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Dietary Patterns and Cognitive Health in Older Adults: A Systematic Review

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Abstract. While the role of diet and nutrition in cognitive health and prevention of dementia in older adults has attracted much attention, the efficacy of different dietary patterns remains uncertain. Previous reviews have mainly focused on the Mediterranean diet, but either omitted other dietary patterns, lacked more recent studies, were based on cross-sectional studies, or combined older and younger populations. We followed PRISMA guidelines, and examined the efficacy of current research from randomized controlled trials and cohort studies on the effects of different dietary patterns. We reviewed the Mediterranean diet, Dietary Approach to Stop Hypertension (DASH) diet, the Mediterranean-DASH diet Intervention for Neurodegenerative Delay (MIND) diet, Anti-inflammatory diet, Healthy diet recommended by guidelines via dietary index, or *Prudent healthy diet*s generated via statistical approaches, and their impact on cognitive health among older adults. Of 38 studies, the Mediterranean diet was the most investigated with evidence supporting protection against cognitive decline among older adults. Evidence from other dietary patterns such as the MIND, DASH, Anti-inflammatory, and *Prudent healthy diets* was more limited but showed promising results, especially for those at risk of cardiovascular disease. Overall, this review found positive effects of dietary patterns including the Mediterranean, DASH, MIND, and Anti-inflammatory diets on cognitive health outcomes in older adults. These dietary patterns are plant-based, rich in poly- and mono-unsaturated fatty acids with lower consumption of processed foods. Better understanding of the underlying mechanisms and effectiveness is needed to develop comprehensive and practical dietary recommendations against age-related cognitive decline among older adult.

Keywords: Alzheimer's disease, anti-inflammatory, cognitive decline, DASH, dementia, dietary pattern, mild cognitive impairment, Mediterranean, MIND, nutrition

INTRODUCTION

Dementia is a global concern, placing a significant financial and social burden on patients, carers, and health care systems [1, 2]. Cardiovascular risk factors, psychosocial factors, lifestyle behaviors, education and social networking, have been consistently linked to cognitive health among older adults [3, 4]. Approximately 30% of the population attributable risk for Alzheimer's disease (AD), the most common cause of dementia, has been calculated to be determined by modifiable environmental factors [5]. In addition, the incidence of neurocognitive decline

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in the older population appears to be declining, suggesting a cohort effect with lifestyle factors having an impact, and diet may also be a promising strategy to postpone, slow, or prevent cognitive decline [6–12].

Despite research into the relationships between single nutrients or food with cognitive decline among older adults, it has been suggested that single nutrients or food are not as important as an integral dietary pattern [6, 8]. Within dietary patterns, the synergies and interactions between multiple nutrients and foods may play an important role to prevent or slow cognitive decline [6–9]. An important question is, whether and how effective different types of dietary patterns are in protecting against neurocognitive decline in older adults?

One of these dietary patterns, the Mediterranean diet originated among countries bordering the Mediterranean Sea in southern Europe. It is characterized by high intake of vegetables, fruits, olive oil, legumes, fish, whole grains, nuts and seeds, moderate wine consumption and low consumption of processed foods, dairy products, red meat, and vegetable oils [13]. A variety of tools to score adherence to the Mediterranean diet exist. Commonly used scoring systems are the 0–9 scoring system by Trichopolou et al. [14] or the 0–55 scoring system by Panagiotakos et al. [15]. The systems are similar in that they both score food component characteristics and include fruit, vegetable, legume, and alcohol intake. However, Trichopolou et al. used population sex-specific cut-offs around the median, while Panagiotakos et al. used pre-defined cut-offs based on frequency of consumption of foods relative to recommended amounts from the Mediterranean diet pyramid [15]. Furthermore, the 0–9 scoring system uses monounsaturated: saturated fat ratio (MUFA: SFA) while the 0–55 scoring system uses olive oil consumption. The 0–9 scoring system scores meat and meat products and fish as two components while the 0–55 system scores fish, poultry, red meat and meat products separately. Instead of non-specific intake of "cereal" and "dairy intake" in the 0–9 scoring system, the 0–55 scoring system redefined the component characteristics as "non-refined cereal" and "full fat dairy".

The DASH diet, the dietary pattern proven to be effective in lowering blood pressure in patients with hypertension or those at high risk [16, 17], was defined as a diet with high consumption of fruits, vegetables, low-fat dairy products, whole grains, poultry, fish and nuts, and low consumption of red meat, fats, sweets, and sugary beverages. DASH requires low consumption of saturated fat but high consumption of low-fat dairy when compared to the Mediterranean diet [18].

The MIND diet, on the other hand, specifies intake of 10 brain healthy food groups, including berries, nuts, beans, whole grains, seafood, poultry, green leafy vegetables, other vegetables, wine, and olive oil. There is little emphasis on overall fruit or dairy intake, compared to the Mediterranean diet. The MIND diet also scores a low intake of 5 unhealthy foods (red meats, butter and margarine, cheese, pastries and sweets, fried/fast food) [19].

Overall, the Mediterranean, MIND, and DASH diets have been associated with lower plasma levels of inflammatory markers [20–22], which suggests diets impact inflammation and therefore may also indirectly affect cognitive health in older adults [23]. Inflammation has been viewed as an important risk factor of neurodegenerative diseases including cognitive impairment and dementia [24], as higher levels of circulating inflammatory markers, especially interleukin-6 (IL-6), tumor necrosis factor-α [TNF-α], and C-Reactive protein (CRP), are associated with brain atrophy and greater cognitive decline [25–28]. In general, anti-inflammatory diets include foods such as vegetables, legumes, fruits, whole grains, and seafood. These foods are naturally rich in vitamins, bioactive nutrients including antioxidants and poly-/mono- unsaturated fatty acids, which have been reported to reduce systemic inflammation [29, 30]. By contrast, an inflammatory diet is characterized by high consumption of red and processed meats, sweets, desserts, fries, and refined grains which may increase inflammation [31, 32].

The low GI diet, classified as food choices with glycemic index (GI) lower than 55 such as legumes, low GI whole grains and fruits, has been shown to assist in managing blood glucose and insulin levels [33].

Other dietary patterns that utilize data reduction methods (e.g., using principle components analysis (PCA), factor analysis, cluster analysis, or reduced rank regression) [34] have also been studied. An example is *the Prudent healthy diet,* characterized by high intake of vegetables and fruits, nuts, whole grains, fish, poultry, and low-fat dairy. *The Prudent healthy diet* is a healthier pattern, and contrasts with the Western diet which is characterized by high intake of red meat and processed foods, refined grains, high fat dairy, and high saturated/trans-fat [35–37].

There is growing evidence that the Mediterranean diet may protect against cognitive decline [38–41]. The MIND diet and the DASH diet, have also shown promising results [42]. On the other hand, the effects of diets such as the low GI diet, commonly used to treat diabetes [43], and to reduce cardiovascular risk factors [44, 45], on cognitive decline in the older population have been little studied. Similarly, there is limited research on the effects of the Anti-inflammatory diet, the *Prudent healthy diet* as opposed to the Western diet, and diets recommended by the World Health Organization or national peak bodies such as the Dietary Guidelines for Americans and the Australian Healthy Eating Guideline on cognitive health of older people [46–48].

Most reviews on the association of dietary patterns with cognitive function have been from studies focusing on the Mediterranean diet [38–41]; very few have reviewed the full variety of dietary patterns. The most recent published systematic review [42] covered Mediterranean, DASH, and MIND diets but only assessed cross-sectional and longitudinal cohort studies, and omitted randomized control studies (RCTs). No recent review has synthesized findings from studies with higher level evidence [49–51] including cohort studies and RCTs, nor examined the full range of dietary patterns and association with cognitive function.

The aim of this systematic review is to provide a comprehensive update on the topic by collating and evaluating the evidence from all human studies of RCTs and prospective cohorts conducted on a variety of dietary patterns and the outcome of cognitive function and/or dementia.

METHODS

Literature search

Process and search terms

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [52]. An electronic literature search was conducted for articles published between January 1997 and September 2017. Databases PubMed, Medline, Cochrane Library, Embase, and Scopus were searched. Key search terms were Diet/ Dietary pattern/ Mediterranean diet/ DASH diet/ MIND diet/ low GI diet/ low fat diet/ low calorie diet/ healthy diet/ prudent diet/ anti-inflammatory diet/ Western

Table 1
Quality assessment of RCTs included in the review (Cochrane Risk of Bias Tool)

Article	Random Sequence generation (Risk of bias)	Allocation concealment (Risk of bias)	Selective reporting (Risk of bias)	Other source of bias	Blinding (participants and personnel) (Risk of bias)	Blinding (outcome assessment)	Incomplete outcome data	Overall bias assessment
Martínez-Lapiscina et al. [63]	Low	Low	Unclear	Yes - performance bias	High	Low	High	High
Valls-Pedret et al. [64]	Low	Unclear	Low	Yes- performance bias	High	Low	Low	High
Knight et al. [70]	Low	Unclear	Low	Unclear	High	Low	Low	High
Lehtisalo et al. [85] & Ngandu et al. [89]	Low	Unclear	Low	Unclear	High	Low	Low	High
Kowk et al. [86]	Unclear	High	Low	Unclear	High	Low	Low	High
Bayer-Carter et al. [91]	Unclear	Low	Unclear	Unclear	Low	Low	Low	High

diet AND cognition/ cognitive function/ memory/ cognitive decline/ dementia/ MCI and Alzheimer's disease. Systematic reviews and meta-analyses were included. References were managed using the Endnote X8 referencing software. Papers and systematic literature reviews were hand searched for additional relevant studies.

Study selection

Abstracts, keywords, and titles were screened by XC, if unable to obtain adequate information then full texts were assessed. We included peer reviewed studies from level I and II levels of evidence ranking, i.e., RCTs and longitudinal studies according to NHMRC level of Evidence [50], if they measured cognitive function or brain morphology and provided follow up regardless of the time frame, to test cognitive function or incident cases of mild cognitive impairment (MCI) or dementia in older populations (>50 years at baseline). We excluded studies that were cross-sectional, not published in English, did not have full-text available, or used non-human participants.

Data extraction and quality assessment

Study and participant characteristics, exposure assessment, length of follow-up, confounders, cognitive assessment methods, key statistical results, and overall quality rating were inserted into a customized extraction table. An extraction table was generated for recent systematic reviews, included as a supplementary table.

Data extraction and quality assessment were first assessed by a single reviewer (XC), cross checked by a second reviewer (FOL), with discrepancies discussed with a third reviewer (HB). Cochrane Risk of Bias tool and the SIGN 50 checklist [53] were used.

The Cochrane Risk of Bias tool [54], rates studies as having low, unclear, or high risk of bias (ROB) based on several criteria: random sequence generation, allocation concealment, selective reporting, blinding, and incomplete outcome data reporting and other biases.

The SIGN 50 checklist assesses selection, performance, attrition and detection bias, confounding and overall methodological quality in longitudinal studies [53]. This assessment tool has 14 questions targeting internal validity and four questions covering overall evaluation of quality. The questions prompt a "Yes", "No", or "Can't Say" answer [55]. Overall, articles were scored Low Quality (–) if they had 1–6 "yes" scores, Acceptable (+) for 7–9 "yes" scores and High Quality (++) for 10–14 "yes" scores.

RESULTS

Study selection

Study selection flow chart is shown in Fig. 1 and PRISMA Checklist is provided as Supplementary Material. From 1,765 articles obtained, 38 studies were eligible for inclusion. Study characteristics and outcomes can be found in Tables 1 and 2. Thirty-two were cohort studies emanating from the US ($n = 17$), France ($n = 2$), Australia ($n = 3$), UK ($n = 2$), Italy ($n = 2$), Sweden ($n = 2$), Asia ($n = 2$), Greece ($n = 1$), and Spain ($n = 1$). Six studies were RCTs; they came from Spain ($n = 2$), Finland ($n = 1$), Australia ($n = 1$), US ($n = 1$), and Hong Kong ($n = 1$). Most papers (5/6 for RCTs and 32/32 for cohorts) assessed community-dwelling older adults.

A priori and a posteriori studies

Most cohort studies included in this review used *a priori* ($n = 27$) approaches by assessing dietary adherence scores to a specific dietary pattern based on consumption of key food components. Patterns included the Mediterranean diet, which was the most studied dietary pattern with three RCTs (two conducted in the Mediterranean area) and 19 cohort studies (5 conducted in Mediterranean countries) using 0–9 [14] or 0–55 scoring system [15]. Other *a priori* studies were the DASH diet ($n = 3$) using 8–40 [37] or 0–10 DASH scoring system [56], and the MIND diet ($n = 3$ studies) using a 0–15 scoring system [57]. Other less studied patterns were the Anti-inflammatory diet ($n = 2$), the Low GI diet ($n = 1$), and the Healthy diet recommended by dietary guidelines ($n = 7$) (see Fig. 2).

By contrast, only seven studies ($n = 2$ overlapped with *a priori* group as reported both *a priori* and *a posteriori* patterns) used *a posteriori* approaches to investigate dietary profiles of a target population (see Fig. 2), including studies on *the Prudent healthy diet* compared to the Western diet ($n = 3$ using PCA [58] or factor analysis [35, 36]), and wheat based diet ($n = 1$, using PCA [59]). Other studies used reduced rank regression [60], cluster analysis [61], and factor analysis [62] to derive population-specific dietary patterns (see Table 3 for details).

Table 2
Characteristics of RCTs included in the review

Author, year, Location, length of follow up	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Martínez-Lapiscina et al. 2013 [63] Spain follow up: 6.5 years	N = 522 from PREDIMED Age: mean 74.6 ± 5.7 years Male: 44.6% Clinical Status: Participants initially free of CVD but at high vascular risk, because of the presence of either type-2 diabetes or at least three of the following major risk factors: current smoking, hypertension, dyslipidemia, overweight or family history of premature CVD.	Med Diet with EVOO (1L/wk), or Med diet with mixed nuts (30g/ d) versus control diet (advice to reduce dietary fat). Foods provided to the Intervention Group but not Control Group	Validated 137 item FFQ questionnaire and a 14-item short questionnaire of adherence to the Med Diet, interview with a trained dietitian	Sex, age, education, APOEε4 genotype, family history of cognitive impairment/ dementia, smoking, physical activity, body mass index, HTN, dyslipidemia, diabetes, alcohol and total energy intake	Cognition/ Incidence of Dementia or MCI Test used: MMSE and CDT; Incidence of Dementia or MCI from medical records	Participants in the Med Diet + EVOO had higher mean MMSE and CDT scores versus control (adjusted differences: +0.62 95% CI +0.18, +1.05, $p = 0.005$ for MMSE, and +0.51 95% CI +0.20, +0.82, $p = 0.001$ for CDT). MMSE and CDT scores were also higher for participants in the Med Diet + Nuts versus control (adjusted differences: +0.57 (95% CI +0.11, +1.03), $p = 0.015$ for MMSE and +0.33 (95% CI +0.003, +0.67), $p = 0.048$ for CDT).
Valls-Pedret et al. 2015 [64] Spain follow up: 4.1 years	N = 447 from PREDIMED Age: mean 66.9 years Male: 47.9 Clinical Status: cognitively healthy, free of CVD but at high cardiovascular risk, because of the presence of either type-2 diabetes or at least three of the following major risk factors: current smoking, hypertension, dyslipidemia, overweight or family history of premature CVD.	Med Diet with EVOO (1L/wk), or a Mediterranean diet with mixed nuts (30 g/ d) versus a control diet (advice to reduce dietary fat). Foods were provided to the intervention but not control Group	Validated 137 item FFQ questionnaire and a 14-item short questionnaire of adherence to the Med Diet, interview with a trained dietitian.	Sex, baseline age, years of education, APOEε4 genotype, smoking, BMI, energy intake, physical activity, diabetes, hyperlipidemia, the ratio of total cholesterol to HDL cholesterol, statin treatment, HTN, and use of anticholinergic drugs	Cognition/Cognitive decline Test used: MMSE RAVLT The verbal paired associates test - a subtest of Wechsler Memory Scale The animal fluency test the Digit Span subtest of the Wechsler Adult Intelligence Scale the Colour Trail Test	Participants allocated to a Med diet plus EVOO scored better on the RAVLT ($p = 0.049$ 95%CI: 3.24, 5.77) and Colour Trail Test part 2 ($p = 0.04$ 95%CI: –10.23, 21.55) compared with controls. Memory composite score was higher in the Mediterranean diet plus nuts ($p = 0.04$ 95%CI: –0.09 to 0.18); frontal cognition composite score was higher in the Med Diet plus EVOO ($p = 0.003$ 95%CI: –0.25, 0.31); global cognition composite was higher in the Med Diet plus EVOO ($p = 0.005$ 95%CI: –0.27, 0.18) compared to controls. All cognitive composite scores significantly ($p < 0.05$) decreased from baseline in controls.

(*continued*)

Table 2
(*Continued*)

Author, year, Location, length of follow up	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Knight et al. 2016 [70] Australia follow up: 6 months	N = 137 the MedLey study Age: mean 72.1 ± 5.0 years Male: 46.7% Clinical Status: normal cognitive function, no previous or current conditions that may cause cognitive impairment without potential health issues	Mediterranean Diet versus control diet - habitual dietary intake (HabDiet). Foods provided to Intervention Group and supermarket gift vouchers for Control Group	Validated FFQ Cancer Council Victoria and 3-day weighed food record, a semi-quantitative daily food check list; fortnightly meeting with a dietitian to provide education and monitor compliance	Age, sex, BMI, education, APOE ε4 allele, self-rated depressive symptoms, sleep quality, anxiety symptoms and stress levels, family history of dementia, AD, incidence of heart attack, high blood pressure, stroke and diabetes, physical activity and the dependent variables (i.e., all individual cognitive test scores, and composite scores for: overall age-related cognitive performance, executive function, speed of processing, memory, visual-spatial ability.	Cognition/Cognitive decline Test used: Executive function by the following four tests: Dodrill's version of the Stroop Test, Initial Letter Fluency (ILF) and Excluded Letter Fluency (ELF) and D-KEFS version of the Tower of London (TOL); Memory by Rey and Schmidt's, RAVLT, Digit Span Forward (DSF) Digit Span Backward (DSB) and the Letter-Number sequencing (LNS) subtest tasks from the Wechsler Adult Intelligence Scale (WAIS-IV) Speed of processing by: Symbol Search and Coding core subtests from WAIS IV Visual-spatial memory ability, The Benton Visual Retention Test (BVRT).	No difference for executive functioning, speed of processing, memory, visual-spatial ability and overall age-related cognitive performance. Executive functioning ($p = 0.33$; 95%CI: –2.58, 7.65); speed of processing ($p = 0.15$; 95%CI: –1.21, 7.70); Memory ($p = 0.50$; 95%CI: –3.88, 7.88); Visual-spatial ability ($p = 0.48$; 95%CI: –0.38, 0.81); overall age-related cognitive performance ($p = 0.19$; 95%CI: –4.00, 19.9).

(*continued*)

Table 2
(*Continued*)

Author, year, Location, length of follow up	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Lehtisalo et al., 2017 [85] & Ngandu et al., 2015 [89] Finland Follow up 2 years	N = 1260 from the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER) Age: 60–77 years Male: 56 Clinical Status: those have a CAIDE (Cardiovascular Risk Factors, Aging and Dementia) Risk Score of 6 points or higher (score based on age, sex, education, systolic blood pressure, BMI, total cholesterol, and physical activity; range 0–15 points). Exclude previously diagnosed dementia/suspected dementia, MMSE <20, disorders affecting safe engagement in the intervention (e.g., malignant disease, major depression, symptomatic cardiovascular disease, revascularization within 1 year previously); severe loss of vision, hearing, or communicative ability	Nutrition Intervention based on national Finnish Dietary Recommendation	Food record in 3 consecutive days completed close to annual visits, include 2 weekdays and 1 weekend day (Thursday to Saturday or Sunday to Tuesday). Dietary adherence score to national dietary recommendations range (0–9)	Age, education, sex and study center, baseline BMI, systolic blood pressure, fasting glucose, LDL-cholesterol and depressive symptoms.	Intake and changes in intake of nutrients during the intervention/cognition Cognition Test used: comprehensive neuropsychological test battery; The executive functioning domain included category fluency test, 19-digit span, concept shifting test, trail making test, and a shortened 40-stimulus version of the original Stroop test. The processing speed domain included letter digit substitution test, concept shifting test, and Stroop test. The memory domain included visual paired associates test, immediate and delayed recall; logical memory immediate and delayed recall; and word list learning and delayed recall.	Composite dietary intervention adherence score range (0–9 points) was 5 0 at baseline and increased in the intervention group after the 1st ($p < 0.001$) and 2nd ($p = 0.005$) year. The difference in change compared with the control group was significant at both years ($p < 0.001$ and $p = 0.018$). Intake of several nutrients decreased in the control group but remained unchanged or increased in the intervention group, significant difference in fiber, w-3/w-6 fatty acids, vitamin C/D/E/folic acid/magnesium. After diet Intervention together with exercise, cognitive training and monitoring of vascular risk for two years, improvement in comprehensive neuropsychological test total score after 24 months was 25% higher in the intervention group than in the control group ($p = 0.03$). Improvement in executive functioning was 83% higher, and in processing speed 150% higher, in the intervention group than in the control group. Significant intervention effect for executive functioning ($p = 0.039$) and processing speed ($p = 0.029$).

(*continued*)

Table 2
(*Continued*)

Author, year, Location, length of follow up	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Kwok et al., 2012 [86] Hong Kong follow up: mean 25 months (range 24–33 months)	N = 429 Age: mean 83 years Male: 15.4% Clinical Status: Tube-fed residents and those on special diet due to chronic renal failure were excluded. non-demented subjects in old age hostels,	Dietary interventions promote intakes of fruit, vegetable, fish and lower salt intake add this in - to either regular group dietary counselling and menu changes or advice on hostel menu only.	24-h recall or food record via face to face interview by RA in those with intact memory or via observation at 3 main meals for MCI subjects For those with impairment in the memory domain of CDR, food intakes during the three main meals were recorded by direct observation by RA. Quantification of nutrients was determined by a dietary computer program 'Food processor', which was based on food tables for Hong Kong and Mainland China.	Baseline characteristics and dietary intakes: age, sex, HTN, diabetes mellitus, education, intakes of fruit, vegetable, fish, and saturated fat	Cognition/Cognitive decline test used: Cognitive tests included clinical dementia rating scale, Chinese MMSE and category fluency test.	Dietary interventions in older people were effective in maintaining fruit and fish intake, but no significant effect on cognition. Subgroup analysis found fewer cognitively normal subjects in intervention group had cognitive decline at 24 months versus control group ($p = 0.065$).
Bayer-Carter et al. 2012 [91] USA follow up: 4 weeks	N = 49 Age: mean age 68.3 years Male: 46.9% Clinical Status: free of major psychiatric disorders, alcoholism, neurologic disorders other than amnesic MCI ($n = 29$), renal or hepatic disease, diabetes mellitus 2, chronic obstructive pulmonary disease, and unstable cardiac disease. None taking cholesterol-lowering medications.	High saturated fat/ high GI (HIGH) diet versus a low saturated fat/low GI (LOW) diet	All food was delivered to the homes of participants twice weekly. Menus were designed by a nutritionist Study participants recorded all food consumed each day to assess adherence. Not validated.	Age, baseline BMI, educational level, and APOE-ε4 status	Cognition/Cognitive decline Test used: Tests of immediate and delayed memory (story recall, word list, and the Brief Visuospatial Memory Test), executive function (Trail-Making Test, part B; Stroop test/interference condition; and Verbal Fluency Test), and motor speed (Trail-Making Test, part A and Stroop test/ matching condition).	The healthy control and amnesic MCI groups showed improved delayed visual recall with the LOW GI diet ($p = 0.04$), but other delayed memory measures did not change significantly. No diet-related changes were observed for immediate memory, executive, or motor speed domains.

AD, Alzheimer's Disease; APOE, Apolipoprotein E; BMI, body mass index; CI, confidence interval; CDT, the Clock Drawing Test; CVD, cardiovascular disease; EVOO, extra virgin olive oil; FFQ, Food frequency questionnaire; GI, glycemic index; HTN, hypertension; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MCI, mild cognitive impairment; Med Diet, Mediterranean diet; MMSE, Mini-Mental Status Examination; PREDIMED, the PREvención con DIeta MEDiterránea study; RAVLT, Rey Auditory Verbal Learning Test; WAIS-IV, the Wechsler Adult Intelligence Scale.

Table 3
Characteristics of cohort studies in this review

Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Berendsen et al. 2017 [18] USA Follow up 6 years Acceptable (+)	N = 16,144 from the Nurses' Health Study. Age: Mean 74.3 ± 2.3 years first cognitive assessment Male (%): 0% Clinical status: free of stroke	DASH diet	116 item FFQ and validation DASH scoring system range 8–40, based on intake of 9 food components	Age and education, and additionally for long-term energy intake and physical activity, BMI, smoking status, alcohol intake, history of depression, multivitamin use, and cardiovascular risk factors (history of diabetes, hypertension, hypercholesterolemia, and/or myocardial infarction. In a subset of 5,822 participants, APOE ε4 alleles tested for interaction	Cognition/cognitive decline Cognition test used: The cognitive battery included: TICS, immediate and delayed recalls of the East Boston Memory test, delayed recall of the TICS 10-word list, category fluency, digit span backward test	Greater adherence to long term DASH score was associated with better average cognitive function, irrespective of APOE ε4 status. For mean z-scores between highest and lowest DASH quintiles $p = 0.04$ (95% CI 0.01, 0.07), $p = 0.009$ for global cognition: 0.04 (9% CI 0.01, 0.07), p trend for verbal memory and 0.16 (95%CI 0.03, 0.29), and $p = 0.03$ for TICS. Those differences were equivalent to being 1 year younger in age. Adherence to DASH score was not associated with change in cognitive function over 6 years.
Berendsen et al. 2017 [19] USA Follow up 6 years High Quality (++)	N = 16,058 from the Nurses' Health Study. Age: 70 and older mean 74.3 ± 2.3 years Male (%): 0% Clinical status: exclude dementia not MCI	MIND diet	116-item Food Frequency Questionnaire The 0–15 MIND score includes ten brain-healthy foods and five unhealthy foods.	Age and education, and additionally for long-term energy intake and physical activity, BMI, smoking status, alcohol intake, history of depression, multivitamin use, and cardiovascular risk factors (history of diabetes, hypertension, hypercholesterolemia, and/or myocardial infarction. In a subset of 5,822 participants, a variable indicating the product of the number of ApoE ε4 alleles (0,1,2) was used to test for effect modification by ApoE ε4. Energy intake adjusted	Cognition/cognitive decline Cognition test used: The cognitive battery included TICS, immediate and delayed recalls of the East Boston Memory test, delayed recall of the TICS 10-word list, category fluency and digit span backward test.	Greater long-term adherence to the MIND diet was associated with a better verbal memory score (multivariable-adjusted mean differences between highest and lowest MIND quintiles = 0.04 (95%CI 0.01, 0.07), $p = 0.006$), but not with cognitive decline over 6 years in global cognition, verbal memory or TICS.

(*continued*)

Table 3
(*Continued*)

Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Ozawa et al. 2017 [23] UK Follow up 10 years High Quality (++)	N = 5083, British civil servant Whitehall II Perspective Cohort Study Age: age 35–79 years baseline mean 56 years Male (%): 71.3% Clinical status: Nil Subjects with implausible total energy intake Excluded.	Inflammatory Dietary pattern characterized as higher intake of red processed meat, peas, legumes and fried food, and lower intake of whole grains	127 item FFQ Validated. Reduced rank regression to determine dietary pattern associated with Interleukin-6.	Age, sex, ethnicity, education and total energy intake. Health related variables included BMI, diabetes mellitus, HTN, smoking, leisure time physical activity, ethnicity, occupational position, education, smoking history. Energy intake adjusted	Cognition/Cognitive decline Cognitive test used: 4 standard tasks: Alice Heim 4-I, short term verbal memory, phonemic fluency, and semantic fluency. Global cognitive score, MMSE	Greater inflammatory diet associated with accelerated cognitive decline at older ages. Greatest decline in highest tertile of inflammatory diet for reasoning (–0.37 SD, 95% CI –0.40, –0.33) compared to lowest tertile (–0.31 SD, 95% CI –0.34, –0.28) global cognition: highest tertile –0.35 (–0.38, –0.32) compared to lowest tertile –0.31 (–0.33, –0.28). stronger association in those less than 56 years.
Gardener et al. 2015 [35] Australia Follow up 3 years Acceptable (+)	N = 527 participants from the AIBL study. Over 79% were born in Australia Age: mean age 69.3 years Male (%): 39.8% Clinical status: cognitive intact, average BMI of 26.3 kg/m^2	Modified Australian Mediterranean diet (AusMeDi), *Prudent healthy diet* and Western diet derived by factor analysis	Cancer Council of Victoria food frequency questionnaire 101 food items, 0–9 Med Diet scoring system	APOE ε4 status, BMI, country of birth (Australia or other), years of education ($\leqslant$12 years or 412 years), past smoking status, energy intake, history of angina, stroke, HTN, heart attack and diabetes	Cognition/cognitive decline Cognition test used: Composite scores constructed for a global cognitive score and six cognitive domains (verbal memory, visual memory, executive function, language, attention, and visuospatial functioning). The full battery comprised the MMSE, California Verbal Learning Test – Second edition, Logical Memory I and II (Story A only), D-KEFS verbal fluency, 30-item Boston Naming Test, Wechsler Test of Adult Reading, Digit Span and Digit Symbol-Coding subtests of the Wechsler Adult Intelligence Scale – Third edition (WAIS– III), the Stroop task (Victoria version), and the Rey Complex Figure Test	Higher baseline adherence to the AusMeDi associated with better performance in the executive function cognitive domain in APOE ε4 allele carriers ($p < 0.01$). Higher baseline Western diet adherence was associated with greater cognitive decline in the visuospatial cognitive domain in APOE ε4 allele non-carriers ($p < 0.01$). All other results were not significant.

(*continued*)

Table 3
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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Shakersain et al. 2016 [36] Sweden Follow up 6 years High Quality (++)	N = 2223 Community based From the Swedish National study on Aging and Care-Kungsholmen (SNAC-K). Age: aged ≥60 mean 70.6 ± 8.9 Male (%): 39.2% Clinical status: dementia-free	Prudent healthy diet versus western diet identified via exploratory factor analysis (principle component)	Validated FFQ with 98 items.	Age, sex, education, civil status, BMI, physical activity, smoking, vascular and other chronic diseases, dietary supplements use, APOE ε4 genotype, energy intake	Cognition Cognition test used: MMSE	Compared with the lowest adherence to each pattern, the highest adherence to prudent pattern was related to less MMSE decline ($p = 0.011$) where highest adherence to western pattern was associated with more MMSE decline ($p < 0.001$). Western diet (β = –0.045 95%CI 0.071, 0.019) and *prudent healthy diet* (β = 0.043 95%CI 0.017, 0.068)
Morris et al. 2015 [57] USA Follow up 4.7 years High Quality (++)	N = 960 participants From retirement communities and senior public housing, the Rush Memory and Aging Project Age: mean age 81.4 ± 7.2 Male (%): 25% Clinical status: free of dementia	MIND diet	144-item validated semi-quantitative FFQ. The 0–15 MIND score includes ten brain-healthy foods and five unhealthy foods.	Age, sex, education, APOE ε4 genotyping, physical activity, total energy intake, smoking, participation in cognitive activity, BMI, depressive symptoms, HTN history, Myocardial Infarction history, diabetes history, medication, stroke	Cognition/cognitive decline Cognition test used: 21 neuropsychological tests included 19 measures cognition in 5 cognitive domains (episodic memory, working memory, semantic memory, visuospatial ability and perceptual speed).	The MIND score was positively associated with slower decline in global cognitive score (β = 0.0092; $p < 0.0001$) and with each of five cognitive domains. The difference in decline rates for being in the top tertile of MIND diet scores versus the lowest was equivalent to being 7.5 years younger in age.
Jacka et al. 2015 [58] AU Follow up 4 years High Quality (++)	N = 255 from the Personality and Total Health Through Life Study Age: mean 62.6 ± 1.42 Male: 56% Clinical status: excluded those with MRI abnormality, stroke or epilepsy	Prudent (healthy) diet versus Western (unhealthy) diet derived using PCA	188-item Commonwealth Scientific and Industrial Research Organisation FFQ	Age, gender, education, labor-force status, depressive symptoms and medication, physical activity, smoking, hypertension and diabetes	hippocampal volume Test used: Magnetic resonance imaging	Every one SD increases in healthy "prudent" dietary pattern was associated with a 45.7 mm^3 (standard error 22.9 mm^3) larger left hippocampal volume, while higher consumption of an unhealthy "Western" dietary pattern was (independently) associated with a 52.6 mm^3 (standard error 26.6 mm^3) smaller left hippocampal volume. While hippocampal volume declined over time, there was no evidence that dietary patterns influenced this decline. No relationships were observed between dietary patterns and right hippocampal volume.

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Qin et al. 2015 [59] China Follow up 7 years Acceptable (+)	N = 1,650 community dwelling, from China Health and N1utrition Survey Age: ≥55 years of age Mean age 64 years Male (%): 49.7% Clinical status: Nil specific	Chinese adapted Mediterranean Diet and two dietary pattern scores derived from PCA	24 h food recall for 3 consecutive days, Adapted 0–9 Med Diet scoring system	Age, gender, region, urbanization index, education, annual household income per capita, physical activity, current smoking, total energy intake, time, BMI, HTN	Cognition/cognitive decline Cognition test used: cognitive screening items from part of the TICS-modified., immediate and delayed recall of a 10-word list (10 points each); counting backward and serial 7's (seven points); orientation assessed by asking the participant the current date (one point each for year, month, and date); and naming the tool used to cut paper (one point).	In those ≥65 years of age, Q3 versus Q1 of adapted Med Diet Q3 had slower rate of cognitive decline ($\beta = 0.042$; 95% CI: 0.002, 0.081) and wheat-based diverse diet Q3 versus Q1 had slower annual decline in global cognitive function ($\beta = 0.069$ SU/year; 95% CI: 0.023, 0.114). No associations in adults <65 years of age.
Gu et al. 2010 [60] USA Follow up 3.9 years Acceptable (+)	N = 2148 northern Manhattan residents, from Washington/Hamilton Heights-Inwood Columbia Aging Project II: WHICAP II Age: mean 77.2 ± 6.6 Male: 32% Clinical status: without dementia	DPs based on 7 AD-related nutrients: saturated fatty acids, vitamin E, vitamin B12, and folate, MUFA/PUFA, derived using reduced rank regression	61-item version of Willett's SFFQ	Recruitment cohort, age, sex, ethnicity, education, smoking status, BMI, caloric intake, comorbidity index, and APOE ε4 genotype	Incidence of dementia Cognition test used: Clinical Dementia Rating (CDR). Diagnosis for the dementia using the neuropsychological battery of tests, the Blessed Dementia Rating Scale, the Schwab and England Activities of Daily Living Scale, and the physician's assessment, and evidence of cognitive and social/occupational function decline as compared with the past, as required by the DSM-III-R.	DP that strongly associated with lower AD risk is characterized by higher intakes of salad dressing, nuts, fish, tomatoes, poultry, cruciferous vegetables, fruits, and dark and green leafy vegetables and a lower intake of high-fat dairy products, red meat, organ meat, and butter. Compared with subjects in the lowest tertile of adherence to this pattern, the AD hazard ratio (95% CI) for subjects in the highest DP tertile was 0.62 (0.43, 0.89) after multivariable adjustment ($p = 0.01$)

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Granic et al. 2016 [61] UK Follow up 5 years Acceptable (+)	N = 791 (302 men and 489 from Northeast UK from The Newcastle 85 + Study Living in community or aged home Age: ≥85 Male (%): 38% Clinical status: nil. Very old adults >= 85 years	3 Dietary Patterns derived by cluster analysis that differed in intake of red meat, potato, gravy, and butter and varied with key health measures, derived using SPSS 2-step clustering	Two day (non-consecutive) 24-h multiple pass dietary recall	Sex; education; marital status; social class, smoking; physical activity; BMI, APOE ε4 status. Chronic diseases included arthritis, HTN, cardiac disease, respiratory disease, cerebrovascular disease, diabetes, and cancer. sex-specific energy quartiles, supplement intake, and number of medications, in sensitivity analysis.	Cognition Cognition test used: SMMSE and the cognitive drug research attention battery.	Compared with DP1 (high red meat) and DP3 (high butter), DP2 (low meat) had better SMMSE ($p < 0.001$) better initial attention ($p < 0.005$) at baseline and follow ups. DP1 and DP3 was associated with overall worse SMMSE scores (β = 0.09, $p = 0.01$ and β = 0.08, $p = 0.02$, respectively) than DP2 after adjustment. Additional adjustment for APOE ε4 genotype attenuated the association to non significant in women but not in men in DP1 (β = 0.13, $p = 0.02$). DP1 and DP3 also had worse concentration (β = 0.04, $p = 0.002$ and β = 0.028, $p = 0.03$, respectively) and focused attention (β = 0.02, $p = 0.01$ and β = 0.02, $p = 0.03$, respectively), irrespective of APOE ε4
Chen et al. 2017 [62] Taiwan Follow up 2 years Acceptable (+)	N = 475 from the elderly health checkup program at National Taiwan University Hospital (NTUH) Age: 65 and older, mean 73 Male (%): 17% Clinical status: excluded use of medication for AD treatment, history of stroke, vegetarians, total energy intake <650 kcal/d, physical activities >10,000 kcal/d.	Three Dietary Patterns (vegetable, meat, and traditional) derived using factor analysis.	44-item semi-quantitative FFQ (which represents a shortened version of a validated 64-item FFQ for Taiwanese) at baseline, a factor analysis based on 24 food groups performed to identify DPs	Age, sex, years of education, and APOE ε4 status, disease history (e.g., HTN,, diabetes mellitus, and hyperlipidemia), and supplement use (e.g., multivitamin and calcium). Physical activity. Depressive symptoms energy intake adjusted	Cognition/cognitive decline Cognition test used: Global cognition determined by the Montreal Cognitive Assessment-Taiwan version. the Wechsler Memory Scale-Third Edition (WMS-III) to assess logical memory and attention (digit span) domains. Verbal fluency tests. Trail making tests (A and B) used to assess executive function. Eleven domain-specific cognitive variables were obtained.	Moderate/high-score "vegetable" DP significantly protected against decline of logical memory (recall I: β = 0.16–0.18, OR = 0.42–0.48; recall II: β = 0.17–0.21); high-score "vegetable" DP increased executive function decline (β = –0.22). A high-score "meat" DP related to decline of verbal fluency-total score (β = –0.19); moderate/high-score "meat" DP protected against attention decline (β = 0.20–0.22). High-score "traditional" DP protected against decline of logical memory-recall I (β = 0.18). No significant association was observed for global cognition.

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Feart et al. 2009 [65] France Follow up 4.1 years Acceptable (+)	N = 1410 from 3 City Study Age: mean 75.9 years Male (%): 37.4% Clinical status: non-demented non-institutionalized	Mediterranean Diet	FFQ with 40 item foods and beverages, administered by trained dietitian and a 24-hour dietary recall. The 10-point (0 to 9) Med Diet Score	Age, sex, education, marital status, caloric intake, APOE ε4 genotype, physical activity, >5 medications/day, depression score, BMI, diabetes, HTN, tobacco use, hypercholesterolemia, stroke	Cognitive decline/ dementia risk Cognitive test used: MMSE, The Isaacs Set Test (IST), The Benton Visual Retention Test (BVRT), and The Free and Cued Selective Reminding Test (FCSRT)	A higher Med Diet score associated with fewer MMSE errors (β = –0.006; 95% CI –0.01, –0.0003; $p = 0.04$ for 1 point of the Mediterranean diet score). No association with performance on the IST, BVRT, or FCSRT over time. No association with risk for incident dementia (HR, 1.12; 95% CI 0.60, 2.10; $p = 0.72$).
Trichopoulou et al. 2015 [66] Greece Follow up 7 years Acceptable (+)	N = 401 from The European Prospective Investigation into Cancer and Nutrition (EPIC-Greece). Age: mean 74 years Male (%): 36% Clinical status: nil specific, generally healthy	Mediterranean diet	validated semiquantitative FFQ with approximately 150 foods and beverages, interviewer administered, The 10-point (0 to 9) Med Diet Score	Age, education, BMI, physical activity, alcohol, smoking, HTN, diabetes, no APOE ε4 adjusted	Cognition/cognitive decline Cognition test used: MMSE	Decline in MMSE performance inversely associated with adherence to Med Diet. For mild versus no decline, OR high versus low 0.46 [95% CI 0.25, 0.87, $p = 0.012$]. For substantial versus no decline, OR high versus low adherence 0.34 (95% CI 0.13, 0.89, $p = 0.025$). Of the nine MDS components, only vegetable consumption exhibited a significant inverse association with cognitive decline
Galbete et al. 2015 [67] Spain Follow up 2 years Acceptable (+)	N = 823 participants from SUN project Age: mean 62 ± 6 years Male (%): 71% Clinical status: Nil total energy intake outside of predefined values (<800 kcal/d for men,<500 kcal/d for women and >4000 kcal/d for men, >3500 kcal/d for women) and were excluded	Mediterranean Diet	A validated 136-item FFQ. The 10-point (0 to 9) Med Diet Score	Age, gender, APOε4, total energy intake, follow up time between baseline and cognitive evaluation, BMI, smoking status, physical activity, diabetes, HTN, hypercholesterolemia, history of CVD, and years of university education	Cognition/cognitive decline Cognition test used: Telephone Interview of Cognitive Status-modified (TICS-m, range 0 to 54 points), not validated in Spanish population	Greater cognitive decline observed among participants with low or moderate adherence to the Med Diet versus those with better adherence (adjusted difference = –0.56 points in TICS-m, 95% CI = –0.99, –0.13).

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Limongi et al. 2017 [68] Italy Follow up 7.1 years Acceptable (+)	N = 5,632, from the Italian Longitudinal Study on Aging (ILSA) Age: mean 73 years Male (%): 43% Clinical status: Nil specific	Mediterranean diet	49-item semi-quantitative FFQ, not previously validated. 0–44 Med Diet score based on Mediterranean pyramid components.	Age, sex, educational level, marital status, smoking status, heart failure, angina, arrhythmia, hypertension, myocardial infarction, diabetes mellitus, stroke, parkinsonism, distal symmetric neuropathy of lower limbs, disability in at least one ADL, BMI), score at the GDS, score at the MMSE and alcohol consumption. energy intake not adjusted	Cognition Cognition test used: MMSE	Participants with a high adherence to Med Diet (highest tertile of the MD score distribution) had an all-cause mortality risk that was of 34% lower versus subjects with low adherence (HR = 0.66; 95% CI: 0.49, 0.90; $p = 0.0144$). Cognition outcomes: when compared highest tertile with lowest tertile, adherence of Med Diet is associated with better cognition scores at baseline (MMSE $p = 0.0097$ GDS $p = 0.0003$) and after follow up (MMSE $p = 0.0331$ GDS $p = 0.0044$), no data on cognition change over years.
Kesse-Guyot et al. 2013 [69] France Follow up 2 years Acceptable (+)	$n = 3083$ from Supplementation with Vitamins and Mineral Antioxidants (SUVIMAX) study Age: mean 52 ± 4.6 years Male (%): 53.7 Clinical status: not specified, community dwelling individuals	Mediterranean diet	24-h dietary records The 10-point (0 to 9) Med Diet Score	Age, sex, education, follow-up time, supplementation group during the trial phase, number of 24-h dietary records, energy intake, BMI, occupational status, tobacco use status, physical activity, memory difficulties at baseline, depressive symptoms, diabetes, HTN, cardiovascular disease.	Cognition Cognitive test used: Neuropsychological evaluation by trained neuropsychologists at baseline. Battery included RI-48, verbal (semantic and phonetic) fluency tasks, forward and backward digit span, Delis-Kaplan trail-making test.	A lower phonemic fluency score with decreasing MSDPS ($p = 0.048$) and a lower backward digit span score with decreasing MDS ($p = 0.03$). A low MDS related to a lower composite cognitive score in subsample of manual workers ($n = 178$, p-interaction = 0.04) hypothesized to have low cognitive reserve. Med Diet adherence did not interact with educational level in relation to cognitive function.

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Vercambre et al. 2012 [71] USA Follow up 5 years Acceptable (+)	N = 2504 from Women's Antioxidant Cardiovascular Study (WACS) Age: mean 72.5 years Male (%): 0 Clinical status: vascular disease or >3 coronary risk factors	Mediterranean diet	The 116 item semi-quantitative FFQ, The 10-point (0 to 9) Med Diet Score	Age at initial cognitive assessment, educational attainment, energy intake, WACS randomization assignments, depression, numerous lifestyle and health variables and incident vascular events during follow-up	Cognitive decline Cognitive test used: TICS, the East Boston Memory Test category fluency- animal test	Consuming a Mediterranean style diet was not related to cognitive decline. No effect modification was detected by age, education, depression, cardiovascular disease severity at WACS baseline, or level of cognition at initial assessment. The mean multivariable-adjusted difference 95%CI in rates of change in the global composite score was 0.01 (–0.01, 0.02) between the second tertile and the first tertile of Mediterranean diet score, and 0.00 (–0.02, 0.01) between the top tertile and the first tertile ($p = 0.88$).
Cherbuin et al. 2012 [72] Australia Follow up 4 years High Quality (++)	N = 1528 from PATH Through Life study Age: 60–64 years baseline Male (%): 48.2 Clinical status: no cognitive impairment in first wave	Mediterranean diet	Commonwealth Scientific and Industrial Research Organisation 215 item FFQ The 10-point (0 to 9) Med Diet Score	Age, sex, education, APOE ε4, genotype, body mass index, physical activity, stroke, diabetes, HTN, and total caloric intake	Cognitive decline/Incidence of MCI or dementia Test used: Clinical Dementia Rating 0.5 global cognition was computed (average z-scores for immediate and delayed recall, digits backward, spot-the-word, symbol-digit modalities test, simple and complex reaction time) DSM-IV criteria were used to assess dementia and delirium.	No protective effect of Adherence to Mediterranean diet against cognitive decline. Excessive caloric intake, and high intake of monounsaturated fats are predictive of MCI ($p < 0.01$).

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Samieri et al. 2013 [73] US Follow up 13 years High Quality (++)	N = 16,058, from Nurses' Health Study (1976) Age: 74.3 ± 2.3 Male (%): 0 Clinical status: free of stroke	Mediterranean Diet	The 61 item Semi-quantitative FFQ The 10-point (0 to 9) Med Diet Score	Age and education, long-term energy intake and physical activity, BMI, smoking, history of depression, multivitamin use, and vascular risk factors (history of diabetes, HTN, hypercholesterolemia, and myocardial infarction)	Cognition/ Cognitive decline Test used: TICS, immediate and delayed recalls of the East Boston Memory test (EBMT), delayed recall of the TICS 10-word list, category fluency and digit span-backward.	The Med diet not associated with decline in global cognition or verbal memory. In a secondary approach examining cognitive status in older age, each higher quintile of long-term Med Diet score was linearly associated with better multivariable-adjusted mean cognitive scores (differences in mean Z-scores between extreme quintiles of Med Diet = 0.06 (95% CI: 0.01–, 0.11); = 0.05 (95% CI: 0.01, 0.08); and = 0.06 (95% CI: 0.03, 0.10) standard units; $p = 0.004$, 0.002, and <0.001 for TICS, global cognition, and verbal memory, respectively).
Olsson et al. 2015 [74] Sweden Follow up 12 years Acceptable (+)	N = 1,038 from Uppsala longitudinal study of adult men Age: mean 71 years Male (%): 100% Clinical status: excluded those with substantial weight loss (10%) between 60–70 years, excluding extremes with a reported energy intake <800 or >4200kcal per day was applied. subgroup of 564 classified using Goldberg's cut-off	Mediterranean like Diet, low CHO high protein diet (LCHP), WHO recommendation diet (Healthy Diet Indicator)	Seven-day food record validated; 0–9 Med Diet scoring system; 1–10 LCHP scoring system; –1 to 8 HDI scoring	Blood pressure, CRP, BGL, HDL, LDL, triglycerides, weight, height, BMI, APOE $\varepsilon 4$ genotype, smoking status, educational level, health status, and physical activity, energy intake	Cognition/ Incidence of MCI or dementia Test used: MMSE AD defined according (NINCDS-ADRDA and DSM-IV criteria.	No association found between Healthy Diet Indicator and any outcomes. HR associated with 1 SD increment in the LCHP score were 1.16 (95% CI: 0.95,1.43) for AD and 1.16 (95%CI: 0.99,1.37) for all-type dementia. Modified MDS was not associated with dementia diagnosis. OR/1 SD increase for modified MDS and all-type cognitive impairment was 0.82 (95% CI: 0.65, 1.05). Subgroup classified by Goldberg method OR for modified MDS and all-type cognitive impairment was 0.32 (95% CI: 0.11, 0.89).

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Haring et al., 2016 [75] US Follow up 9.11 years High Quality (++)	N = 6425 from Women's health initiative (WHI) Memory study Age: 65–79 years Male (%): 0% Clinical status: Post-menopausal women cognitively intact at baseline excessive or low energy intake	Dietary patterns characterized by alternate Mediterranean diet (aMED), HEI-2010 and AHEI 2010) and DASH	122 item WHI food frequency questionnaire. Dietary patterns 0–9 aMED score; 0–110 aHEI-2010 score; 8–40 DASH score	Age, race, education, family income, BMI, smoking, HTN, physical activity, diabetes, depression, history of cardiovascular disease, hormone replacement, modified MMSE score, total energy intake. APOE $\varepsilon 4$ adjustment in a sub-sample of 5,180 white women.	Cognitive decline/Incidence of MCI or PD Cognition test used: 3MS Diagnosis of MCI/PD made following "four phase protocols as outlined by WHIMS trial and WHIMS extension study" in person or validated telephone cognitive assessment. Physician classify MCI/PD according to DSM– IV criteria.	No relationship across dietary patterns and MCI/PD was found ($p = 0.30$, 0.45, 0.44 and 0.23). In Subset of white women with APOE $\varepsilon 4$ adjusted and found higher adherence to Med diet and AHEI-2010 was associated with lower risk of MCI incidents ($p = 0.03$).
Buhushan et al. 2017 [76] USA Follow up 4 years Acceptable (+)	N = 27,842 male health professionals From the Health Professionals' Follow-up Study Age: 40–75 years at baseline, mean age 51 years Male (%): 100% Clinical status: no self-reported Parkinson's disease excluding individuals with energy intake of <800 or >4200 kcal/day	Mediterranean diet	self-administered mailed FFQ 131 items 0–9 Med Diet scoring system	Age, smoking history, diabetes, HTN, depression, and hypercholesterolemia. BMI, physical activity. Total energy intake not adjusted	Cognition/cognitive decline Cognition test used: Subjective Cognitive Function (SCF) scores are based on 6 yes/ no questions	Compared with men having a MD score in the lowest quintile, those in the highest quintile had a 36% lower odds of a poor SCF score (OR 0.64, 95% CI 0.55, 0.75; $p < 0.001$) and a 24% lower odds of a moderate SCF score (OR 0.76, 95% CI 0.70, 0.83; $p < 0.001$). Both remote and more recent diet contributed to this relationship. Long-term adherence to the Mediterranean diet pattern was strongly related to lower subjective cognitive function decline.

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Gu et al., 2010 [77] USA Follow up 4 years Acceptable (+)	N = 1219 northern Manhattan residents, from Washington/Hamilton Heights-Inwood Columbia Aging Project II: WHICAP II Age: mean 76.7 ± 6.4 Male: 33.4% Clinical status: without dementia	Mediterranean diet	61-item version of Willett's semi-quantitative FFQ 0–9 Med Diet scoring system	Age, education, caloric intake, BMI, gender, smoking status at baseline, ethnic groups (non-Hispanic Black, Hispanic, non-Hispanic White or Other). APOE ε4 status	Cognition/Incidence of AD Cognition test used: the Selective Reminding Test; the Benton Visual Retention Test; the WAIS-R similarities subtest; the Dementia Rating Scale; the Rosen drawing test; the Boston Naming Test; the Boston Diagnostic Aphasia Examination; the phonemic fluency and category fluency test; AD criteria for the DSM-III-R and the NINCDS-ADRDA	Better adherence to MD tended to be associated with significantly lower risk for AD After adjustment for age, gender, race, and education, compared to subjects in the lowest tertile of MD score, HR (95% CI) for subjects in the highest tertile was 0.66 (0.41, 1.04) after multivariable adjustment, $p = 0.04$. Additional adjusting for other factors (including APOE ε4, comorbidity, smoking status, caloric intake, and BMI), the results were essentially the same: the HR (95% CI) comparing subjects in the highest tertile to the lowest was 0.66 (0.41, 1.06), $p = 0.06$.
Koyama et al., 2015 [78] US Follow up 7.9 years Acceptable (+)	N = 2,326, from the Health, Aging, and Body Composition (Health ABC) study Male (%): 48.7% Age 70–79 years Clinical status: Exclude non-AD dementia, schizophrenia, bipolar disorder, significant current depression, Parkinson's disease, cancer (other than basal cell skin carcinoma) within the last 2 years, symptomatic stroke, insulin-dependent diabetes, uncontrolled diabetes mellitus or current regular alcohol use exceeding two standard drinks per day women or four per day men	Mediterranean diet (from Mediterranean Diet score)	modified 108-item Block FFQ. interviewed by trained examiners. 0–55 Med Diet score;	APOE ε4 status, BMI, current smoking, physical activity, depression, and diabetes, age, sex, education, total energy intake	Cognition/cognitive decline Cognition test used: Repeated 3MS score, validated interviewer-administered instrument measuring several cognitive domains including orientation, registration, attention, recall, and visuospatial ability.	Among blacks, participants with high Med Diet scores had a significantly lower mean rate of decline on the 3MS compared with participants with lower Med Diet scores (middle and bottom tertiles). The mean difference in points per year was 0.22 (95% CI: 0.05, 0.39; $p = 0.01$) after adjustment. No association between Med Diet scores and change in 3MS score was seen among white participants ($p = 0.14$).

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Morris et al., 2015 [79] USA Follow up 4.5 years High Quality (++)	N = 923 participants From retirement communities and senior public housing, the Rush Memory and Aging Project Age: 58–98 mean age 81 Male (%): 25% Clinical status: free of dementia	MIND diet DASH diet Mediterranean diet	144-item validated SFFQ. 0–15 MIND diet scoring system, 0–10 DASH dit scoring system, and 0–55 Med Diet scoring system	Age, education, APOE $\varepsilon 4$ genotyping, physical activity, BMI, depressive symptoms, HTN history, Myocardial Infarction history, diabetes history, medication, stroke, total energy intake	Cognition/cognitive decline Cognition test used: 19 neuropsychological tests included measures of orientation, attention, memory, language and visual perception. AD diagnosis- criteria of the joint working group of the National Institute of Neurological and Communicative Disorders and stroke and AD and related disorders association.	In basic adjusted + cardiovascular condition model: Compared to 1st tertile, higher tertiles had lower rates of AD. For MIND diet: 2nd tertile (HR = 0.64, 95% CI 0.42, 0.97) and 3rd tertiles (HR = 0.47, 95% CI 0.29, 0.76) For DASH 3rd tertile (HR = 0.60, 95% CI 0.37, 0.96) For Mediterranean diet 3rd tertile (HR = 0.49, 95 % CI 0.29, 0.85) were associated with lower AD rates.
Scarmeas et al., 2009 [80] USA Follow up 4.5 ± 2.7 years High Quality (++)	N = 2364 from the Washington Heights-Inwood Columbia Aging Project (WHICAP) Age: mean 76.9 years Male (%): 32 Clinical status: Non-demented, community dwellers	Mediterranean diet	61-item version of Willett's semi-quantitative FFQ, 0–9 Med Diet scoring system	Cohort, age, sex, ethnicity, education, APOE $\varepsilon 4$ genotype, caloric intake, BMI, and duration between baseline dietary assessment and baseline diagnosis	MCI /AD incidence Cognitive test used: The neuropsychological battery: tests of memory (short and long-term verbal and nonverbal); orientation; abstract reasoning (verbal and non-verbal); language (naming, verbal fluency, comprehension and repetition); and construction (copying and matching). Clinical Dementia Rating (CDR) assigned. AD diagnosis by consensus clinical judgment, criteria of the NINCDS-ADRDA and DSM-III-R	Compared with subjects in the lowest Med Diet adherence tertile, subjects in the middle tertile had 17% less risk (HR = 0.83; 95% CI 0.62, 1.12; $p = 0.24$) of developing MCI and those in the highest tertile had 28% less risk (HR = 0.72; 95% CI 0.52, 1.00; $p = 0.05$) of developing MCI (HR = 0.85; 95% CI 0.72–1.00; $p = 0.05$). Assessment of the conversion from MCI to AD, showed compared with subjects in the lowest Med Diet adherence tertile, the middle tertile had 45% less risk (HR = 0.55; 95% CI 0.34, 0.90; $p = 0.01$) of developing AD and those in the highest tertile had 48% less risk (HR = 0.52; 95% CI 0.30, 0.91; $p = 0.02$) of developing AD (HR = 0.71; 95% CI 0.53, 0.95; $p = 0.02$).

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Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Scarmeas et al., 2006 [81] USA Follow up 4 ± 3.0 years High Quality (++)	N = 2258 from the Washington Heights-Inwood Columbia Aging Project (WHICAP) Age: mean 77.2 ± 6.6 years Male (%): 32 Clinical status: community-based, non-demented	Mediterranean diet	61-item version of Willett's semi-quantitative FFQ, 0–9 Med Diet scoring system	Cohort, age, sex, ethnicity, education, APOE ε4 genotype, caloric intake, smoking, medical comorbidity index, and BMI	Cognition/ Incidence of AD Cognitive test used: Cognitive battery administered covering memory, orientation, abstract reasoning, language and construction. AD diagnoses were made by consensus clinical judgment, criteria of the NINCDS-ADRDA and DSM-III-R	Higher adherence to the Med Diet was associated with lower risk for AD (HR, 0.91; 95% CI, 0.83, 0.98; $p = 0.015$). Compared with subjects in the lowest Med Diet tertile, subjects in the middle Med Diet tertile had a HR of 0.85 (95% CI, 0.63, 1.16) and those at the highest tertile had a HR of 0.60 (95% CI, 0.42, 0.87) for AD ($p = 0.007$).
Tangney et al., 2011 [82] USA Follow up 7.6 years Acceptable (+)	N = 3790 from Chicago Health and Aging Project Age: mean 75.4 ± 6.2 year Male (%): 38.3 Clinical status: Nil. 60.2% of the sample was black	Mediterranean type diet or Healthy Eating Index 2005 (HEI-2005)	Modified Harvard 139 question food frequency questionnaire. 0–55 Med Diet score; The HEI-2005 is a 12-component measure of dietary quality range 0–100 scores	Age, sex, race, education, participation in cognitive activities and total energy intake (kcal; for Med Diet and Med Diet wine scores), and the interaction between time and each variable, estimate the influence of adherence to Med Diet wine score on rates of within-person change in cognitive score over time also included total alcohol intake.	Cognition/Cognitive decline Cognitive test used: East Boston tests of immediate and delayed recall, the MMSE, and the Symbol Digit Modalities Test.	Higher Med Diet scores and Med Diet wine scores associated with reduced declines in cognitive function ($p = 0.0004$, and $p = 0.0009$, respectively). No associations observed for HEI-2005 scores.

(*continued*)

Table 3
(*Continued*)

Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Tsivgoulis et al., 2013 [83] USA Follow up 4.0 ± 1.5 years High Quality (++)	N = 17,478 from the Reasons for Geographic and Racial Differences in Stroke (REGARDS) cohort Age: 64.4 ± 9.1 (range 45–98) Male (%): 43 Clinical status: No history of stroke, non-impaired cognition at baseline	Mediterranean diet	Self-administered Block 98 FFQ and two 24-hour recalls 0–9 Med Diet scoring system	Age, race, sex, region of residence, BMI, waist circumference, household income, education, smoking status, alcohol use, physical activity level, history of heart disease, diabetes mellitus, atrial fibrillation, systolic blood pressure, diastolic blood pressure, high cholesterol, antihypertensive regimen, perceived general health status, and depressive symptoms.	Cognition/ Incident Cognitive Impairment (ICI) Cognitive test used: Six-item Screener (SIS)	Higher adherence to Med Diet was associated with lower likelihood of(ICI)(OR 0.87; 95% CI 0.76, 1.00). There was no interaction between race ($p = 0.2928$) and association of adherence to Med Diet with cognitive status. Interaction effect of diabetes found ($p = 0.0134$) on the relationship between adherence to Med Diet with ICI; high adherence to Med Diet was associated with a lower likelihood of ICI in nondiabetic participants (OR 0.81; 95%CI 0.70, 0.94; $p = 0.0066$) but not in diabetic individuals (OR 1.27; 95% CI 0.95, 1.71; $p = 0.1063$).
Hayden et al. 2017 [84] USA Follow up 9.7 years Acceptable (+)	N = 7085 women From Women's Health Initiative Memory Study (WHIMS) Age: (65–79 years), mean age 71 Male (%): 0% Clinical status: Without MCI	Inflammatory diet, by Dietary Inflammatory Index (DII) scores	WHI FFQ based on block FFQ, 32 food parameters Dietary pattern analyzed using DII method to generate weighted scores for inflammatory effect	Age, education, total energy intake, BMI, physical activity, history of non-steroidal anti-inflammatory drug APOE ε4, race, baseline self-reported diabetes, high cholesterol, HTN and smoking	Cognitive decline/Incidence of MCI and PD Cognition test used: MMSE, the Consortium to Establish a Registry for Alzheimer's Disease battery, Trail making test part A and B, Structured psychiatric interview (PRIME-MD), cognitive and behavioral changes interview, Modified TICS, East Boston Memory Test, Digit Span and Verbal Fluency -Animals, Dementia Questionnaire	High Dietary Inflammatory scores associated with greater cognitive decline and earlier onset of MCI. Adjusted hazard ratios comparing lower (anti-inflammatory; group 1 referent) to higher dietary Inflammatory scores were group 2-HR: 1.01 (0.86, 1.20); group 3-HR:0.99 (0.82, 1.18); group 4- HR:1.27 (1.06, 1.52)

(*continued*)

Table 3
(*Continued*)

Author, year, Location, Length of follow-up, Quality of Study	Participants and setting	Type of diet studied	Dietary intake assessment	Confounders accounted for	Outcome/Measurement of outcome	Key Findings
Wengreen et al. 2009 [87] USA Follow up 11 years High Quality (++)	$n = 3634$ from the Cache County Study on Memory and Aging (CCMS) study Age: >65 mean 74.6 years Male (%): 42.7 Clinical status: non-demented	Overall diet quality and variety from recommended food score (RFS) according to dietary guidelines for Americans	142-item modified version of the FFQ used in the Nurses' Health Study	Education, age at baseline, gender, APOE ε4 genotype, physical activity, use of multivitamin/mineral supplements, total energy intake, activity of daily living, BMI, history of usual alcohol intake, smoking, and history of diabetes, stroke, and heart attack at the baseline interview	Cognitive function and cognitive decline Cognitive test used: The 100-point 3MS for dementia screening and cognitive function	After 11 y of follow-up, those with the highest RFS declined by 3.4 points over 11 y compared with the 5.2-point decline experienced by those with the lowest RFS ($p = 0.0013$).
Smyth et al. 2015 [88] Canada Follow up 56 months Acceptable (+)	N = 27860 From the ONTARGET (Ongoing Telmisartan Alone and in Combination with Ramipril Global Endpoint Trial) and TRANSCEND (Telmisartan Randomised Assessment Study in ACE Intolerant Subjects with Cardiovascular Disease) Age: mean 66.2 ± 7.1 Male: 70.8% Clinical Status: with a history of one or more of coronary, cerebral, or peripheral artery disease, or high-risk diabetes. Exclude acute coronary syndrome, acute stroke, congestive heart failure, or important renal insufficiency	Diet quality measured using the modified AHEI	20- item FFQ. The mAHEI was developed to measure overall diet quality according to dietary guidelines	Age, BMI, blood pressure, baseline MMSE score, sex, trial enrolment, treatment allocation, geographical region, education, smoking, physical activity, medical history including stroke/TIA, hypertension, diabetes mellitus, and myocardial infarction], and medication use -statin, β-blocker, antithrombotic.	Cognition/cognitive decline Cognition test used: MMSE Cognitive decline defined as 3 or more points decrease in MMSE any anytime during follow-up.	During 56 months of follow-up, 4,699 cases of cognitive decline occurred. Lower risk of cognitive decline among those in the healthiest dietary quintile of modified Alternative Healthy Eating Index compared with lowest quintile (HR 0.76, 95% CI 0.66, 0.86, Q5 versus Q1). ($p < 0.01$). Lower risk of cognitive decline was consistent regardless of baseline cognitive level.

3MS, Modified Mini mental State Examination; AD, Alzheimer's disease; AHEI, Alternate Healthy Eating Index; APOE, Apolipoprotein E; BMI, body mass index; CHO, carbohydrate; CVD, cardiovascular disease; CI, confidence interval; CRP, C-reactive protein; DASH, Dietary Approach to Stop Hypertension; DSM, the Diagnostic and Statistical Manual of Mental Disorders; DSM-III-R, the Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition (DSM-III-R); FFQ, Food frequency questionnaire; GI, glycemic index; HEI, Healthy Eating Index; HDI, Healthy Diet Indicator; HTN, hypertension; HR, hazard ratio; MMSE, Mini-Mental Status Examination; Med Diet, Mediterranean diet; MCI, mild cognitive impairment; MIND, the Mediterranean-DASH diet Intervention for Neurodegenerative Delay; MDS, Mediterranean Diet Score; MSDPS, Mediterranean-Style Dietary Pattern Score; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association; OR, odds ratio; PCA, principal component analysis; PD, probable dementia; RFS, Recommended Food Score; SD, standard deviation; SFFQ, semi-quantitative food frequency questionnaire; SMMSE, Standardized Mini-Mental State Examination; TIA, transient ischemic attack; TICS, Telephone Interview for Cognitive Status.

Overall eight articles published results of more than one dietary pattern from the same cohort, and these are discussed separately under the appropriate dietary patterns.

Exposure and outcome assessment

Nutritional assessment tools to determine dietary pattern exposure varied. The most commonly used were the semi-quantitative Food Frequency Questionnaire (FFQ), or a food record or 24-h recall, either self-administered or researcher-administered, for both RCTs and cohort studies.

Most studies focused on cognitive change and used the Mini-Mental State Examination (MMSE) score or a neuropsychological test battery. Tests generally covered a broad range of cognitive skills including language, memory (short-term and working), visual perception, executive function, cognitive flexibility, global cognitive function, and cognitive processing. In detail, memory tests included recognition, immediate recall, delayed recall, face-name recall, paired associates, and semantic memory. Executive function tests included working memory, verbal fluency, reasoning, attention, and processing speed. Composite measures of episodic memory (e.g., immediate and delayed recall) were also included. Global cognition was measured using composite measures of cognitive function. Studies also investigated brain morphology using magnetic resonance imaging, or diagnosis of incident cases of MCI or dementia as assessed by neurologists or neurophysiologists.

Quality assessment

All RCTs received a high risk of bias due to the long-term nature of nutrition interventions and impossibility of complete double blinding. Among longitudinal studies thirteen received “High Quality” with remaining nineteen articles assessed as “Acceptable” (see Tables 1 and 3 for results from the Cochrane Risk of Bias and the SIGN 50 quality assessment).

Dietary patterns and cognitive health: A priori patterns

Mediterranean diet

RCTs in Mediterranean countries: Two RCTs which investigated the Mediterranean diet in Spain and reported positive outcomes, targeted those at high cardiovascular risk but without cardiovascular disease at baseline [63, 64], from the multicenter randomized prevention trial PREDIMED (PREvención con DIeta MEDiterránea) study. Both studies had high risk of bias due to the difficulty of blinding.

The earlier PREDIMED study [63] reported a positive link between Mediterranean diet supplemented with either extra virgin olive oil (EVOO) 1 L/week or raw mixed nuts (walnuts, hazelnuts, and almonds) 30 g/day and cognition which was assessed by MMSE and Clock Drawing Test (CDT) after 6.5 years, as well as a lower incidence of MCI and dementia compared to a control diet. In the more recent clinical trial conducted in a subcohort from PREDIMED, two intervention groups followed the Mediterranean diet supplemented with either EVOO (1 L/week) or mixed nuts (30 g/d) [64]. They were compared to a control group of those receiving dietary advice on a reduced fat diet. After a median follow up of 4.1 years, participants allocated to a Mediterranean diet plus EVOO scored significantly better than controls on the Rey Auditory Verbal Learning Test (RAVLT) and Colour Trail Test part2. The Mediterranean diet plus nuts group had significantly improved memory composite, while Mediterranean diet plus EVOO group had significantly better performance of the frontal and global cognition composites than control group.

Cohort studies in Mediterranean countries: Five cohort studies evaluated the Mediterranean diet and were conducted in the Mediterranean area (France $n = 2$, Italy $n = 1$, Spain $n = 1$, and Greece $n = 1$). All had acceptable study quality, and all supported a positive link between Mediterranean diet and better cognitive health in older adults.

Among those, four studies used MMSE or Telephone Interview of Cognitive Status (TICS) to measure cognition. The Three-City study reported that a higher Mediterranean diet score was associated with better MMSE performance but not with other cognitive tests on verbal/visual function or with incidence of dementia [65]. Similarly, The European Prospective Investigation into Cancer and Nutrition (EPIC) [66] reported an inverse association between adherence to the Mediterranean Diet and decline in MMSE scores. The Spanish SUN (Seguimiento Universidad de Navarra) cohort study [67] reported greater cognitive decline (as assessed by the TICS) in participants with low or moderate adherence to the Mediterranean Diet compared to those with higher adherence. The Italian Longitudinal Study

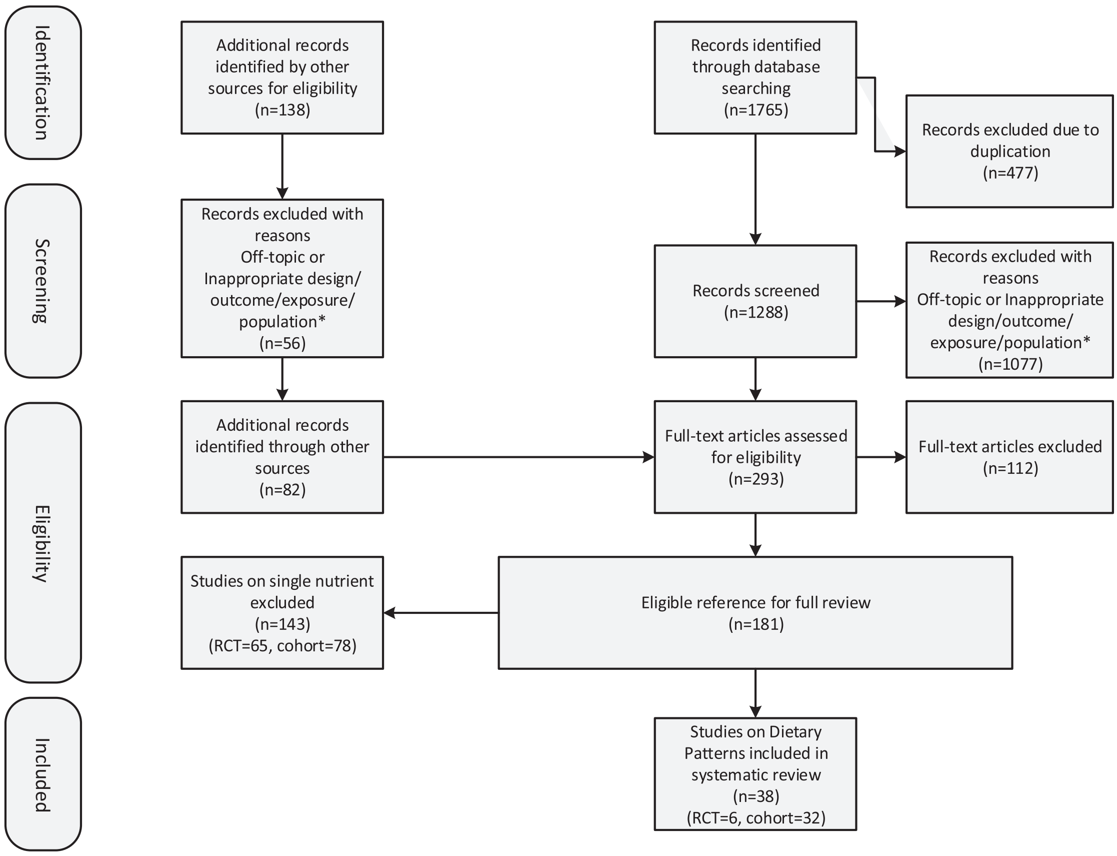

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram. *included those cognitive function assessed and followed up regardless of the time frame, to test cognitive function or brain morphology or incidence of MCI/dementia in older populations (>50 years at baseline), excluded those not published in English, or without full-text available, those with non-human participants, articles that did not assess cognition or brain morphology or incidence of MCI/dementia as outcome and cross-sectional studies.

on Aging (ILSA) reported that higher adherence to Mediterranean diet was associated with better MMSE scores among older adults [68] although cognition was not a primary outcome for this study.

In the SU.VI.MAX (Supplementation with Vitamins and Mineral Antioxidants) study, lower backward digit span and lower phonemic fluency scores were associated with poorer adherence to Mediterranean diet over 13 years [69], no effect was observed on composite cognition score.

RCTs in non-Mediterranean Western countries: The only RCT completed in a non-Mediterranean area was the Australian Medley study [70], which reported no evidence that Mediterranean diet benefited cognitive function compared to a habitual dietary intake after 6 months.

Cohort studies in non-Mediterranean Western countries: Fourteen cohort studies were undertaken in non-Mediterranean western countries, the majority from the US ($n = 11$). Five studies reported little to no association of adherence to the Mediterranean diet with cognitive decline [71–75]. However, the majority, nine studies [35, 76–83] provided evidence of statistically significant positive association between the Mediterranean diet and the protection of cognitive health.

Among those studies finding no effect, most received "High Quality" ($n = 3$) while the rest were "acceptable" ($n = 2$). Two studies that measured cognitive function using a cognitive test battery, were the Women's Antioxidant Cardiovascular Study (WACS) [71] which followed 2,504 participants with vascular disease or coronary risk factors for five years, and the US Nurses' Health Study which followed 16,058 stroke free female nurses at baseline for six years [73]. Three of these five studies looked at incidence of MCI or dementia as the primary outcome, including the PATH Through Life study in Australia which followed 1528 community dwelling participants for 4 years [72], the Uppsala longitudinal

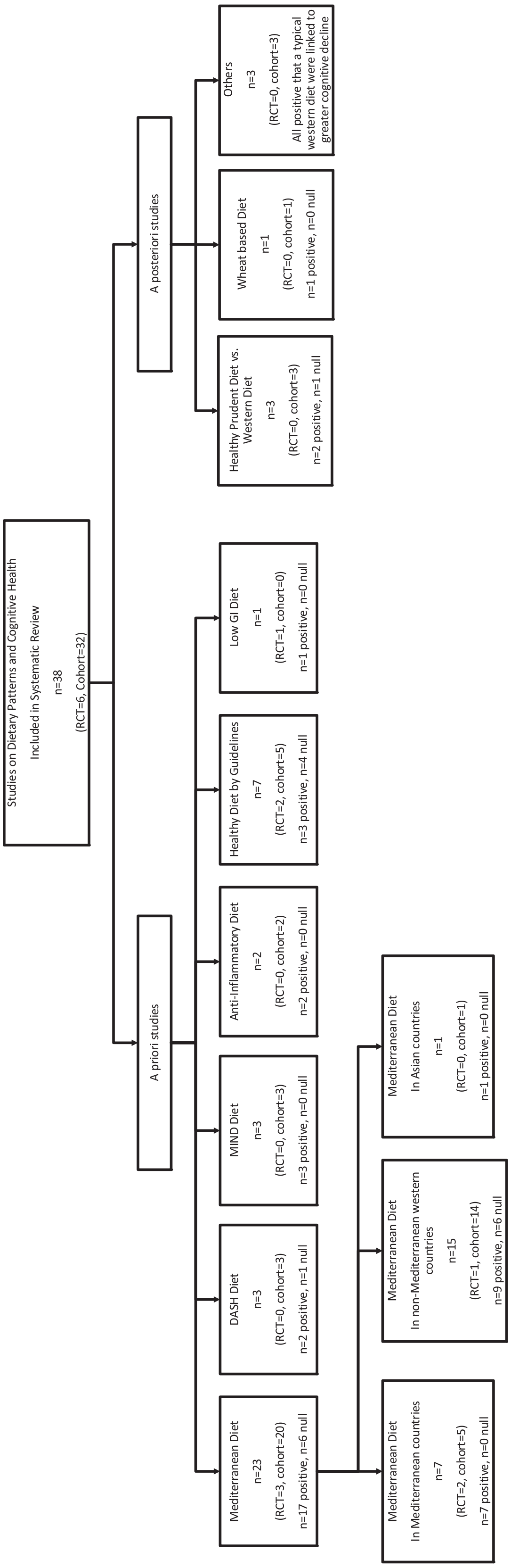

Fig. 2. Dietary patterns and study outcomes.

study that followed older men for 12 years [74], and the US Women's Health Initiative Memory (WHI) study which followed cognitively intact (at baseline) post-menopausal white women aged more than 65 years for 9 years [75]. Most results of the five studies were adjusted for apolipoprotein E (APOE) $\varepsilon 4$ genotype except for Nurses' Health Study [73] and WACS [71].

By contrast, nine cohort studies, of which five received "acceptable" study quality and four were ranked as "high quality", revealed statistically significant associations that the Mediterranean diet protected against cognitive decline in older adults.

Four of the nine studies assessed cognitive decline using either cognitive tests averaged for composite measure of global cognition [82], or modified MMSE (3MS) [78], a comprehensive neuropsychological battery [35], or a Subjective cognitive function questionnaire [76]. The Chicago Health and Aging Project (CHAP) reported higher Mediterranean diet scores were associated with slower rates of cognitive decline after an average 7.6 years follow up on 3790 participants aged 75.4 years on average at baseline [82], while The Health, Aging and Body Composition study in the US [78] reported varied findings among racial groups and positive effects from the Mediterranean diet was only observed among black but not white participants. By contrast, the Australian Imaging Biomarkers and Lifestyle study of Ageing reported no significant effects in subjects without MCI or AD at baseline, except for APOE $\varepsilon 4$ allele carriers, in whom higher Mediterranean diet scores were associated with less decline in executive functioning after 36 months [35]. The (male) Health Professionals' Follow-up study [76] reported that long-term adherence to the Mediterranean diet was strongly linked to lower subjective ratings of change in cognitive function. A limitation of this study is that cognitive function results had relied on subjective self-reporting of six "yes" or "no" questions, rather than performance-based methods [76].

Among the nine studies, five assessed incidence of MCI or AD as clinical outcome [77, 79–81, 83]. The US study Washington/Hamilton Heights-Inwood Columbia Aging Project (WHICAP) 1992 and WHICAP 1999 [77, 80, 81] found that higher adherence to the Mediterranean fiet was associated with reduced risk for developing MCI or AD. Similar conclusions were drawn from The Reasons for Geographic and Racial Differences in Stroke Study (REGARDS) which followed up 17,478 participants, mean age 64.4 years and cognitively intact with no history of stroke at baseline, for 4 years [83], and reported high adherence to Mediterranean diet was associated with a lower likelihood of incident cognitive impairment in nondiabetic but not diabetic individuals. Moreover, in the Rush Memory and Aging Project (MAP), the highest tertile of Mediterranean diet scores were found to have lower AD rates [79].

Cohort study in Asian countries: Only one longitudinal cohort study conducted in Asia [59] with acceptable study quality found a benefit for a Mediterranean-like diet, modified to suit local eating habits (Table 5). The diet shared similar characteristics with the Mediterranean diet such as high consumption of fruits, vegetables, and grains, as well as low consumption of meat and dairy foods. Qin et al. reported that among the 1,650 community dwelling persons more than 65 years old followed for 5.3 years, those in the highest tertile had a slower rate of cognitive decline than people in the lowest tertile of the adapted Mediterranean diet.

DASH diet

The three studies that examined the effect of adherence to the DASH diet on cognitive health in later life reported mixed results [18, 75, 79]. The majority of the studies received a "high quality" rating ($n = 2$).

Two studies reported positive effects from the DASH diet [18, 79]. The Rush Memory and Aging Project followed-up 923 elderly men and women mean aged 81.4 years old, and reported modest but positive links between the highest tertile of DASH diet adherence and lower rates of AD [79]. The Nurse's Health Study computed a long-term DASH score from five previous dietary assessments and reported greater adherence was associated with better composite scores of global cognition and verbal memory irrespective of APOE $\varepsilon 4$ [16]. However, during the next six years, no association between DASH scores and change in cognition were found [18]. By contrast, the Women's Health Initiative Memory Study (WHIMS) [75] reported that DASH scores were not associated with incidence of MCI or dementia in older women generally or in those with hypertension. Various cut-off scores for highest quintiles were selected including 28 [75] and 31 [18], respectively, for the 8–40 DASH scoring system [37] and 5 [79] was used for 0–10 DASH scoring system [56].

MIND diet

Three cohort studies, all with high study quality, found protective effects of the MIND diet on cognition.

The Rush Memory and Aging Project reported that moderate adherence to the MIND diet was associated with lower rates of AD [79], slower decline in a global cognitive score and five cognitive domains (episodic memory, semantic memory, perceptual organization, perceptual speed, working memory) [57]. The difference between highest and lowest quintiles in MIND scores was calculated to be equivalent to being 7.5 years younger in cognitive health [57, 79]. In addition, the US Nurse's Health Study [19], where 16,058 older women aged 70 and over were followed up for 6 years with multiple assessments of dietary intake and cognition, reported long-term adherence to the MIND diet was moderately associated with better verbal memory in later life, but not with global cognition, verbal memory or TICS. All studies adjusted for multiple covariates including APOE $\varepsilon 4$ and used the same 0–15 MIND scoring system [57], but had different MIND score cut-offs for highest quintiles [57, 79].

Anti-inflammatory/inflammatory diet

Two studies that investigated dietary patterns associated with inflammation, characterized by high consumption of foods such as red and processed meats, sweets, deserts, chips, and refined grains [31, 32], found significant impacts on cognitive function; however, divergence in results were reported for different age groups [23, 84]. Among the two studies, one was of high quality while the other received an "acceptable" quality assessment rating.

The Whitehall II cohort study [23] followed 5,083 participants whose median age was 56 years for 10 years. They reported higher intake of an inflammatory dietary pattern was associated with accelerated cognitive decline. The greatest decline in global cognition and reasoning was found in the highest tertile of inflammatory diet when compared to lowest tertile. In an age-stratified analysis, higher inflammatory scores were linked to significantly faster cognitive decline in reasoning in the age <56 group, while no significant association was found among those aged 56 and older.

The WHIMS researched the inflammatory pattern [84] by following up 7,085 women aged at 65–79 years for 9.7 years with annual cognitive function assessments. They found that higher dietary pro-inflammatory scores were associated with greater cognitive decline and earlier onset of MCI, after adjustment for multiple covariates. This study suggested the existence of a possible threshold effect.

Healthy diet recommended by dietary guidelines

Two RCTs [85, 86] (both with high risk of bias) and five cohort studies (high quality $n = 2$ and acceptable quality $n = 3$) investigated diets complying with the dietary guidelines of national peak bodies or the World Health Organization's Healthy Diet Indicator tool. Mixed results were reported and three studies [85, 87, 88] found associations with cognitive benefits.

The Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER), a randomized 2-year multi-domain lifestyle intervention trial [85, 89], assessed cognitive decline in 1,260 participants aged 60–77 years at baseline. This study reported cognitive benefits in groups which received dietary intervention together with exercise, cognitive training, and monitoring of vascular risk. In FINGER, dietary counselling was based on the Finish Nutrition Recommendations and a composite dietary intervention adherence score was generated based on the consumption of fruit, vegetables, fish, whole grain cereals, low fat milk, and meat products, as well as the limiting of sucrose intake and using vegetable margarine and rapeseed oil instead of butter [89] (see Table 2 for details).

A Hong Kong RCT [86] included 419 participants with mean age of 83 years living in old age hostels, and provided nutrition intervention including counselling and menu change, with a mean follow up time of 25 months. They reported that although nutrition interventions were effective in maintaining fruit and fish intake compared to control group, this did not result in a significant reduction in cognitive decline.

Four studies researched the effect of adherence to the dietary guidelines for Americans, using either the Recommended Food Score (RFS) [87], modified Alternative Healthy Eating Index (mAHEI) [88], HEI (Healthy Eating Index) -2005 [82], or HEI-2010 [75, 88]. The Cache County Study on Memory and Aging in US [87] evaluated effects on cognition of adherence to the RFS, which was developed to assess diet quality and food variety related to the dietary guidelines for Americans [90]. After 11 years follow up, those in the highest RFS quartile declined by 3.4 points compared with the 5.2 point decline in those in the lowest RFS quartile [87]. With regards to the mAHEI, lower risk of cognitive decline was found among those in the healthiest dietary quintile, compared with lowest quintile, regardless of baseline cognitive level [88].

No association with cognition change was observed in the CHAP study using HEI-2005 scores [82]. Similarly, the WHIMS reported no significant relationship between adherence to HEI-2010 or Alternate HEI-2010, with incidence of MCI or probable dementia in older women [75].

One of the five studies, the Uppsala longitudinal study, examined the HDI by following 1038 older men over 12 years and found no association between HDI and any of the cognition outcomes [74].

Low GI diet

Only one RCT (high risk of bias) examined the effect of GI on cognition by comparing healthy older adults or those with amnestic MCI allocated to high saturated fat, high GI or low saturated fat, low GI diets [91]. Both cognitive healthy and amnestic MCI participants had better scores on delayed visual recall with the low saturated fat, low GI combined diet, although not in immediate memory, executive and motor speed domains. However, a major limitation of this study is the small sample size ($n = 49$) and short intervention time (4 weeks) and the combination of effect from saturated fat and GI.

Dietary patterns and cognitive health: A posterori patterns

Prudent healthy diet versus Western diet

Findings from three cohort studies (high quality $n = 2$ and acceptable quality $n = 1$) of the Prudent healthy diet (see Table 3) reported mixed findings [35, 36, 58].

Two studies used factor analysis (principle components) to extract dietary patterns [35, 36]. The Australian Imaging, Biomarkers and Lifestyle (AIBL) Study of Ageing [35] reported no significant relationships between adherence to a computer generated Prudent healthy diet and cognition, measured by a comprehensive battery of neuropsychological tests either for global or single domain scores (see Table 3 for details) [92]. By contrast, The Swedish National study on Aging and Care-Kungsholmen (SNAC-K) [36] found that the highest adherence to their *Prudent healthy diet* was related to less MMSE decline, and highest adherence to a Western dietary pattern was associated with greater MMSE decline. The decline associated with the Western diet was attenuated when accompanied by higher adherence to *Prudent healthy diet* [36, 92]. However, as these diet patterns were computer generated and based on the subjects consumption patterns, the definition of the *Prudent healthy diets* differed between studies with AIBL emphasizing nuts, tomatoes, potatoes and garlic as single food groups whereas SNAC-K study defined a *Prudent healthy diet* by the inclusion of cereals legumes, rice/pasta, water and cooking/dressing oil [35, 36].

In addition, the first and only human longitudinal study that investigated the impact of diet on changes in magnetic resonance imaging (MRI) over time is the Personality and Total Health Through Life Study, which focused on a subsample of 255 participants aged 60–64 years at baseline with two MRI scans 4 years apart. This study reported that a Western diet, characterized by lower intakes of naturally nutrient-dense foods and higher intakes of unhealthy foods was associated with smaller left hippocampal volume [58].

Wheat-based diverse diet

The China Health and Nutrition Survey, with acceptable study quality, assessed a wheat-based diverse diet, derived by factor analysis. The top tertile was associated with slower annual decline in global cognitive function [59] among adults 65 years and older. The wheat based diverse diet shared some features of the Mediterranean diet, and was characterized by high intakes of wheat buns, deep-fried wheat, nuts, fruits, moderate- to high-fat red meat, poultry and game, egg, fish, dairy, sugar, vinegar, soy sauce, plant oil, and with low intake of animal-source cooking fat.

Others

Three cohort studies [60–62] investigated the impact of other dietary patterns from *a posteriori* statistical approaches, and reported mixed results. Overall dietary patterns that shared features of a typical Western diet were linked to greater cognitive decline consistently across all studies.

Among the prospective cohort studies, Gu et al. reported in 2010 that the dietary pattern which was found to be protective against the development of AD had higher consumption of salad dressing, nuts, fish, tomatoes, poultry, cruciferous vegetables, fruits, dark and green leafy vegetables, with lower intake of high-fat dairy, red meat, organ meat, and butter [60]. Dietary patterns were derived by reduced rank regression, using predetermined food groups as predictor variables and seven potentially AD-related nutrients as response variables (see Table 3 for details).

In the UK Newcastle 85+ cohort study, dietary patterns (DPs) derived by cluster analysis that differed in intake of red meat, potato, gravy, and butter, were studied for their effect on cognition [61]. When compared with DP2 group (low meat intake, high intake of fruits, vegetables, fish, nuts, whole grains and dairy), men in DP1 group (high red meat, gravy and potato dishes, low in butter) scored worse in initial attention and MMSE, and DP3 (high butter intake and low in unsaturated fats, moderate intake of red meat) was associated with a 3.2-fold increased risk of cognitive decline despite APOE ε4 status. Both DP1 and DP3 had overall worse concentration and focused attention.

A prospective cohort study in Taiwan researched three dietary patterns characterized as vegetable, meat based, or traditional. High score "traditional" pattern was found to protect against decline in logical memory-recall I [62]. Mixed results were reported on the other two patterns: the moderate or high score "vegetable" pattern was significantly associated with less decline of logical memory, although high score "vegetable" pattern was linked to greater decline in executive function. A high-score "meat" pattern was related to decline of verbal fluency, but protection against attention decline [62].

DISCUSSION

Of studies included in this review, the Mediterranean diet was the most investigated with evidence supporting protection against cognitive decline among older adults. Research on other diets such as the MIND, DASH, and Anti-inflammatory diets was more limited but showed promising beneficial results, especially for the MIND diet which received a high quality rating for all three studies [93].

Within studies on the Mediterranean diet, there were differences in outcomes between Mediterranean and non-Mediterranean countries. This suggests that the effects of diet on cognition are complex and likely to vary across geographic, cultural, or sociodemographic contexts [94–97]. For example, cultural values and lifestyle in the Mediterranean area, such as social connection and sense of community, meals being traditionally cooked at home using slower cooking methods such as boiling and stewing, enjoyed slowly and mindfully, meal times shared with family and friends rather than rushing through the meals or eating in front of a screen [8], may partly explain the discrepancies observed in studies. The supportive evidence of a modified Mediterranean diet in Asian countries, suggests the possibility of adapting the principles of a Mediterranean diet to suit local foods, culture, and eating habits [59].

Discrepancies of results in western countries may result from cultural and demographic diversity of the populations being studied [94]. For example, the Australian RCT Medley study, while based on a multicultural population, included only 70 of 137 (51%) participants born locally, and the comparison habitual diet may not have been a typical Western diet. Secondly, more highly educated participants (such as in [71, 73, 98]), are more likely to be living a healthier lifestyle and perform better on cognitive tasks. Many studies controlled for education and lifestyle factors but residual confounding and the impact of clustering of health behaviors may remain. Cognitive decline may be harder to detect in these groups requiring sensitive cognition tests and longer follow up [70]. Studies that excluded people with potential underlying health issues, targeting generally healthy participants [73, 78] may be less likely to detect a protective effect from the Mediterranean diet on cognition than those that included participants at risk of cardiovascular disease, as modification of cardiovascular risk factors may alter rates of cognitive decline [75]. In summary, differences in protective outcomes with the Mediterranean diet may result from differences in populations with respect to their culture or education, general health, level of physical activity, and specifically their risk of cardiovascular disease, and baseline cognition.

One potential mechanism by which the Mediterranean diet may protect against cognitive decline is through improving vascular health and preventing cardiovascular diseases due to its richness in poly-/mono- unsaturated fats [99]. A diet rich in poly-/mono-unsaturated fat improves insulin sensitivity, has an anti-diabetic effect [100–102] and lowers cardiovascular disease risk. Anti-diabetic effects of diet may also benefit cognition by maintaining relatively stable brain glucose levels; even small changes in glucose levels can alter metabolic homeostasis, which has been consistently linked to insulin resistance and cognitive impairment in older individuals [33, 103]. In support of the impact of fat quality, the positive association between the Mediterranean diet and cognition disappeared when monounsaturated fat: saturated fat ratio (MUFA:SFA) was excluded from the Mediterranean diet scoring system [104], suggesting that there is an important role of high MUFA:SFA ratio for protection of cognition [67].

The positive link between the Mediterranean diet and cognition protection may be also due to the higher consumption of antioxidants, as brain oxidative stress is associated with neurodegeneration [38]. Antioxidants in Mediterranean diets include phenolic compounds, and anti-inflammatory agents such as omega 3 fatty acids. Importantly urinary polyphenol excretion, a biomarker of adherence to the Mediterranean diet [105], has been associated with better memory, indicating the likelihood that phenolic compounds may benefit cognition in older adults [106]. In addition, EVOO consumption, compared to regular olive oil and other vegetable oils [107, 108], has resulted in significantly lower plasma inflammatory markers and increased anti-oxidant capacity [109, 110]. This is consistent with the PREDIMED study [63, 64] findings that a Mediterranean diet plus EVOO, or nuts, resulted in better cognition performance, indicating that the quality of oil as determined by the level of anti-oxidant and anti-inflammatory agents is important. It remains unclear as to what is an adequate therapeutic amount of EVOO and how long it needs to be taken to protect against cognitive decline, despite a recent trial reporting that 12 months of EVOO (26 g) to replace all vegetable oil (olive oil, high-oleic safflower oil, high-oleic sunflower oil, canola oil and hydrogenated vegetable oils) in Mediterranean diet may benefit-cognition [111].

Likewise, long-term inflammation might damage the blood-brain barrier leading to cognitive impairment, and increase the risk of neurodegenerative diseases [24], as higher levels of circulating inflammatory markers are associated with greater cognitive decline [112, 113]. Anti-inflammatory diets were associated with slower cognitive decline in older adults, however, the effect varied with age [23, 84]. Ozawa et al. reported a significant protective effect only in those under 56 years [23] while Hayden et al. reported protection against cognitive decline for those above 65 years [84]. Contributing factors to the difference may include different research methods such as selection of inflammatory diet scoring system. While one is based on specific food-based loading factors associated with one inflammatory marker [23], the other used the DII (Dietary Inflammatory Index) system, which includes a set of eight pro-inflammatory nutrients, 19 anti-inflammatory nutrients, and "10 whole foods and spices, caffeine, flavones, flavonols, flananones, anthocyanidins and isoflavones" [32, 84]. Selection of cut-points for tertiles may also make a difference as a possible threshold effect was suggested [84].

Similarly, the benefits of MIND and DASH diets could also be related to their richness in mono-/poly-unsaturated fats, anti-oxidant, anti-inflammatory, and anti-diabetic effects. The low GI diet has also been commonly used for its anti-diabetic effects [33]. Additionally, the DASH diet is effective in managing hypertension [17], which may confer greater benefit in older people at higher cardiovascular risk [16]. Interestingly, when comparing low-fat dairy intake, the DASH diet requires "moderate to high consumption, 2-3 serves daily", while the Mediterranean diet requires "low consumption". The role of low-fat dairy with a Mediterranean diet remains uncertain, and differences in dairy intake might contribute to inconsistent results from the Mediterranean diet in western countries when compared to DASH diet, thus further research on the role of low-fat dairy on cognitive health is required [114]. When compared to the Mediterranean diet, the MIND diet emphasizes berry and nut intake, as well as scoring unhealthy food groups, and whilst it has shown consistent protective effects [57, 79], this requires further investigation.

Divergent results from research on *the Prudent healthy diet* may be due to the nature of *a posteriori* studies, as dietary patterns were generated by data reduction methods, based on different populations and different subjects consumption pattern. Other factors may include dietary assessment tools and differences in cut-off and factor loadings selected [35, 36]. In brain imaging studies, longer follow-up time may be needed particularly to separate dietary and aging effects on brain atrophy [58].

Encouragingly, the potential detrimental effects on cognition in older adults from unhealthy foods in a Western diet such as fast food meals, sugary drinks, and fatty snacks may be corrected greatly by adding healthier options such as fruits, vegetables, nuts, and whole grains [36]. This suggests the importance of more healthy dietary patterns with foods naturally rich in nutrients, even when Western diets have been mostly followed previously.

Overall, the dietary patterns that were found to be protective against cognitive decline, are plant-based, rich in poly- and mono-unsaturated fatty acids with reduced consumption of processed foods. As we focused on dietary patterns, a comprehensive review of the effects of single food groups on cognition among older adults is outside the scope of this article. However, several studies of dietary patterns further analyzed their results to determine which components may be key to cognitive protection, and mixed results have been reported. For example, vegetable consumption, compared to other Mediterranean food components [104], was shown to have a significant inverse association with cognitive decline [66], which is in line with earlier research on vegetables and cognition [115, 116]. On the other hand, moderate alcohol consumption and a high ratio of MUFA:SFA were also found to have a weak association with cognition. Of DASH diet components, vegetables, nuts, and legumes appear to be the key components [18]. Examination of MIND food group components and their impact on outcomes demonstrated that excluding high saturated fat components attenuated the association between the MIND score and verbal memory, perhaps because less saturated fat results in a higher MUFA:SFA [19]. Relationships of other foods with anti-inflammatory effects and cognitive health were also studied [115–120]. A link between fermented food and pickles and protection against logical memory decline is currently under investigation [62]. The effect may be seen as an anti-inflammatory effect [121], or explained by anti-oxidants and possibly probiotics like lactic acid bacteria in pickled foods, highlighting the need for further research on the relationship between probiotics, gastrointestinal health, and cognition [62].

We identified limitations common to many studies. Firstly, long-term medications, e.g., hypolipidemic, anti-hypertensive, anti-diabetic, and anti-cholinergic drugs, were only adjusted for in a few studies [63, 64]. Secondly, most studies only assessed dietary intake at baseline, which introduces performance bias, as dietary intake may change over the years of a trial, due to a change of eating habits secondary to medications, influences from society, friends, and family members and high risk for or diagnoses of medical conditions such as diabetes, hypertension, and cardiovascular disease [71]. In some studies, cognitive function was not assessed at baseline precluding assessment of the impact of the intervention on cognitive change over the years, although inferences may be drawn from looking at differences in cognitive function between groups at follow up [63]. Thirdly, for those with shorter follow up times the findings may reflect reverse causality, as cognitive impairment and AD are preceded by relatively long periods of subclinical cognitive decline which could influence eating patterns [69]. Fourthly, only 20 of the 38 studies adjusted for the APOE $\varepsilon4$ allele which is a major genetic risk factor for more rapid cognitive decline and earlier onset of dementia. Fifthly, it is not possible to adjust for all known risk factors, and future studies should consider including physical activity levels, obesity, diabetes, smoking, and alcohol as covariates. Sixthly, there are no standard cut-offs for diet adherence scores, for example, Mediterranean diet adherence scores. As tertiles were used, cut-off points varied [19, 35, 59, 75, 77–79]. Future research is needed to determine the cut-off points for the level of adherence required to generate an effect [59, 78]. Seventhly, a common limitation among all RCT studies is, the single blinded nature, as due to the nature of nutrition trials using foods, it is not feasible to double blind RCTs for long term studies into nutrition interventions. Finally, there is limited evidence from longitudinal or intervention studies on associations between dietary patterns and neuro imaging outcomes [58]. Continuing research with longer follow up of older people may provide insight and better understanding on the changes in brain morphology, activity and function, in addition to cognitive function tests outcomes.

Future trials and observational studies should investigate the effectiveness of food components as well as the whole diet, take APOE $\varepsilon4$ genotype into consideration as well as multiple covariates, such as gender, age group (from >50 years to >85), medical conditions, gastrointestinal health, and report use of medications or nutrition supplements due to chronic conditions. Validated dietary assessment tools should be employed multiple times throughout long follow ups with analysis on dietary change over the years, and a comprehensive cognitive battery and neuro imaging included for outcome assessment.

Conclusion

This review adds to previous reviews in that it includes for the first time, higher level of evidence from six RCTs and 32 cohorts which were classified into different dietary patterns and investigated the potential effect of different diets on cognitive function among older adults. Overall, the findings support positive relationships between dietary patterns which are plant-based, rich in poly/monounsaturated fatty acids with reduced consumption of processed foods and cognitive health in older adults. More research is required for better understanding of the underlying mechanisms and effectiveness, in order to develop comprehensive and practical nutrition interventions and dietary recommendations to protect against cognitive decline and dementia with aging.

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SUPPLEMENTARY MATERIAL

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