|  |
| --- |
| **Supplementary Table 1.** Search terms used in PubMed MEDLINE |
| (("Red Meat"[MeSH Terms] OR "Meat Products"[MeSH Terms] OR (("meat"[Title/Abstract] OR "meats"[Title/Abstract]) AND "red"[Title/Abstract]) OR ("beef"[Title/Abstract] OR "veal"[Title/Abstract] OR "bison"[Title/Abstract]) OR ("beeves"[Title/Abstract] OR "veals"[Title/Abstract])) NOT "Ruminants"[MeSH Terms]) AND ("Nervous System"[MeSH Terms] OR "Diagnostic Imaging"[MeSH Terms] OR "Diagnostic Imaging"[MeSH Subheading] OR "image processing, computer assisted"[MeSH Terms] OR ("MRI"[Title/Abstract] OR "magnetic resonance imaging"[Title/Abstract] OR "resting-state MRI"[Title/Abstract] OR "resting state magnetic resonance imaging"[Title/Abstract] OR "diffusion tensor imaging"[Title/Abstract] OR "resting state magnetic resonance imaging"[Title/Abstract] OR "volume analysis"[Title/Abstract]) OR "diagnostic techniques, neurological"[MeSH Terms]) |
| Filtered to humans only |

|  |  |
| --- | --- |
| **Supplementary Table 2.** References of excluded studies at the full-text screening level | |
| **Citation** | **Reason for exclusion** |
| (1–24) | Exposure not adequately specified |
| (25–27) | Incorrect exposure |
| (28–32) | Outcomes exclude cognition |
| (33) | Outcomes not adequately specified |
| (34) | Exposure not measured in relation to outcome |

|  |  |  |
| --- | --- | --- |
| **Supplementary Table 3.** Descriptions of variables captured from the included studies in the final database | | |
| **Variable** | **Description** | **Variable Type** |
| **Study-level information** | | |
| Index | Order articles were entered into the database | Numeric |
| Citation | Last name of the first author and year of publication | Free text |
| Source | Traverse Science reference for which search a particular study came from | Free text |
| Title | Title of paper | Free text |
| Year | Publication year | Numeric |
| Journal | Title of journal | Free text |
| Authors | Last Name, Initials of first author | Free text |
| Abstract | Type of research article | Free text |
| PMID | PubMed ID of the article | Numeric |
| DOI | DOI of the article | Free text |
| Study Type | Whether the study was an intervention or observational | Categorical;Qualitative |
| Study Design | Whether the study was a parallel-arm, single-arm or crossover trial, or if observational by type, was cross-sectional, cohort, or case-control | Categorical;Qualitative |
| Study Notes | Additional details about the study type and/or design | Free text |
| Subject Location, Country | Country where participants of the study were located | Multi-categorical |
| Sex | Biological sex of participants enrolled in the study | Categorical;Qualitative |
| Age Category | Whether the participants/subjects were infants (<3 years), children (3-11 years), adolescents (12-17 years), adults (18-64 years), or seniors (65+ years) | Multi-categorical;Qualitative |
| Cognitive Status at Baseline | Whether the subjects were selected at baseline to include cognitive-related impairments or were at risk of cognitive-related impairments | Multi-categorical;Qualitative |
| Total vs Component | Whether the beef/red meat intake was reported as total diet or a component thereof | Categorical;Qualitative |
| Subject Notes | Additional details about subjects which may be important | Free text |
| Intervention Sample Size, Randomized | The total number of subjects who were randomized to a treatment group | Quantitative |
| Intervention Number of Trial Arms | The number of intervention groups included in the trial | Quantitative |
| Randomization | Whether or not study was randomized | Categorical;Qualitative |
| Randomization Factor(s) | Factors used (if any) to randomize participants into group assignments | Categorical;Qualitative |
| Subjects Blinded | Whether the subjects were blinded in the trial | Categorical;Qualitative |
| Researchers Blinded | Whether the researchers were blinded in the trial | Categorical;Qualitative |
| Data Analysts Blinded | Whether the were data analysts blinded in the trial | Categorical;Qualitative |
| Intervention Duration | The duration of the intervention trial. For cross-over trials, this is the length of each arm. | Quantitative |
| Intervention Duration Unit | Unit of intervention duration (*e.g.*, days, weeks, months) | Categorical;Qualitative |
| Intervention Duration in Months | All intervention duration units converted to the same unit of measure i.e., months | Quantitative |
| Clinical Trial Registration No. | The registration number of the trial, if registered | Numeric |
| Observational Sample Size, Analyzed | The total analytical sample size | Quantitative |
| Max FU Time, Cohorts | How long the study followed-up with participants for ascertainment of the outcome | Quantitative |
| FU Time Unit | Unit of follow-up time (*e.g.,* days, weeks, months) | Categorical;Qualitative |
| Max FU Time in Months | All FU time units converted to the same unit of measure i.e., months | Quantitative |
| Parent Study | If the study is analysing data from a larger study or cohort | Free text |
| Cognition Assessment Tool | The name of the assessment tool and/or methods that were used to assess cognition as reported in the paper | Multi-categorical;Qualitative |
| Notes | Additional notes regarding the measured outcomes or study conclusions | Free text |
| Overall Risk of Bias | The level of risk for potential bias in the study (*e.g.*, low, moderate, high) | Categorical;Qualitative |
| **Group Level** | | |
| Index | The order in which studies were entered into the database | Numeric |
| Citation | Last name of the first author and year of publication | Free text |
| Title | The title of the paper | Free text |
| Group No. | A number (1, 2, 3, etc.) given to each subset of meat category with associated data | Numeric |
| Group Identifier | A label/tag given to each subset of meat category with associated data (where applicable) | Free text |
| Concentration As | Whether the beef/red meat concentration was reported as a categorical intake or a specific mean value was provided | Categorical;Qualitative |
| Meat Form (as specified in the text) | The meat type/form as provided in the paper *e.g.*, red meat, red and processed meat | Free text |
| Meat form, Condensed | The meat type/form categorized into one of the following groups: beef only, red meat includes beef, red meat unspecified | Categorical;Qualitative |
| Group Sample Size | The number of subjects/participants in a specific group, as specified in “Group Identifier” | Quantitative |
| MOA | The method of ascertainment of dietary intake data i.e. how did authors determine dietary intake | Categorical;Qualitative |
| Concentration (as specified in text) | The concentration of beef/ red meat as reported in the paper | Quantitative |
| Average Type | Whether the reported intake is a mean or median | Categorical;Qualitative |
| CE (as specified in text) | The concentration error value as reported in the paper | Quantitative |
| CE Type (as specified in text) | Whether the CE value is reported as a standard error (SE), standard deviation (SD) or range (*e.g.*, IQR) in the paper | Categorical;Qualitative |
| Concentration Unit (as specified in text) | How beef/red meat consumption was measured/quantified *e.g.*, servings/day, g/week, times/week, as reported in the paper | Categorical;Qualitative |
|  |  |  |
| Convert to per day | Where intake concentrations are provided as per week/per month etc., to be converted to a per day intake amount | Quantitative |
| Servings or Grams | Whether the intake amount is in servings or grams daily amount | Categorical;Qualitative |
| Convert servings to grams | Where intake concentrations are provided as servings, to be converted to a gram intake amount | Quantitative |
| Concentration Merged (g/day) | The concentration of beef/red meat intake in g/day (studies which reported concentration in different units were converted to g/day) | Quantitative |
| CE, converted | The concentration error of beef/red meat after conversion to g/day | Quantitative |
| CE Type, converted | The converted CE value, in the case that a standard error (SE) was converted to a standard deviation (SD) | Categorical;Qualitative |
| Lower Range | The lower limit of a reported IQR, or calculated as the smallest value of the class interval | Quantitative |
| Upper Range | The upper limit of a reported IQR, or calculated as the highest value of the class interval | Quantitative |
| CV, % | The coefficient of variation, entered as a percentage | Quantitative |
| Concentration at Baseline/Outcomes | Was the reported concentration provided as a baseline intake or was it related to measured cognition outcomes | Categorical;Qualitative |
| Processed (Y/N) | Whether the subset contained processed meats or not | Categorical;Qualitative |
| Notes | Additional notes regarding the study and/or data extracted at the group-level | Free text |
| Unprocessed red meat intake, mean | The mean estimated intake of unprocessed red meat per specific region, as reported in Miller et al.(35) | Quantitative |
| Unprocessed red meat intake, L95CI | The lower 95% confidence interval for estimated unprocessed red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| Unprocessed red meat intake, U95CI | The upper 95% confidence interval for estimated unprocessed red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| Processed red meat intake, mean | The mean estimated intake of processed red meat per specific region, as reported in Miller et al.(35) | Quantitative |
| Processed red meat intake, L95CI | The lower 95% confidence interval for estimated processed red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| Processed red meat intake, U95CI | The upper 95% confidence interval for estimated processed red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| Total Red Meat Intake, Mean | The mean estimated intake of total red meat per specific region, as reported in Miller et al.(35) | Quantitative |
| Total red meat intake, L95CI | The lower 95% confidence interval for estimated total red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| Total red meat intake, U95CI | The upper 95% confidence interval for estimated total red meat intake per specific region, as reported in Miller et al.(35) | Quantitative |
| CE, concentration error ; CI, confidence interval ; CV, coefficient of variation ; MOA, method of ascertainment | | |

| **Supplementary Table 4.** Classification of cognitive tools by tool type | | |
| --- | --- | --- |
| **Type** | **Tool\*** | **Reference** |
| Domain-specific | 4-IADL | (36) |
| 9-HPT | (37) |
| Beery Test of Visual-Motor Integration | (38) |
| BRIEF-A | (39) |
| CANTAB | (40) |
| CogState | (41) |
| DECO | (42) |
| Digit Span Tests (forwards, backwards) | (43) |
| EBMT | (44) |
| RPM | (45) |
| Stroop Test | (46) |
| Global | MMSE or variation (includes TICS) | (47,48) |
| MoCA | (49) |
| Peabody Picture Vocabulary Test or variation | (50) |
| TMT | (51) |
| WISC-R or variation | (52) |
| WPPSI-III | (53) |
| SDQ | (54) |
| Abbreviations: 4-IADL, 4-Instrumental Activities of Daily Living; 9-HPT, 9-Hole Peg Test ; BRIEF-A, Behavior Rating Inventory of Executive Function – Adult Version ; CANTAB, Cambridge Neuropsychological Test Automated Battery ; DECO, Détérioration Cognitive Observée ; EBMT, East Boston Memory Test ; RPM, Raven’s Progressive Matrices ; MMSE, Mini-Mental State Examination ; MoCA, Montreal Cognitive Assessment ; TMT, Trail Making Test ; WISC-R, Wechsler Intelligence Scale for Children ; WPPSI-III, Wechsler Preschool and Primary Scale of Intelligence ; SDQ, Strengths and Difficulties Questionnaire ; TICS, Telephone Interview for Cognitive Screening | | |
| \*School test scores and other custom tools are not included this table. | | |

**References**

1. Hepsomali P & Groeger JA (2021) Diet and general cognitive ability in the UK Biobank dataset. *Sci Rep-uk* 11, 11786.

2. Corley J, Cox SR, Taylor AM, et al. (2020) Dietary patterns, cognitive function, and structural neuroimaging measures of brain aging. *Exp Gerontol* 142, 111117.

3. Bramorska A, Zarzycka W, Podolecka W, et al. (2021) Age-related cognitive decline may be moderated by frequency of specific food products consumption. *Nutrients* 13, 2504.

4. Soest APM van, Hermes GDA, Berendsen AAM, et al. (2020) Associations between pro- and anti-inflammatory gastro-intestinal microbiota, diet, and cognitive functioning in Dutch healthy older adults: The NU-AGE study. *Nutrients* 12, 3471.

5. Fischer K, Lent DM van, Wolfsgruber S, et al. (2018) Prospective associations between single foods, Alzheimer’s dementia and memory decline in the elderly. *Nutrients* 10, 852.

6. Prinelli F, Fratiglioni L, Kalpouzos G, et al. (2019) Specific nutrient patterns are associated with higher structural brain integrity in dementia-free older adults. *Neuroimage* 199, 281–288.

7. Ozawa M, Shipley M, Kivimaki M, et al. (2017) Dietary pattern, inflammation and cognitive decline: The Whitehall II prospective cohort study. *Clin Nutrition Edinb Scotl* 36, 506–512.

8. Granic A, Davies K, Adamson A, et al. (2016) Dietary patterns high in red meat, potato, gravy, and butter are associated with poor cognitive functioning but not with rate of cognitive decline in very old adults. *J Nutrition* 146, 265–274.

9. Hernández-Galiot A & Goñi I (2017) Adherence to the Mediterranean diet pattern, cognitive status and depressive symptoms in an elderly non-institutionalized population. *Nutrición Hosp* 34, 338–344.

10. Gu Y, Nieves JW, Stern Y, et al. (2010) Food combination and Alzheimer disease risk: a protective diet. *Arch Neurol* 67, 699–706.

11. Rahman A, Baker PS, Allman RM, et al. (2007) Dietary factors and cognitive impairment in community-dwelling elderly. *J Nutrition Heal Aging* 11, 49–54.

12. Chan R, Chan D & Woo J (2013) A cross sectional study to examine the association between dietary patterns and cognitive impairment in older Chinese people in Hong Kong. *J Nutrition Heal Aging* 17, 757–765.

13. Tangney CC, Kwasny MJ, Li H, et al. (2011) Adherence to a Mediterranean-type dietary pattern and cognitive decline in a community population. *Am J Clin Nutrition* 93, 601–607.

14. Kim KY & Yun J-M (2018) Association between diets and mild cognitive impairment in adults aged 50 years or older. *Nutr Res Pract* 12, 415–425.

15. Gardener SL, Rainey-Smith SR, Barnes MB, et al. (2015) Dietary patterns and cognitive decline in an Australian study of ageing. *Mol Psychiatr* 20, 860–866.

16. Torres SJ, Lautenschlager NT, Wattanapenpaiboon N, et al. (2012) Dietary patterns are associated with cognition among older people with mild cognitive impairment. *Nutrients* 4, 1542–1551.

17. Shin D, Lee KW, Kim M-H, et al. (2018) Identifying dietary patterns associated with mild cognitive impairment in older Korean adults using reduced rank regression. *Int J Environ Res Pu* 15, 100.

18. Haring B, Wu C, Mossavar-Rahmani Y, et al. (2016) No association between dietary patterns and risk for cognitive decline in older women with 9-year follow-up: data from the Women’s Health Initiative Memory Study. *J Acad Nutr Diet* 116, 921–930.

19. Shakersain B, Santoni G, Larsson SC, et al. (2016) Prudent diet may attenuate the adverse effects of Western diet on cognitive decline. *Alzheimer’s Dementia* 12, 100–109.

20. Hosking DE, Nettelbeck T, Wilson C, et al. (2014) Retrospective lifetime dietary patterns predict cognitive performance in community-dwelling older Australians. *Brit J Nutr* 112, 228–237.

21. França VF, Barbosa AR & D’Orsi E (2016) Cognition and indicators of dietary habits in older adults from southern Brazil. *Plos One* 11, e0147820.

22. Katsiardanis K, Diamantaras A-A, Dessypris N, et al. (2013) Cognitive impairment and dietary habits among elders: the Velestino study. *J Med Food* 16, 343–350.

23. França VF, Azzolini T, Pissaia E, et al. (2018) Diet, epidemiological factors and cognitive impairment: a cross-sectional study in the elderly population. *Braz Arch Biol Techn* 61, e18180225.

24. Hill E, Clifton P, Goodwill AM, et al. (2018) Dietary patterns and β-amyloid deposition in aging Australian women. *Alzheimer’s Dementia Transl Res Clin Interventions* 4, 535–541.

25. Morgan J, Taylor A & Fewtrell M (2004) Meat consumption is positively associated with psychomotor outcome in children up to 24 months of age. *J Pediatr Gastr Nutr* 39, 493–498.

26. Samuelsson J, Najar J, Wallengren O, et al. (2022) Interactions between dietary patterns and genetic factors in relation to incident dementia among 70-year-olds. *Eur J Nutr* 61, 871–884.

27. Ozawa M, Ninomiya T, Ohara T, et al. (2013) Dietary patterns and risk of dementia in an elderly Japanese population: the Hisayama Study. *Am J Clin Nutrition* 97, 1076–1082.

28. Hagemeier J, Tong O, Dwyer MG, et al. (2015) Effects of diet on brain iron levels among healthy individuals: an MRI pilot study. *Neurobiol Aging* 36, 1678–1685.

29. Krebs NF, Mazariegos M, Chomba E, et al. (2012) Randomized controlled trial of meat compared with multimicronutrient-fortified cereal in infants and toddlers with high stunting rates in diverse settings. *Am J Clin Nutrition* 96, 840–847.

30. Krebs NF, Westcott JE, Butler N, et al. (2006) Meat as a first complementary food for breastfed infants: feasibility and impact on zinc intake and status. *J. Pediatr. Gastroenterol. Nutr.* 42.

31. Murphy SP, Gewa C, Grillenberger M, et al. (2007) Designing snacks to address micronutrient deficiencies in rural Kenyan schoolchildren. *J Nutrition* 137, 1093–1096.

32. Murphy SP, Gewa C, Liang L-J, et al. (2003) School snacks containing animal source foods improve dietary quality for children in rural Kenya. *J Nutrition* 133, 3950S-3956S.

33. Neumann CG, Bwibo NO, Murphy SP, et al. (2003) Animal source foods improve dietary quality, micronutrient status, growth and cognitive function in Kenyan school children: background, study design and baseline findings. *J Nutrition* 133, 3941S-3949S.

34. Nyaradi A, Foster JK, Hickling S, et al. (2014) Prospective associations between dietary patterns and cognitive performance during adolescence. *J Child Psychol Psyc* 55, 1017–1024.

35. Miller V, Reedy J, Cudhea F, et al. (2022) Global, regional, and national consumption of animal-source foods between 1990 and 2018: findings from the Global Dietary Database. *Lancet Planet Heal* 6, e243–e256.

36. Katz S (1983) Assessing self‐maintenance: activities of daily living, mobility, and instrumental activities of daily living. *J Am Geriatr Soc* 31, 721–727.

37. Poole JL, Burtner PA, Torres TA, et al. (2005) Measuring dexterity in children using the Nine-hole Peg Test. *J Hand Ther* 18, 348–351.

38. Beery KE, Buktenica N & Beery N (1967) *Developmental Test of Visual-motor Integration: Administration and Scoring Manual*. Westchester, IL: Follett Educational Corporation.

39. Gioia GA, Isquith PK, Guy SC, et al. (2022) *BRIEF®2 Behavior Rating Inventory of Executive Function®, Second Edition*. Lutz, FL: PAR, Inc.

40. Luciana M & Nelson CA (2000) Neurodevelopmental assessment of cognitive function using CANTAB: Validation and future goals. In *The foundation and future of functional neuroimaging in child psychiatry*, pp. 379–397 [Ernst M, Rumsey J, editors]. Cambridge University Press.

41. CogState Digital Cognitive Assessment. <https://www.cogstate.com/clinical-trials/digital-cognitive-assessment/.>

42. Ritchie K & Fuhrer R (1992) A comparative study of the performance of screening tests for senile dementia using receiver operating characteristics analysis. *J Clin Epidemiol* 45, 627–637.

43. Reynolds CR (1997) Forward and backward memory span should not be combined for clinical analysis. *Archives Clin Neuropsychology Official J National Acad Neuropsychologists* 12, 29–40.

44. Albert M, Smith LA, Scherr PA, et al. (1991) Use of brief cognitive tests to identify individuals in the community with clinically diagnosed Alzheimer’s disease. *Int J Neurosci* 57, 167–178.

45. Raven J (1965) *Advanced Progressive Matrices Sets I and II*. London: H.K. Lewis.

46. Stroop JR (1935) Studies of interference in serial verbal reactions. *J Exp Psychol* 18, 643–662.

47. Folstein MF, Folstein SE & McHugh PR (1975) “Mini-mental state” A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 12, 189–198.

48. Brandt J, Spencer M & Folstein M (1988) The telephone interview for cognitive status. *Neuropsychiatry neuropsychol. behav. neurol.* 1, 111–118.

49. Nasreddine ZS, Phillips NA, Bédirian V, et al. (2005) The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc* 53, 695–699.

50. Dunn LM & Dunn LM (1981) Peabody Picture Vocabulary Test (revised). <https://www.nlsinfo.org/content/cohorts/nlsy79-children/topical-guide/assessments/peabody-picture-vocabulary-test-revised.>

51. Reitan RM (1958) Validity of the Trail Making Test as an indicator of organic brain damage. *Percept Motor Skill* 8, 271–276.

52. Wechsler (1974) *Wechsler Intelligence Scale for Children – Revised*. New York: The Psychological Corporation.

53. Wechsler D (2002) Wechsler Preschool and Primary Scale of IntelligenceTM Third Edition (WPPSITM - III). <https://www.pearsonassessments.com/store/usassessments/en/Store/Professional-Assessments/Cognition-%26-Neuro/Wechsler-Preschool-and-Primary-Scale-of-Intelligence-%7C-Third-Edition/p/100000422.html.>

54. Goodman R (1997) The strengths and difficulties questionnaire: a research note. *J Child Psychol Psyc* 38, 581–586.