium to Establish a Registry for Alzheimer's Disease, AFT: Animal Fluency Test, DSST: Digit Symbol Substitution Test, MMSE: Mini-Mental State Evaluation, MoCA: Montreal Cognitive Assessment, AA: African American, STICS-m: Spanish version of the modified Telephone Interview for Cognitive Status, 6-CIT: Six-item Cognitive Impairment Test, MCI: Mild cognitive impairment, MMI: Mild Memory Impairment, GRS: Genetic risk score, TDI: Townsend deprivation index. ACE-III: Addenbrooke's cognitive examination III.

¹Data presented as mean (mean \pm SD) unless otherwise specified.

²Age at baseline of total sample.

³Percent women of entire cohort.

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Table 3. Number of included studies for each exposure to outcome combination.

Exposure	Outcomes		
	Cognitive performance or decline	Cognitive impairment/MCI	Dementia
Vegetarian diet vs. non-vegetarian diet	0	4 (MMSE: n=1; ACE-III: n=1; 6-CIT: n=1; Neuropsychological tests: n=1)	3 (Consensus panel, NIA-AA criteria: n =1; hospital records: n=1; ICD codes from death register and medical claims data: n=1)
Plant-based diet indices (PDI, hPDI, uPDI, PVD)	3 (STICS-m: n=1; Neuropsychological tests: n=2)	8 (MMSE: n=5; MOCA: n=2; Neuropsychological tests: n=1)	4 (Consensus panel, DSM-III-R and NINCDS-ADRDA criteria: n=1; ICD codes from hospital records and death register data: n=3)

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Table 4. Assessment of study quality using the Newcastle-Ottawa Scale.

Study	Selection				Comparability	Outcome			Total score
	Representative -ness of the exposed cohort	Selection of the non- exposed cohort	Ascertainment of exposure	Outcome not present at start of study	Comparability of cohorts	Assessment of outcome	Length of follow-up	Adequacy of follow-up cohorts	
Giem et al. (1993) ^a	0	1	0	1	2	0	0	0	4
Giem et al. (1993) ^b	0	0	0	1	2	0	0	0	3
Gatto et al. (2021)	0	1	1	0	1	1	1	0	5
Gazbare & Palekar (2024)	1	1	0	0	2	1	0 ¹	0 ¹	5
Fan et al. (2023)	0	1	0	1	2	1	0	1	6
Singh et al. (2021)	0	1	0	0 ¹	2	1	0 ¹	0 ¹	4
Tsai et al. (2022)	0	1	0	1	2	1	0	1	6
Kaur & Kaur (2022)	0	1	0	0 ¹	2	1	0 ¹	0 ¹	4
van Soest et al. (2023) ^c	0	1	1	1	2	1	0	0	6
van Soest et al. (2023) ^d	0	1	1	0 ¹	2	1	0 ¹	0 ¹	5
Liu et al. (2022)	1	1	1	0	2	1	1	1	8
Chen et al. (2025)	1	1	1	1	2	1	0	1	8
Liang et al. (2022)	1	1	1	1	2	1	1	0	8
Zhu et al. (2022)	1	1	1	1	2	1	1	1	9
He et al. (2025)	1	1	0	0 ¹	0	1	0 ¹	0 ¹	3
Peng et al. (2025)	0	1	0	0 ¹	2	1	0 ¹	0 ¹	4
Gong et al.(2025)	1	1	1	0 ¹	2	1	0 ¹	0 ¹	6
De Crom et al. (2023)	1	1	1	1	2	1	1	1	9
Munoz-Garcia et al. (2020)	0	1	1	1	2	1	0	0	6
Wu et al. (2019)	1	1	1	0	2	1	1	1	8
Zhou et al. (2021)	1	1	1	0	2	1	1	1	8
Shang et al. (2023)	1	1	1	1	2	1	0	1	8
Wu et al. (2023)	1	1	1	1	2	1	0	1	8
Zhang et al. (2023)	1	1	1	1	2	1	0	1	8

^aunmatched substudy^bmatched substudy^clongitudinal analysis

^dcross-sectional analysis

^lQuestions not applicable to cross-sectional studies

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Figure 1. Flowchart of systematic literature search for studies that met the study inclusion and exclusion criteria.

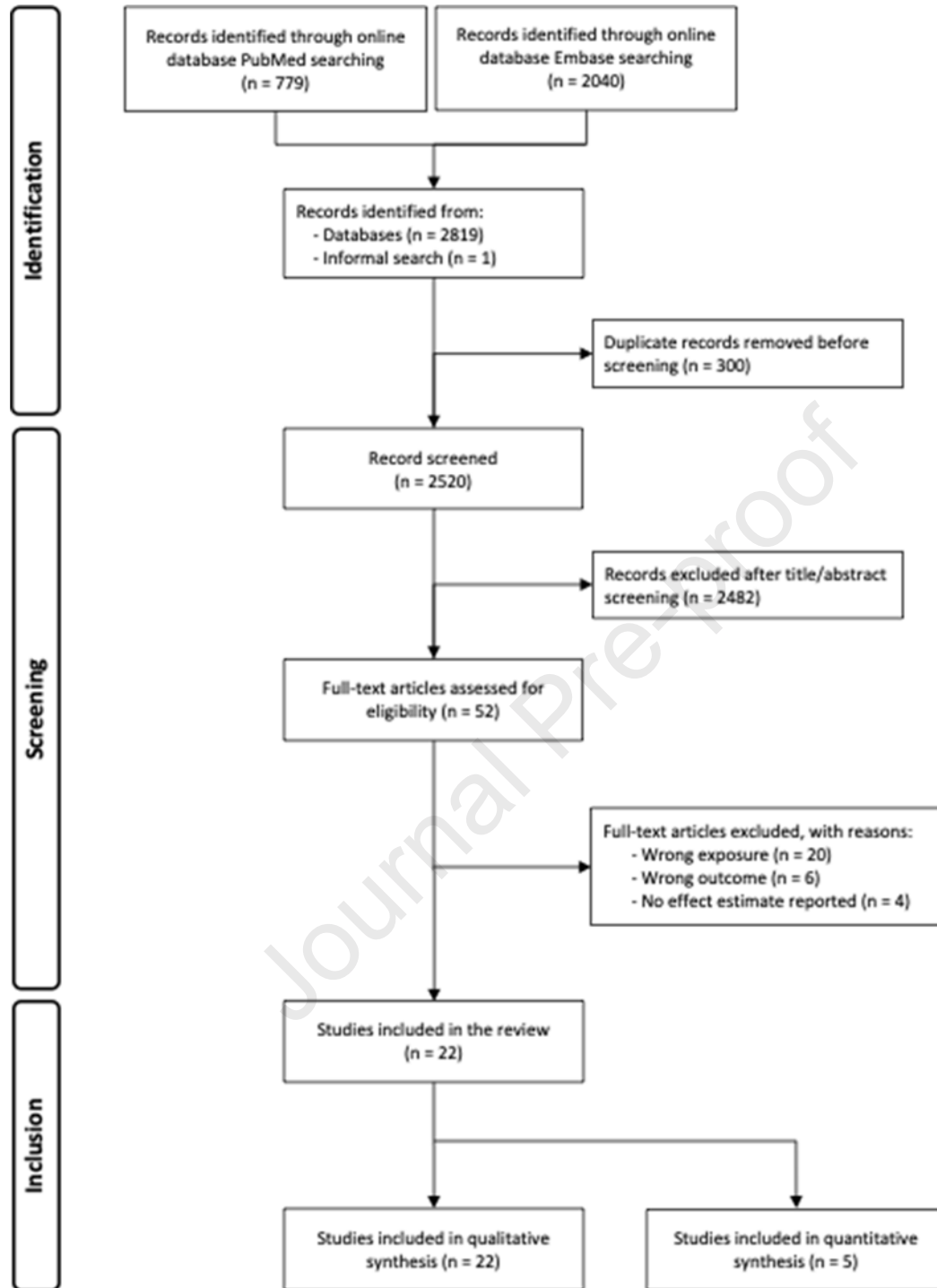
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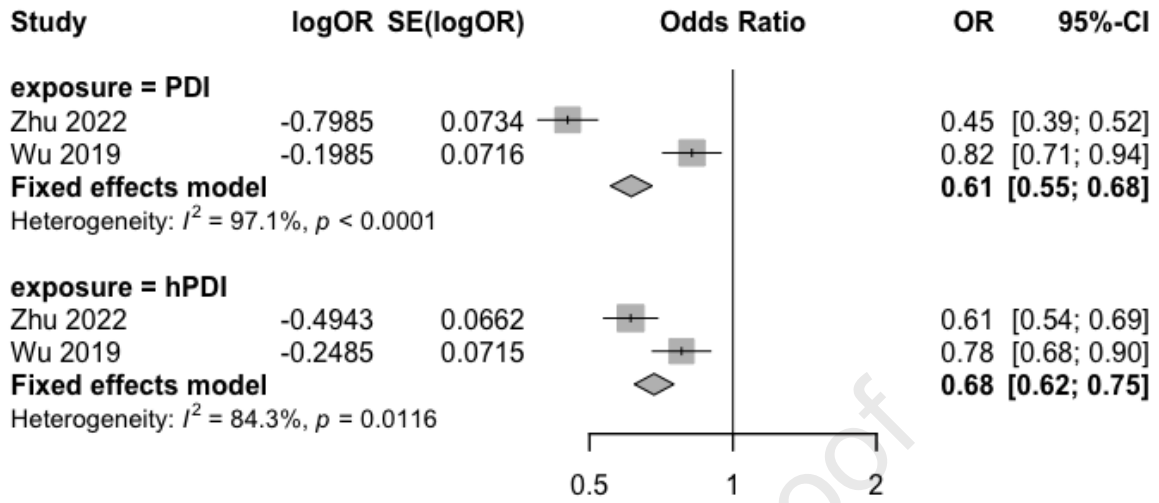
Figure 2: Association of each plant-based diet index (PDI) with odds of cognitive impairment, for high (quartile 4) compared with low (quartile 1) adherence to each plant-based diet pattern. Weights of each estimate are represented by the size of the square. The black lines represent the individual estimate effects (vertical), and the 95% CI. The x -axis is the odds ratio. The diamonds represent the pooled effect sizes and 95% CIs, estimated using fixed effect models. I^2 refers to the proportion of heterogeneity between studies. The study by Zhu (2022) was conducted in the Chinese Longitudinal Healthy Longevity Survey, and the study by Wu (2019) was conducted in the Singapore Chinese Health Study.

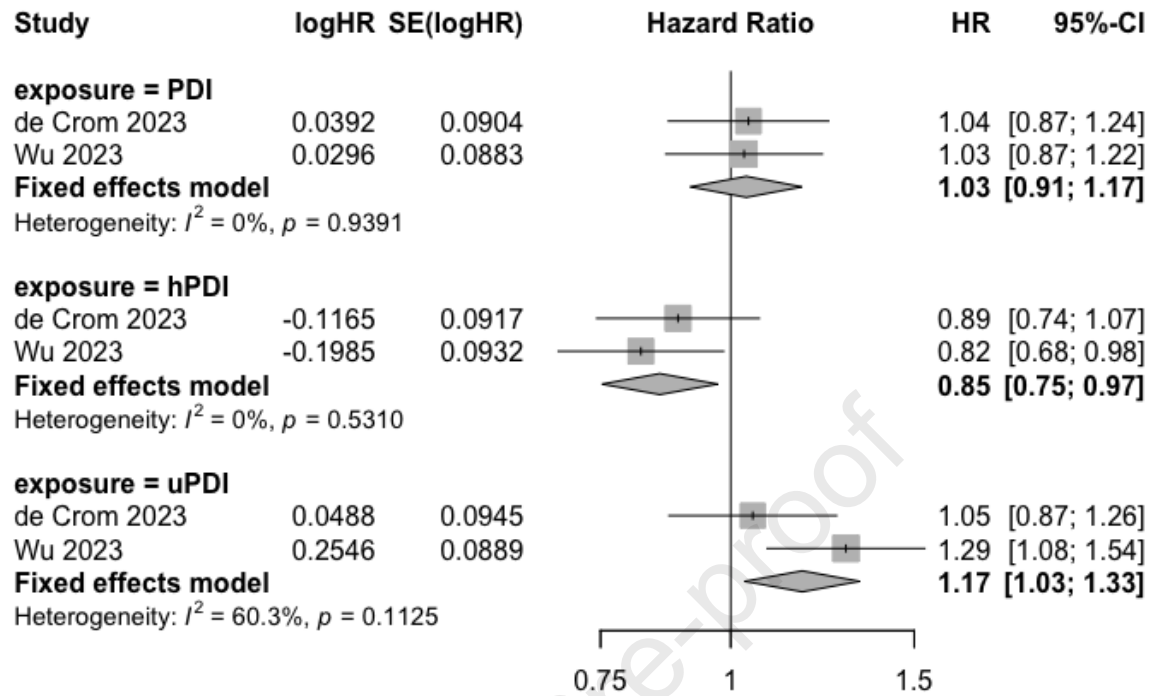
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Figure 3: Association of each plant-based diet index (PDI) with dementia risk, for high (quintile 5) compared with low (quintile 1) adherence to each plant-based diet pattern. Weights of each estimate are represented by the size of the square. The black lines represent the individual estimate effects (vertical), and the 95% CI. The x -axis is the hazard ratio. The diamonds represent the pooled effect sizes and 95% CIs, estimated using fixed effect models. I^2 refers to the proportion of heterogeneity between studies. The study by de Crom (2023) was conducted in the Rotterdam study, and the study by Wu (2023) was conducted in the UK Biobank.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Jean-Philippe Drouin-Chartier reports a relationship with Dairy Farmers of Canada that includes: consulting or advisory, funding grants, and speaking and lecture fees. Jean-Philippe Drouin-Chartier reports a relationship with Weston Family Foundation that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.