

The Impact of Meat Consumption on Cognitive Outcomes and Dementia: A
Systematic Review

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DECLARATION

I certify that the whole of this work is the result of my individual effort, and that all sources have been acknowledged.

Signed [Signature] (Student)

Date 4th APRIL 2025

DECLARATION

I am satisfied that this work is the result of the Student's effort.

Signed (Lecturer)

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1 Abstract

Introduction: Ageing population is rising with longer life expectancies, leading to numerous challenges (Ungvari *et al.*, 2021). Healthy cognitive ageing is becoming a priority, with increased focus on preventing or delaying poor cognitive outcomes and dementia (Farrar, 2024). Nutrition has shown to be a significant modifiable risk factor for neurodegeneration, with evidence suggesting reduced risk with a healthy dietary pattern (Tanaka *et al.*, 2018; Charisis *et al.*, 2021). Further evidence suggests that a frequent consumption of meat is a risk factor for poorer health outcomes, through several mechanisms (Ungvari *et al.*, 2023; Tripodi *et al.*, 2025). However, evidence is inconsistent across studies exploring the association between meat consumption and risk of neurodegeneration (Bramorska *et al.*, 2021; Zhang *et al.*, 2020).

This systematic review aimed to evaluate the association between meat consumption and the risk of poorer cognitive outcomes including dementia, through investigating current evidence within this area.

Method: A systematic search was conducted across PubMed, Science Direct, Cochrane Library, Google Scholar, EBSCO and University of Wales Trinity Saint David, from 1 January 2010 up to January 2025, in line with PRISMA guidelines, included studies were assessed using the Newcastle-Ottawa Quality assessment scale.

Results: Of the 397 studies screened, 10 studies met the inclusion criteria, 8 were prospective and 2 cross-sectional.

Most of the studies reported both mixed and no associations across all meat types, two studies identified increased risk with red meat, four identified reduced risk, five studies identified increased risk with processed meat. Three studies identified reduced risk with poultry, two studies identified increased risk with total meat and one identified reduced risk.

Discussion: Findings are inconsistent, with numerous no associations found, mainly due to methodological differences with a possible indication of protective effects of poultry and red meat, and an increased risk in processed meats. This review potentially promotes the importance of a balanced meat consumption, with reduced consumption of processed meats, highlighting the need for public health guidance through education and campaigns on differentiating between the different types of meats and their outcomes. There is a need for further research in this area to clarify any of the potential associations.

2 Introduction

Worldwide, ageing population and extended life expectancies are linked to many challenges, with the population aged over 65 years estimated to rise to 1.6 million by 2050 (Mealy and Sorensen, 2020; Brayne and Wu, 2022), such longevity has raised awareness of cognitive health, with its preservation becoming a public health priority (Ungvari *et al.*, 2021).

Cognitive decline can occur as a result of normal ageing, additionally a variety of impairing neuropathologies of which are not a natural consequence of ageing can accumulate decades prior to decline, such as dementia (Boyle *et al.*, 2021; Chowdhary *et al.*, 2022).

Mild Cognitive Impairment (MCI) is a transitional state between normal cognitive ageing and dementia, 10%-15% of cases progress to dementia, investigating factors that increase risks are fundamental to reduce incidence (Nien *et al.*, 2023; Anderson, 2019; Brito *et al.*, 2023; Lissek, 2021; Iadecola *et al.*, 2019).

Dementia, an irreversible condition is a broad term for several diseases that affect cognitive ability, it is one of the greatest global health challenges worldwide, in 2019 55 million people were living with dementia, this is likely to increase to 152.8 million by 2050 (Nichols *et al.*, 2022). It is the seventh leading cause of death, with nearly 10 million new cases every year (World Health Organization, 2023a). In the United Kingdom, 982,000 people are living with dementia, Females are disproportionately impacted, with Female longer life expectancy not explaining the disparity (Farrar, 2024).

Amongst the older population dementia is the leading cause of mortality and morbidity, largest contributor of Disability-Adjusted Life Years (Nandi *et al.*, 2022; Livingston *et al.*, 2024), the most common form is Alzheimer's Disease (AD) present in around 60%-70% of cases, affecting memory, cognitive ability and behaviour (Dominguez *et al.*, 2021). Average age of onset dementia is 65 years, although 6%-9% of individuals are diagnosed with cognitive decline or early-onset dementia, often beginning at 30 (Chiari *et al.*, 2022; De Veen *et al.*, 2021).

Prevention and a delay in the progression of the disease is a major public health priority, the most recent UK economic report by Farrar (2024) emphasised the current cost as £42 billion, estimated to increase to £90 billion by 2040, majority of these costs fall on social care, unpaid carers and healthcare.

The pathogenesis and progression of cognitive impairment and dementia are a consequence of multifactorial conditions, including age and the genetic apolipoprotein E (APoE) $\epsilon 4$ allele, however around 40% of cases are connected to modifiable risk factors (Wahl *et al.*, 2019; Rodriguez *et al.*, 2017; Berendsen *et al.*, 2018). To date, no counteracting treatments are available to reduce progression and prevalence, therefore a focus on primary preventative measures through a lifelong upstream approach is recommended (Orgeta *et al.*, 2019; Alty, Farrow and Lawler, 2019). The Global Action Plan on the public health response to dementia 2017-2025 (World Health Organization, 2017), highlighted actions and targets for a promotion of a healthy balanced diet to reduce dementia risk.

Nutrition has shown to be pivotal in neurodegeneration, with an adherence to a healthy dietary pattern associated with a lower risk of cognitive impairment (Van De Rest *et al.*, 2015). Excessive meat consumption, particularly red and processed meats has long been recognised as a risk factor for poorer health outcomes, including Type 2 Diabetes, colorectal cancer and cardiovascular disease (CVD) (Liang *et al.*, 2024).

CVD has been recognised to share similar pathophysiological pathways as cognitive impairment and dementia, such as inflammation and increased oxidative stress, increasing the risk of AD, possibly due to atherosclerosis (Santos *et al.*, 2017; Libera, Howiecka and Stasiak, 2021; Guo *et al.*, 2021) whilst greater cardiovascular health is linked to lower rates of dementia (Tini *et al.*, 2020; Samieri *et al.*, 2018).

The consumption of meat has been an evolving topic in recent years due to sustainability, animal welfare and health, its consumption increased from 70 million tons in the 1960's to 315 million tons in 2013 (Mattiuzzi and Lippi, 2021). The Scientific Advisory Committee on Nutrition (SACN) has recommended that the daily intake of red meat does not exceed 70g (Public Health England, 2011). Studies have recently highlighted a reduction in consumption, particularly red and processed meat (Stewart *et al.*, 2021; Public Health England, 2020). Arguably, there has been a recent uptake in the Carnivore diet, a diet high in animal protein (Palmer, 2025), additionally the Organization for Economic Co-operation and Development, forecast a global increase in meat production by 2030 (OECD-FAO, 2021).

Meat can be categorised into several categories such as red meat, poultry and processed meat, it is acknowledged as a high-quality source of protein, providing high value bioavailable nutrients, some of which are difficult to obtain, often regarded as an important part of a balanced diet (Leroy and Cofnas, 2020; World Health Organization, 2023).

The essential amino acids found in meat and its contribution to iron intake, have found to be an important factor for improved cognition and neurological development (McCann *et al.*, 2020; (Azargoonjahromi, 2025). Shi *et al.* (2019) study found that greater intake of iron through meat in comparison to plant-based iron resulted in improved cognition, arguably excessive iron levels in the brain have been found to increase incidence of all-cause dementia (Liu *et al.*, 2023).

Nitrate found naturally in meat is an important source of Nitric Oxide (NO), essential for regulating several systems, including the cerebrovascular, cardiovascular and central nervous system, with higher dietary intake found to improve cognitive performance (Rajendra *et al.*, 2024). Arguably, Nitrite intake from processed meats can possibly be neurodegenerative (Tripodi *et al.*, 2025; Rajendra *et al.*, 2024; Liu *et al.* (2023).

Red and processed meat can be high in saturated fat, increasing low density lipoprotein cholesterol, negatively impacting neurogenesis, with greater intake increasing risks (Bovalino *et al.*, 2016; Pan *et al.*, 2022; Dai *et al.*, 2023; Brain *et al.*, 2023; Papier *et al.*, 2023).

Furthermore, red meat is a rich source of methionine, crucial for biochemical processes, although excess can lead to increased rate in neurodegeneration due to increased levels of total plasma homocysteine (tHCy) (Ungvari *et al.*, 2023; Ravaglia *et al.*, 2003; Zellner *et al.*, 2011; Smith *et al.*, 2018). Additionally, studies have linked the cooking methods of meat as a possible risk factor for cognitive diseases, due to advanced glycation end products (AGE's) which can increase oxidative stress, inflammation and neurotoxicity (Zhang *et al.*, 2023; Blake *et al.*, 2023; Huang, Huang and Dong, 2023; (Palimeri, Palioura and Kandarakis, 2015; Beerli *et al.*, 2022).

Inconsistent associations have been found between studies that have explored the relationship between meat consumption and cognitive outcomes, with conflicting results, a current area of uncertainty (Bramorska *et al.*, 2021). A study by Titova *et al.* (2013) found that healthy cognitive ageing and greater brain volume was observed in individuals that ate a low intake of meat, additionally a recent study by Bramorska *et al.* (2021) found that meat, particularly

red meat had a negative effect on memory. This has been supported in population health studies, highlighting early-onset cognitive aging with a frequent consumption of red meat (Ungvari *et al.*, 2023). Several studies have supported the role of the Mediterranean diet, with has limited meat consumption, particularly processed and red meat with long-lasting neuro protective effects (Tanaka *et al.*, 2018; Charisis *et al.*, 2021; Garcia-Casares *et al.*, 2021; Shannon *et al.*, 2023; Kheirouri and Alizadeh, 2022; Preez *et al.*, 2024).

Arguably, several studies have highlighted the protective effect of meat with increase in dietary protein having a positive association on cognitive outcomes and dementia (Li *et al.*, 2020; Wade *et al.*, 2019; Cui *et al.*, 2024; Zupo *et al.*, 2022).

A recent systematic review on Ultra-processed foods found the processing of foods, particularly meat could increase the risk of dementia (Henney *et al.*, 2024). Additionally, a systematic review and meta-analysis by Zhang *et al.* (2020) found insufficient evidence and inconsistent findings to establish a relationship between meat consumption and cognitive disorders.

A pre-liminary search of existing literature undertaken prior to commencing this review revealed a gap in the up-to-date systematic reviews available on this topic, with a significant number of recently published studies investigating the associations between the consumption of meat and cognitive outcomes.

Systematic reviews are known for their best practice for examining and summarising the best available original evidence on a specific question, the methodological rigour and strict PRISMA guidelines eliminates much of the bias, essential for informing and developing dietary guidelines, providing a vital resource of high-quality evidence for science, policymakers and healthcare professionals (Greenhalgh, Thorne and Malterud, 2018; Munn *et al.*, 2018; Henry *et al.*, 2018). Therefore, it was decided that a systematic review would be chosen for this review.

Accordingly, in this systematic review, the primary objective was to critically explore, synthesise and summarise the existing available evidence on prospective and cross-sectional studies, distinguishing an association, and direction of association between an exposure, the long-term intake of meat, including red meat, processed meat and poultry and the risk associated with the outcome, cognitive function and risk of incident dementia.

Additionally, the secondary objective was to explore if the association identified could provide a development to evidence based dietary guidelines on meat consumption, whilst suggesting areas for future research. The aim of this systematic review is to develop a fuller understanding through investigating and reporting the current evidence on the association of meat consumption on cognitive outcomes, including dementia.

3 Method

This Systematic Review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Page *et al.*, 2021) (Appendix C).

3.1 Search Strategy

The research question can be translated to PECOS framework: (P) general population over 30 years; (E) higher meat consumption, particularly red or processed meat; (C) no or lower intake of meat; (O) cognitive decline/dementia/ AD or risk of dementia/ AD, using valid and reliable measurements; (S) cohorts and cross-sectional studies. Following a preliminary search to gain a clearer insight on the research area, a literature search was conducted in January 2025 using electronic databases. PubMed, Science Direct, Cochrane Library, Google Scholar, EBSCO and University of Wales Trinity Saint David were searched, with articles included from 1 January 2010 to 20 January 2025.

The search strategy included a combination of words using Boolean Operators (Ely and Scott, 2007), the following terms were included: (“Meat Consumption” OR “Red Meat” OR “Processed Meat OR “Meat Products” OR “Animal protein”) AND (“Cognitive Decline” OR “Cognitive impairment” OR “Neurodegeneration” OR “Dementia” OR Alzheimer’s disease” OR “Dementia onset”). Additionally, a manual search of reference lists of the identified studies and related systematic reviews were carried out, detecting any further relevant studies that may not have been found in the search. The search was restricted to studies in English and human subjects only.

3.2 Inclusion and Exclusion Criteria

Initially eligible studies were screened by title and abstract, excluding studies that did not meet the eligibility criteria. Eligible studies met the following inclusion criteria:

(1) due to potential diagnosis of early-onset dementia, often beginning at >30 years, (Chiari *et al.*, 2022; De Veen *et al.*, 2021) studies were included if performed on adults or the elderly (aged 30 years or older); (2) studies that considered any ethnic group or geographical region; (3) studies that evaluated the frequency or amount of meat intake with a description on consumption, with a focus on processed meat, red meat and poultry; (4) studies that included an outcome measure of assessing cognitive decline, cognitive impairment, cognitive function and/or dementia through the use of standardised tests or diagnostic criteria or hospital/medical records for diagnosis of dementia or AD; (5) observational studies and clinical trials, including cohort, cross-sectional and longitudinal.

In addition, studies were excluded if they met the following criteria: (1) non-peer reviewed; (2) reviews and book chapters; (3) studies that only included participants with an existing health problem (e.g., CVD, cancer); (4) studies with insufficient methodological quality, inadequate control for confounding variables.

Following the initial screening, full texts of eligible studies were retrieved, through reading entire text, their eligibility was assessed for meeting the criteria described above.

3.3 Data Extraction

Data was extracted from the final selected studies and summarised into a table. The following data was extracted: first author's name, year of publication, country and name of study, sample size, age of participants and sex distribution, type of study, follow-up time, measure of exposure, measure of outcome, main findings and conflicts of interest.

3.4 Quality Assessment

Newcastle-Ottawa Quality assessment scale (NOS) (Appendix A) was used to assess the quality and risk of bias of included studies, NOS is validated and considered to be of appropriate use for systematic reviews and observational cohort studies, as recommended by the Cochrane Collaboration for observational cohort studies (Lo, Mertz and Loeb, 2014; Farrah *et al.*, 2019). The NOS was originally created for cohort and case-control studies (Moskalewicz and Oremus, 2020) therefore, where appropriate, a modified version of the NOS was used for cross-sectional studies (Appendix B).

Briefly, the NOS consists of three criteria (selection, comparability and outcome), based on a star scoring system, selection criteria have four items, maximum one star for each, comparability has one item with potential to score a maximum of two stars, outcome criteria has three items with maximum of one star for each. A maximum of 9 stars can be given, higher scores indicating a higher quality study, with 6 stars or more considered as high quality (Wells *et al.*, 2021). For the adapted NOS for cross-sectional studies the maximum score was 10, with 7 stars or more considered as high quality (Herzog *et al.*, 2013).

Based on the criteria mentioned above, scores were calculated for each study and rated from higher to lower score, conflicts of interest were considered and are mentioned in both results and discussion sections below.

4. Results

4.1 Search Results

Initially, the search strategy identified 397 articles from an investigation of electronic databases of PubMed, Science Direct, Cochrane Library, Google Scholar, EBSCO and University of Wales Trinity Saint David (UWTSD). After removal of 37 duplicates, 360 articles were screened and assessed through title and abstract, 167 studies were excluded, leaving 193 studies for screening through full text. On screening eligibility through full text, 185 studies were excluded based on the inclusion and exclusion criteria, two based on animal studies, sixty-seven had the incorrect exposure measurements, eighty-one had incorrect outcome measurements, and thirty-five were excluded due to not being able to obtain full text.

In addition, two were retrieved through manual searching of reference lists, finally ten studies met inclusion and were included in this review.

The selection process followed is outlined below as a flow chart in Figure 1.

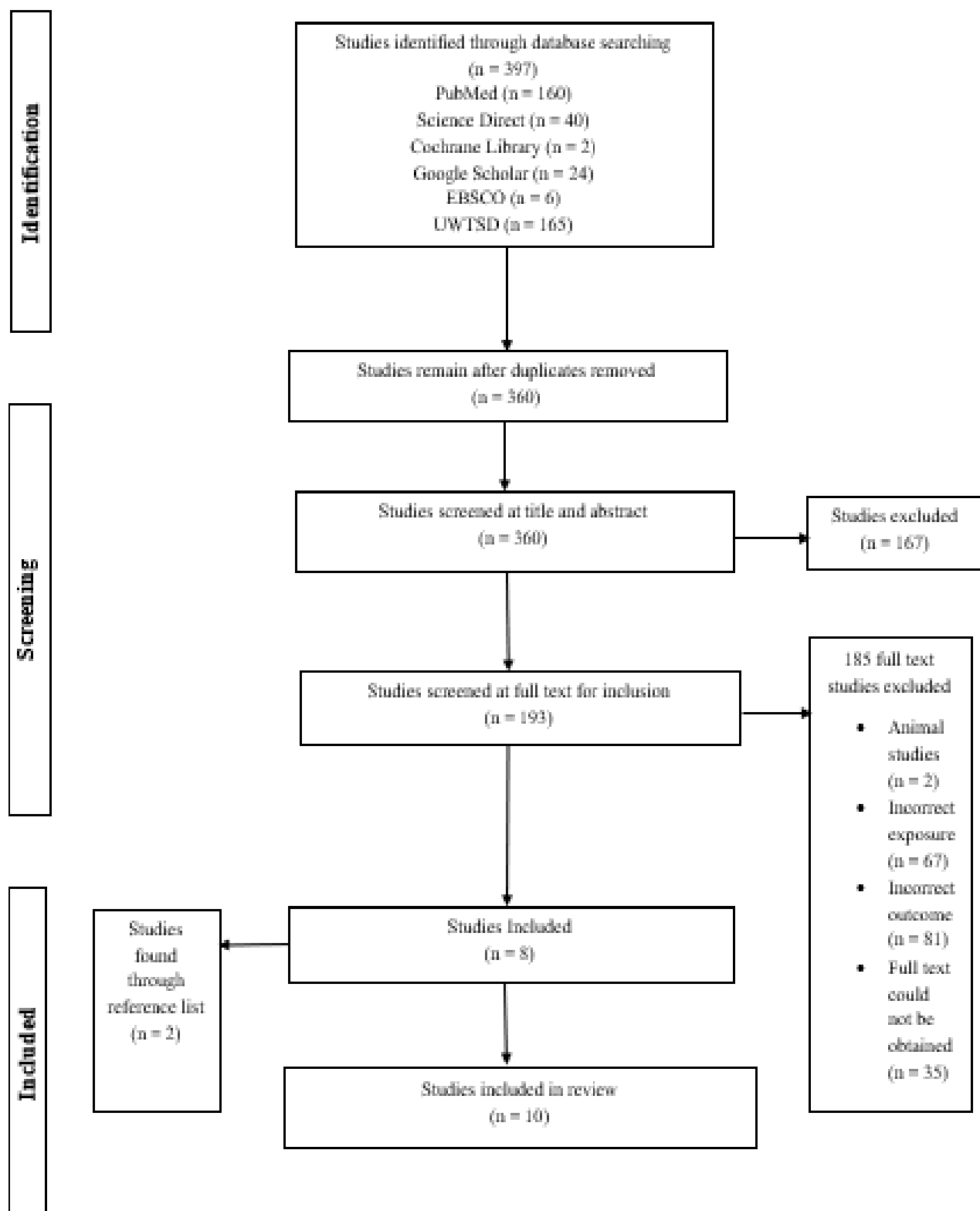


Figure 1. Flowchart of study selection process resulting in 10 studies included in the review.

4.2 Characteristics of Included Studies

The characteristics of the included studies are summarised below in Table 1. Of the ten included studies, eight were prospective (Zhu *et al.*, 2018; Takeuchi and Kawashima, 2021; Ylilauri *et al.*, 2022; Jiang *et al.*, 2020; Zhang *et al.*, 2021; Li *et al.*, 2025; Sun *et al.*, 2021; Fischer *et al.*, 2018) and two were cross-sectional (Bajerska *et al.*, 2014; Hepsomali and Groeger, 2021). The included studies were conducted in various countries, two in United States (Li *et al.*, 2025; Sun *et al.*, 2021), two in United Kingdom (Takeuchi and Kawashima, 2021; Zhang *et al.*, 2021), one in China (Zhu *et al.*, 2018), one in Poland (Bajerska *et al.*, 2014), one in Finland (Ylilauri *et al.*, 2022) one in Singapore (Jiang *et al.*, 2020) and one in Germany (Fischer *et al.*, 2018). The sample size of studies ranged from 87 (Bajerska *et al.*, 2014) to 505,505 (Takeuchi and Kawashima, 2021) participants, follow-up ranged from 8 (Zhang *et al.*, 2021) to 43 years (Li *et al.*, 2025).

One study focused on Female participants (Sun *et al.*, 2021) and one on Males (Ylilauri *et al.*, 2022), five studies had a majority of Female participants (Zhu *et al.*, 2018; Takeuchi and Kawashima, 2021; Zhang *et al.*, 2021; Li *et al.*, 2025; Fischer *et al.*, 2018), while two had a majority of Male participants (Jiang *et al.*, 2020; Hepsomali and Groeger, 2021) one study did not report sex distribution (Bajerska *et al.*, 2014). Publication year ranges from 2014 (Bajerska *et al.*, 2014) to 2025 (Li *et al.*, 2025). The mean baseline age of participants was more than 50 years, except for one study that had a mean baseline age of 48.9 years (Li *et al.*, 2025).

For the exposure of meat consumption, the measurement was carried out in three studies through administering only an FFQ (Li *et al.*, 2025; Bajerska *et al.*, 2014; Sun *et al.*, 2021), two studies used UK Biobank touchscreen FFQ (Hepsomali and Groeger, 2021; Takeuchi and Kawashima, 2021), one study used an intake screener developed by the AgeCoDe study (Fischer *et al.*, 2018).

One study used a FFQ and additionally used a 24-hour recall and a FFQ in a subset of participants (Jiang *et al.*, 2020), one study used a FFQ and the Oxford WebQ dietary questionnaire (Zhang *et al.*, 2021), one study used a FFQ and a 24-hour recall (Zhu *et al.*, 2018), and one study used a four-day food record (Ylilauri *et al.*, 2022).

Four studies evaluated total meat intake (Ylilauri *et al.*, 2022; Takeuchi and Kawashima, 2021; Zhang *et al.*, 2021; Bajerska *et al.*, 2014), eight studies evaluated the intake of red meat (Ylilauri *et al.*, 2022; Zhang *et al.*, 2021; Sun *et al.*, 2021; Hepsomali and Groeger, 2021; Fischer *et al.*, 2018; Li *et al.*, 2025; Jiang *et al.*, 2020; Zhu *et al.*, 2018) seven studies evaluated the intake of processed meat (Sun *et al.*, 2021; Ylilauri *et al.*, 2022; Hepsomali and Groeger, 2021; Zhang *et al.*, 2021; Fischer *et al.*, 2018; Li *et al.*, 2025). Six studies evaluated the intake of poultry (Zhu *et al.*, 2018; Sun *et al.*, 2021; Takeuchi and Kawashima, 2021; Bajerska *et al.*, 2014; Zhang *et al.*, 2021; Jiang *et al.*, 2020).

Among the selected studies, three studies included the outcome of dementia incidence (Sun *et al.*, 2021; Takeuchi and Kawashima, 2021; Zhang *et al.*, 2021), four studies included only an evaluation of cognitive function (Zhu *et al.*, 2018; Hepsomali and Groeger, 2021; Bajerska *et al.*, 2014; Jiang *et al.*, 2020), three studies included both outcomes of cognitive function and dementia (Ylilauri *et al.*, 2022; Li *et al.*, 2025; Fischer *et al.*, 2018).

Four studies included the outcome of incidence of AD (Ylilauri *et al.*, 2022; Li *et al.*, 2025; Zhang *et al.*, 2021; Fischer *et al.*, 2018) and one study included an additional evaluation of subjective cognitive decline (Li *et al.*, 2025).

For the outcome of cognitive function, six studies used Mini-Mental State Examination and/or other neuropsychological tests (Ylilauri *et al.*, 2022; Bajerska *et al.*, 2014; Hepsomali and Groeger, 2021; Li *et al.*, 2025; Fischer *et al.*, 2018; Jiang *et al.*, 2020), one study used questions on memory and decision making (Zhu *et al.*, 2018), for subjective cognitive decline a questionnaire was used (Li *et al.*, 2025). For the outcome of dementia and AD, four studies used hospital medical records and death certificates (Sun *et al.*, 2021; Takeuchi and Kawashima, 2021; Li *et al.*, 2025; Zhang *et al.*, 2021), and three used the International Classification of Diseases (ICD-8-10) criteria (Ylilauri *et al.*, 2022; Zhang *et al.*, 2021; Fischer *et al.*, 2018).

Majority of studies adjusted the results for age, sex, Body Mass Index, education, alcohol, smoking, co-morbidities and physical activity. Additionally, five studies adjusted for total energy intake (Zhu *et al.*, 2018; Sun *et al.* 2021; Ylilauri *et al.*, 2022; ; Li *et al.*, 2025; Jiang *et al.*, 2020), three studies controlled for hormone use (Sun *et al.*, 2021; Takeuchi and Kawashima, 2021; Li *et al.*, 2025), four studies for family history of disease (Sun *et al.*, 2021;

Takeuchi and Kawashima, 2021; Li *et al.*, 2025; Zhang *et al.*, 2021). Five adjusted for additional nutritional factors such as fruit, vegetables and fat (Sun *et al.*, 2021; Ylilauri *et al.*, 2022; Li *et al.*, 2025; Zhang *et al.*, 2021; Jiang *et al.*, 2020), four for cholesterol (Sun *et al.*, 2021; Li *et al.*, 2025; Jiang *et al.*, 2020; Fischer *et al.*, 2018) and three for depression (Takeuchi and Kawashima, 2021; Li *et al.*, 2025; Fischer *et al.*, 2018).

Table 1. Characteristics of 10 included studies

Title	First Authors Name/ Year of Publication	Country/ Study Name	Sample Size/ Sex Distribution/ Age (Years)	Follow-up Time	Exposure Measures	Outcome Measures	Main Findings	Conflict Of Interest	Quality Score
Prospective Studies									
A Prospective Investigation of Dietary Intake and Functional Impairments Among the Elderly	Zhu <i>et al.</i> , 2018	China (The Shanghai Men's Health Study SMHS (2002-2015) and The Shanghai Women's Health Study SWHS (1996-2015))	30484 (Female 18,458/ Male 12,026) 70-86	14.4 years	FFQ over the past 12 months 24-hour dietary recalls - recorded twice a month for SWHS and once a month for SMHS consecutively for 12 months. Red Meat, Poultry	Questions were used to evaluate impairments in memory, and decision making. Outcomes defined as: no, minor, or serious impairments.	- High red meat intake (fourth quintile: 44.7–64.3 g/d for women, 52.9–75.8 g/d for men) was associated with a lower likelihood of impairments in memory (aOR = 0.86, 95% CI: 0.75, 0.99), and decision-making (aOR = 0.82, 95% CI: 0.72, 0.93). - Higher poultry intake was associated with having less difficulty in making decisions (OR = 0.84, 95% CI: 0.74, 0.97). - Higher consumption of poultry showed significant inverse associations with impairments in memory and decision-making only among the population with less than a high-school education.	None Declared	8
Meat Consumption and Risk of Incident Dementia: Cohort Study of 493,888 UK Biobank Participants	Zhang <i>et al.</i> , 2021	United Kingdom (UK Biobank)	493,888 (Female 269,197/ Male 224,691) 56.5 ± 8.1 40-69	8 years	FFQ 47 items/ Processed meat, Unprocessed Poultry, Unprocessed Beef, Unprocessed Lamb/Mutton and Unprocessed Pork. Oxford WebQ Dietary Questionnaire/ Previous 24 h/ Portion Sizes and daily intake in grams.	Dementia – Hospital Records/ Death Registers/ Classified using International Classification of Diseases (ICD) codes/ Self-reported.	- Each additional 25 g/day intake of processed meat associated with increased risks of incident all-cause dementia (HR: 1.44; 95% CI: 1.24, 1.67; <i>P</i> -trend <0.001) and AD (HR: 1.52; 95% CI: 1.18, 1.96; <i>P</i> -trend = 0.001), significant association observed. 50-g/d increment in unprocessed red meat intake associated with reduced risks of all-cause dementia (HR: 0.81; 95% CI: 0.69, 0.95; <i>P</i> -trend = 0.011) and AD (HR: 0.70; 95% CI: 0.53, 0.92; <i>P</i> -trend = 0.009). - The linear trend was not statistically significant for	One Author is the director of University of Leeds company Dietary Assessment Ltd.	6

							unprocessed poultry in relation to risk of all-cause dementia. • For total meat, there was a border line increased risk of incident all-cause dementia (HR: 1.09;95%CI:1.00,1.19; P-trend=0.057)		
Diet and Dementia: A Prospective Study	Takeuchi and Kawashima, 2021	United Kingdom (UK Biobank cohort)	502,505 (Female 273,382/ Male 229,122) 56.5 (8.0) 37–73	10 years	FFQ - 29 questions Processed Meat, Poultry, Beef, Lamb, Pork, Total Meat.	All-cause dementia - Hospital Records/ Death Register Data	• Moderately high meat intake was associated with a reduced risk of subsequent onset dementia compared with the highest and lowest meat intake. • In the case of total meat, the group of the second highest intake (level3) showed significantly lower risk of dementia compared with each of the other 3 groups.	None Declared	7
Associations of Dairy, Meat, and Fish Intakes with Risk of Incident Dementia and with Cognitive Performance : the Kuopio Ischaemic Heart Disease Risk Factor Study (KIHD)	Ylilauri <i>et al.</i> , 2022	Finland (The Kuopio Ischaemic Heart Disease Risk Factor Study)	2497 (Male 2497) 53 ±5.1 (54.3) 42–60	22 years	Guided food recording - 4 days/ one weekend day by household measures. Food records checked by nutritionist and participant and estimated with NUTRICA. Total meat, red meat, processed red meat, and unprocessed red meat.	Cognitive – Neuropsychological Tests - (MMSE, TMT, VFL, SRT, VRT). Incident Dementia or AD - National health registers using International Classification of Diseases (ICD) codes.	• Intake of total meat, red meat, processed red meat, or unprocessed red meat not associated with risk of dementia. • Compared with men in the lowest tertile, men in the highest tertile of processed red meat intake recalled 2.5 words less in the SRT test (95% CI -4.4, -0.7 words; <i>P</i> -trend = 0.008) and scored 1.0 points less in the VRT test (95% CI-1.8, -0.2 words; <i>P</i> -trend = 0.01). • Higher intake unprocessed red meat associated with better performance in the MMSE. Highest tertile scored 0.4 points more than lowest tertile (95% CI – 0.02, 0.9 points; <i>P</i> -trend = 0.06). Higher score in TMT 4.9s faster performance compared to lowest tertile (95% CI -8.8, -1.0 words; <i>P</i> -trend = 0.01), significant association.	One author CEO of MAS-Metabolic Analytical Services Oy.	8
Meat Consumption in Midlife	Jiang <i>et al.</i> , 2020	Singapore	16,948	20 years	FFQ 165 items/ Red Meat, Poultry,	Cognitive - SM-MMSE	• Compared to lowest quartile, highest quartile of red		

and Risk of Cognitive Impairment in Old Age: the Singapore Chinese Health Study		(Singapore Chinese Health Study)	(Female 10,034/ Male 6914) 73.18 ± 6.41		Preserved/Processed Meat. X2 24hr-recalls & FFQ subset of 810 participants.	by trained interviewers	meat associated increased risk of cognitive impairment (OR 1.16, 95% CI 1.01-1.32, <i>P</i> for trend = 0.009), significant association. • No association for poultry intake with Corresponding value for poultry intake was 0.89 (95% CI 0.78-1.02, <i>P</i> for trend =0.10).	None Declared	8
Prospective Associations between Single Foods, Alzheimer's Dementia and Memory Decline in the Elderly	Fischer <i>et al.</i> , 2018	Germany Ageing, cognition and dementia Primary Care Patients (AgeCoDe) and Needs, health service use, costs and health-related quality of life in a large sample of oldest-old primary care patients (AgeQualiDe)	2622 (Female 1712/ Male 910) 75+81.2 ± 3.4	10 years	Food intake screener developed by AgeCoDe. 8-item cognitive health food intake screener Red Meat and processed meat (sausages) 5 frequency options	AD and other dementias structured interview (SIDAM, based on DSM-IV and ICD-10 criteria) Cognitive impairment (SIDAM Cognitive Score/ MMSE score and ADL score/ CERAD battery test) Dementia (NINCDS-ADRDA criteria) Vascular Dementia (Hachinski – Rosen Scale/ Medical history/ NINDS-AIREN criteria) Mixed Dementia (Global Deterioration Scale/ Blessed Dementia Rating Scale)	• No significant associations were observed between higher red meat and sausage intake and incident AD or memory decline.	None Declared	7
Long-Term Intake of Red Meat in	Li <i>et al.</i> , 2025	United States	133,771	43 years	Semiquantitative FFQ (SFFQs)	Dementia - Self-reported Dementia	• Processed Red Meat Intake ≥0.25 serving per day, compared with <0.10	None Declared	7

Relation to Dementia Risk and Cognitive Function in US Adults		(Nurses' Health Study NHS and Health Professionals Follow-Up Study HPFS)	(Female 65.4%/ Male 34.6%) Dementia analysis 48.9 Cognitive Function Analysis 74.3 Subjective Cognitive Decline 77.9		61 to over 150 items Processed and Unprocessed Red Meat 9 Frequency Options	and Statistics Records/ National Death Index/ Family Reports/ Postal System Cognitive Function – TICS/ Cognitive Battery Tests Subjective Cognitive Decline - Questionnaires Cognitive Domains	serving per day, 13% higher risk of dementia (HR 1.13; 95% CI 1.08-1.19; <i>P</i> linearity <0.001). 14% higher risk of SCD (RR 1.14; 95% CI 1.04-1.25; <i>P</i> linearity = 0.004), significant association. • Higher processed red meat accelerated aging in global cognition (1.61 years per 1 serving per day increment [95% CI 0.20-3.03]) and verbal memory (1.69 years per 1 serving per day increment [95% CI 0.13-3.25], both <i>P</i> linearity = 0.03), significant association. • Unprocessed red meat intake ≥ 1.00 serving per day, compared with <0.50 serving per day, 16% higher risk of SCD (RR 1.16; 95% CI 1.03-1.30; <i>P</i> linearity = 0.04).		
Association of Major Dietary Protein Sources with All-Cause and Cause-Specific Mortality: Prospective Cohort Study	Sun <i>et al.</i> , 2021	Unites States (Women's Health Initiative WHI Study)	102, 521 (Female) 50-79	18 years	FFQ - 122 food items Analysis Nutrition Data Systems for Research/ MyPyramid Equivalents Database	Dementia Mortality Death Certificates/ Hospital Medical Records/ Autopsy Reports/ Links to National Death Index	• Processed red meat consumption was associated with higher risk of dementia mortality (HR, 1.20 [1.05, 1.32]) • Poultry Consumption (HR, 0.85 [0.75, 0.97])) was associated with lower risk of dementia mortality.	Not clearly stated	6
Cross-Sectional Studies									
Diet and General Cognitive Ability in the UK Biobank Dataset	Hepsomali and Groeger, 2021	United Kingdom (UK Biobank)	48,749 (Female 22,126/ Male 26,623) 55.7 40-69	=	UK Biobank FFQ/ Healthy Diet Score Unprocessed red meat (Beef, lamb/mutton and pork) intake scores.	Cognitive battery tests (Pair matching, reaction time, prospective memory, fluid intelligence, numeric memory) to calculate a general	• Unprocessed red meat intake benefit's cognitive ability, significant association. • Lack of association between processed meat and cognitive ability.	None Declared	5

						cognitive ability score			
Eating Patterns are Associated with Cognitive Function in the Elderly at Risk of Metabolic Syndrome from Rural Areas	Bajerska <i>et al.</i> , 2014	Poland	87 (Sex not reported) 70.0 ± 6.5	=	FFQ - 13 groups Frequency and portion size intake over the last month. Meat and Meat Products	Global cognitive (MMSE), executive function (cognitive test battery). Including the Tests yielded 16 separate grading scales.	• The consumption of red meat and meat products was negatively related to executive function ($\beta = -0.02$, 95% CI: -0.03 – -0.007 , standardized $\beta = -0.33$, $p = 0.01$) and global cognition ($\beta = -0.02$, 95% CI: -0.04 – -0.007 , standardized $\beta = -0.25$, $P = 0.01$), significant association.	None Declared	6

4.3 Quality Assessment

The NOS revealed that out of the ten studies, for prospective studies, eight scored as good/high quality, scores were either 6 (Zhang *et al.*, 2021; Sun *et al.*, 2021), 7 (Takeuchi and Kawashima, 2021; Li *et al.*, 2025; Fischer *et al.*, 2018) or 8 (Zhu *et al.*, 2018; Ylilauri *et al.*, 2022; Jiang *et al.*, 2020). Among the cross-sectional studies both scored a medium quality, a score of 6 (Bajerska *et al.*, 2014) and a score of 5 (Hepsomali and Groeger, 2021).

As presented in Table 2 and 3 below.

Of the prospective studies, two studies scored high on selection and comparability criteria (Zhu *et al.*, 2018; Takeuchi and Kawashima, 2021), three studies scored high on outcome and comparability criteria (Ylilauri *et al.*, 2022; Jiang *et al.*, 2020; Sun *et al.*, 2021), three studies were weak on both selection and outcome criteria (Zhang *et al.*, 2021; Fischer *et al.*, 2018; Li *et al.*, 2025). Of the cross-sectional studies one study was weak on selection and comparability (Hepsomali and Groeger, 2021) and one study was weak on selection only (Bajerska *et al.*, 2014). As presented in Table 2 and 3 below.

Of the ten included studies, seven reported that there were no conflict of interest (Zhu *et al.*, 2018; Takeuchi and Kawashima, 2021; Bajerska *et al.*, 2014; Li *et al.*, 2025; Zhang *et al.*, 2021; Jiang *et al.*, 2020; Fischer *et al.*, 2018), one did not clearly state conflict of interest (Sun *et al.*, 2021), two studies declared conflict of interest (Ylilauri *et al.*, 2022; Hepsomali and Groeger, 2021).

Table 2. Quality assessment of eight included prospective studies using Newcastle-Ottawa Scale

Newcastle-Ottawa scale assessment criteria for prospective cohort studies	Zhu <i>et al.</i> , 2018	Zhang <i>et al.</i> , 2021	Takeuchi and Kawashima, 2021	Ylilauri <i>et al.</i> , 2022	Jiang <i>et al.</i> , 2020	Fischer <i>et al.</i> , 2018	Li <i>et al.</i> , 2025	Sun <i>et al.</i> , 2021
Selection (Max 4 stars)								
1. Representativeness of the exposed cohort	*	*	*	—	*	*	—	—
2. Selection of the non-exposed cohort	*	*	*	*	*	*	*	*
3. Ascertainment of exposure	*	*	*	*	*	—	*	—
4. Demonstration that outcome of interest was not present at start of study	*	—	*	*	—	*	*	—
Comparability (Max 2 stars)								
1. Comparability of cohorts on the basis of the design or analysis controlled for confounders	**	**	**	**	**	**	**	**
Outcome (Max 3 stars)								
Assessment of outcome	—	*	*	*	*	*	—	*
Was follow-up long enough for outcomes to occur	*	—	—	*	*	—	*	*
Adequacy of follow-up of cohorts	*	—	—	*	*	*	*	*
Total (Max 9 stars)	8	6	7	8	8	7	7	6

Each * indicates one star; Source: Adapted from Kusama *et al.* (2022)

Table 3. Quality assessment of two included cross-sectional studies using Newcastle-Ottawa Scale

Newcastle-Ottawa scale assessment criteria cross-sectional studies	Hepsomali and Groeger, 2021	Bajerska <i>et al.</i> , 2014
Selection (Max 5 stars)		
1. Representativeness of the sample	—	—
2. Sample Size	*	—
3. Non-respondents	—	—
4. Ascertainment of the exposure	—	*
Comparability (Max 2 stars)		
1. Comparability of subjects in different outcome groups on the basis of design or analysis. Confounding factors controlled	—	**
Outcome (Max 3 Stars)		
1. Assessment of outcome	**	**
2. Statistical test	*	*
Total (Max 10 stars)	5	6

Each * indicates one star Source: Adapted from Kusama *et al.* (2022)

4.4 Red Meat

Two studies showed a positive association between an increase in intake of red meat and risk of cognitive impairment (Jiang *et al.*, 2020), significant association ($p < 0.01$), and subjective cognitive decline (Li *et al.*, 2025). Three studies showed a higher intake associated with better cognitive function and lower likelihood of cognitive impairments (Hepsomali and Groeger, 2021; Zhu *et al.*, 2018; Ylilauri *et al.*, 2022), significant association ($p < 0.01$) observed in one cognitive test in Ylilauri *et al.* (2022) study. One study (Zhang *et al.*, 2021) showed greater intake reduced risk of all-cause dementia and AD. Additionally, one study found no association between red meat intake and cognitive function (Li *et al.*, 2025), four studies found no association between intake and dementia (Fischer *et al.*, 2018; Sun *et al.*, 2021; Ylilauri *et al.*, 2022; Li *et al.*, 2025).

Detailed information can be found in Table 1.

4.5 Processed Meat

Out of the ten studies, three studies showed a greater intake of processed meat associated with higher risk of dementia (Sun *et al.*, 2021; Li *et al.*, 2025; Zhang *et al.*, 2021), the results from Sun *et al.* (2021), Li *et al.* (2025) and Zhang *et al.* (2021) being significant ($p < 0.01$). Zhang *et al.* (2021) also showed an increase in risk of AD. Ylilauri *et al.* (2022) showed a higher intake associated with cognitive impairment, Li *et al.* (2025) showed increased risk of subjective cognitive decline and accelerated aging global cognition, being significant ($p < 0.01$).

The study by Hepsomali and Groeger (2021) found no association between intake and cognitive function, Ylilauri *et al.* (2022), found no association between intake and risk of dementia, additionally Fischer *et al.* (2018), found no association between intake and AD or memory decline.

Detailed information can be found in Table 1.

4.6 Poultry

Out of the ten studies, one study found an intake of poultry associated with lower risk of dementia (Sun *et al.*, 2021), study by Zhu *et al.* (2018), found higher intake associated with less difficulty in making decisions, with an inverse significant association found in participants with lower education levels. Additionally, Li *et al.* (2025) showed a replacement of poultry for processed meat, associated with a lower risk of dementia. One study showed no association with intake and cognitive impairment (Jiang *et al.*, 2020), two studies found no association with intake and risk of dementia (Zhang *et al.*, 2021; Ylilauri *et al.*, 2022).

Detailed information can be found in Table 1.

4.7 Total Meat

One study showed a moderately high intake of total meat reduced risk of dementia compared to the highest and lowest meat intake (Takeuchi and Kawashima, 2021), one study showed higher intake associated with worsened cognitive function, described as significant ($p < 0.01$) (Bajerska *et al.*, 2014). Zhang *et al.* (2021) study found a borderline increased risk of all-cause dementia and Ylilauri *et al.* (2022) study found no association between intake and risk of dementia.

Detailed information can be found in Table 1.

5 Discussion

The purpose of this systematic review was to identify, examine and summarise current evidence on the relationship between meat consumption and cognitive outcomes, including dementia. This systematic review identified a total of ten observational studies, eight were prospective in design and two cross-sectional. The studies examined several different cognitive outcomes: cognitive impairment, cognitive performance, cognitive ability, cognitive function, cognitive decline, subjective cognitive decline, dementia and AD. The review highlighted that there is a significant amount of research in this area, with an additional 7 studies published on the topic since the previous systematic review (Zhang *et al.*, 2020).

Several of the included studies show that frequent consumption of processed meat is associated with a higher risk of poorer cognitive outcomes and dementia including AD, with a significant association found in three studies. Meat considered as processed within the studies included sausages, frankfurters, luncheon meats, bacon, ham, meat pies, kebab meat, burgers, chicken nuggets, salami and jellied meats.

The association regarding frequent red meat consumption and frequent poultry intake is lacking in evidence, to risk to both, cognitive outcomes and dementia. Meat considered as red meat within the studies included beef, pork, lamb and mutton, meat considered as poultry within the studies included chicken and turkey. Interestingly, four studies observed a protective effect of red meat consumption on cognitive outcomes, dementia and AD, three studies also observed a protective effect of poultry intake on cognitive outcomes and dementia, with a significant association found in one study.

Since a significant number of studies found no association between meat consumption and cognitive outcomes, including dementia, it is difficult to reach a definitive conclusion. Findings should also be interpreted with caution due to different methodological factors between studies, such as duration of studies and follow-up, the wide range of cognitive outcomes, and the varying range of meat consumption assessed, with a lack of evaluation on the same types of meat across all studies.

The results found in this systematic review are somewhat consistent with the previous systematic review done within the same subject area (Zhang *et al.*, 2020), with a potential protective effect observed in some studies, and a lack of clear and consistent findings with insufficient associations. However, a meta-analysis would need to be carried out in this review to comprehensively compare findings.

This review does support previous review findings which have explored the processing of foods with cognitive outcomes, highlighting that the intake of processed meats may increase risks (Henney *et al.*, 2024). In addition, the findings from this review align with outcomes from reviews assessing dietary patterns, such as the mediterranean diet which excludes processed meats, with reduced risks to cognitive impairments (Kheirouri and Alizadeh, 2022). The findings also are in alignment with findings from Liang *et al.* (2024), that in the wider perspectives processed meat has a negative effect on general health outcomes.

Aligning with previous studies that have revealed that higher intake of processed meats could increase the risk of poorer cognitive outcomes (Liang *et al.*, 2024; Henney *et al.*, 2024; Kheirouri and Alizadeh, 2022), the findings from this review are partly consistent with the previous research.

There are multiple mechanisms that may explain the potential underlying association. Firstly, a possible pathway could be due to the large amount of Nitrite and Nitrates found in the preservation of processed meats, an excessive amount can create a Nitrite reaction, resulting in the formation of *N*-Nitrosamine compounds (Tripodi *et al.*, 2025; Rajendra *et al.*, 2024). These compounds increase oxidative stress and inflammation, impairing mitochondrial function, a pathogenesis of dementia (Tripodi *et al.*, 2025; Rajendra *et al.*, 2024), a recent study by Liu *et al.* (2023) found that a greater exposure led to an alteration in cognitive function.

However, a limited number of human studies have explored the association, significant positive associations have been found in animal studies, with further investigation needed (Liu *et al.*, 2023).

Secondly, the possible increase in tHCy from excess consumption of methionine from red and processed meat, potentially increasing oxidative stress and inflammation, as found in Ungvari *et al.* (2023) study, elevated levels were found to disrupt neurotransmitter systems, leading to cognitive dysfunction. Additionally, Ravaglia *et al.* (2003) observed that high homocysteine levels were considered as a marker for cognitive impairment. Furthermore, a recent

consensus statement by Smith *et al.* (2018) emphasised that other components influence the strength of homocysteine levels as a risk factor for dementia, potentially a factor for the lack of associations in this review, due to differences in confounding variables accounted for, further research is needed in this area.

Thirdly, the high levels of saturated fatty acids and triglycerides in meat, particularly processed meat, increase the risks of CVD, and therefore increasing dementia risk. A review by Brain *et al.* (2023) observed that the mechanism could be due to a build of lipids in the brain, impacting protective neuro enzymes against oxidative stress, additionally reduced cardiac output could cause cerebral hypoperfusion and hypoxia, increasing systemic inflammation. Although some studies have considered CVD and stroke as a covariate in this review, the influence of CVD on cognitive function could exist prior to formal diagnosis (Bovalino *et al.*, 2016), a possible explanation for inconsistent findings across the studies.

Lastly, the way that meat is prepared and cooked could be another potential mechanism in the way that meat might influence cognitive health, AGEs contribute to a heightened level of oxidative stress, inhibiting the signalling pathways affecting neuroplasticity, contributing to an increase in cognitive decline and the progression of neurodegenerative diseases (Zhang *et al.*, 2023; Blake *et al.*, 2023; Beeri *et al.*, 2022). Reducing the intake of high dietary sources of AGEs including processed meats has been shown to reduce risks of neurodegenerative diseases, including AD (Palimeri, Palioura and Kandarakis, 2015).

This is a relatively new area of investigation on an approach to reduce dementia prevalence, there is a need for further well-designed dietary intervention studies to clarify the associations. The studies included in this review did not account for cooking methods, which may have contributed to the lack of consistent associations between meat consumption and cognitive outcomes.

Furthermore, meat particularly unprocessed meat, including red and poultry are considered good sources of high-value protein, providing several important vitamins and minerals, including B12, A, D, K2, Iron, Zinc and Selenium, additionally several important bioactive compounds, taurine, creatine, carnosine and others (World Health Organization, 2023). These essential compounds have been found to be protective of brain health, highlighting their need for sufficient cognitive function (Leroy and Cofnas, 2020). There are several mixed

findings to the mechanisms associated with meat consumption and cognitive outcomes including dementia, with no definitive answers, further research is needed in this area.

5.1 Strengths of included studies

The included studies in this review have several strengths, firstly based on the NOS, majority of the studies scored as high-quality, indicating that any bias was reduced and was not influenced, enhancing the validity of the recommendations and findings through generating more reliable results (Ahn and Kang, 2018).

Secondly, included studies controlled for many confounding variables, nine out of ten studies controlled for several co-morbidities and physical activity, seven out of ten studies controlled for socioeconomic status. Several studies controlled for other nutrients, fruit, vegetables and fat and all studies controlled for education, Jiang *et al.* (2020) included education-specific cut off points due to participants low education levels, reducing the misclassification of cognitive impairment with low education levels, establishing true causality whilst increasing validity (Yan, Karmur and Kulkarni, 2019).

Additionally, a significant number of studies declared no conflict of interest, with only one study not disclosing, this reduces bias in the studies, leading to more reliable findings (Norris *et al.*, 2011). Lastly, several studies in this review had large sample sizes, ranging from 2497 to 502,505, improving the statistical power and the generalisability of the findings to the population (Andrade, 2020).

5.2 Limitations of included studies

There are several limitations which are present within the studies in this review, firstly there were many different forms of measuring the exposure cognitive outcomes across the studies. Some studies (Zhu *et al.*, 2018; Li *et al.*, 2025; Fischer *et al.*, 2018) used neuropsychological test battery, that did not include all possible cognitive outcomes.

Secondly, not all studies assessed the same cognitive outcomes, increasing the difficulty of comparison within the studies, reducing the ability to establish true associations. Additionally, six studies investigated dementia as an outcome, although only two studies (Ylilauri *et al.*, 2022; Zhang *et al.*, 2021) used the validated ICD-8-10 criteria (Cerullo *et al.*, 2020). Studies by Takeuchi and Kawashima (2021), Li *et al.* (2025), Sun *et al.* (2021) and Fischer *et al.* (2018), used hospital records and death registers, in which measurement errors may have occurred. Studies by Li *et al.* (2025) and Zhang *et al.* (2021) also used self-reported dementia as an ascertainment, whilst Jiang *et al.* (2020) did not exclude people with cognitive impairment at recruitment, potentially leading to misclassification, reverse causation and skewing of the results, therefore it is difficult to establish true findings.

Furthermore, measurements of meat consumption were conducted in five studies (Bajerska *et al.*, 2014; Takeuchi and Kawashima, 2021; Hepsomali and Groeger, 2021; Li *et al.*, 2025; Fischer *et al.*, 2018), using only an FFQ, with a selected number of studies taking measurements at baseline only, with no additional measurements at follow-ups, a potential of diet to modify over this time. FFQ's used in isolation are known to have several limitations, including a potential bias and lack of validation in epidemiological studies, and should be used with caution when used solely for contributing to dietary guidance (Cui *et al.*, 2023).

An important limitation is that only five studies (Zhu *et al.*, 2018; Sun *et al.*, 2021; Ylilauri *et al.*, 2022; Li *et al.*, 2025; Jiang *et al.*, 2020) adjusted for total energy intake, resulting in a lack of potential confounding, interpretations of the studies might potentially be misleading, this is of importance to the outcome of neurodegenerative disorders, as energy intake could potentially be associated with both cognitive outcomes and dementia (Yeh *et al.*, 2022; McKenzie *et al.*, 2022). The population of Li *et al.* (2025) study consisted of white health professionals, limiting the generalisability of the findings, additionally the population of Bajerska *et al.* (2014) study were at a high risk of metabolic syndrome, again making the findings difficult to generalise across populations.

Despite the majority of prospective studies having a sufficient follow-up period, three studies (Takeuchi and Kawashima, 2021; Zhang *et al.*, 2021; Fischer *et al.*, 2018) had a follow-up time of 10 years or less. As a result of the pathology and slow progression of cognitive decline to dementia or AD, a short-follow up period could have resulted in lack of

associations, impairing the ability to differentiate between reverse causation and causality for contributing variable for its progression, reducing statistical power (Strain *et al.*, 2020).

Lastly, due to several studies (Zhu *et al.*, 2018; Ylilauri *et al.*, 2022; Takeuchi and Kawashima, 2021; Hepsomali and Groeger, 2021; Bajerska *et al.*, 2014; Fischer *et al.*, 2018) assessing overall dietary intake, eating patterns and food groups, it is difficult to isolate both the risks and/or any protective benefits of meat consumption, particularly differing types of meats as occasionally food groups are combined into a single category (Tapsell *et al.*, 2016).

5.3 Strengths of the review process

This review is among a limited number of other reviews that have focused on meat consumption and cognitive outcomes, without focusing on specific dietary patterns such as the Mediterranean diet. From the studies included in this review, six out of ten had a large proportion of Female participants, with one study focusing primarily on Females, this is of importance addressing the existing gap in research and Female disparity within Dementia prevalence (Samaei, Jenkins and McGregor, 2022; Farrar, 2024). Additionally, a clear protocol was followed with multiple databases searched and used, a wide range of years were included in the review, with several of the most up to date studies in this area, not included in the previous systematic review. Due to the inclusion criteria, the review used several studies from many geographical regions and different cultures, including Poland, Finland, United States and the United Kingdom, enhancing the generalisability of the findings.

5.4 Limitations of review process

Several limitations are present in this review, firstly the nature of observational studies signifies that there is a potential of the study design to not allow for a definitive conclusion. Despite the importance of observational studies in studying causes with long progression time, such as diet with health outcomes, confounding threats their validity (Dekkers *et al.*, 2019), limiting the generalisability.

Secondly, only ten studies were included in this review, although there is no set amount of studies that are required for systematic reviews, with a broad distribution often observed (Gray, 2020), due to the lack of adequate follow-up time in several of the included studies and the latency period and nature of cognitive decline and dementia, it is possible that the validity and statistical power of the review could have been strengthened with the incorporation of more studies.

Additionally, two of the studies included were cross-sectional in their design, despite having the advantage of showing connections between variables, they lack some ability in establishing the causality (Spector, 2019). Lastly, although this review was conducted and reported in line with best practice, following both the PRISMA guidelines and the NOS, the lack of calibration within a research team could have resulted in a lack of diverse perspectives, potentially effecting its validity (Siddaway, Wood and Hedges, 2019).

5.5 Recommendations for future research

Whilst several additional studies have been published and met the criteria to be included in this review, this review has emphasised the same methodological limitations as found in the previous systematic review. Although a focus on additional research in this area has been conducted, it has signified that there is still a need for further well-designed studies in this area.

Future research should focus on increasing longitudinal intervention studies, with an emphasis on long follow-up times to strengthen the evidence of causality. Additionally, future studies should ensure the inclusion of multiple confounders and covariates and recruit participants prior to middle age to better distinguish risk factors, due to the nature and underlying mechanisms of cognitive decline and dementia.

Due to the challenges of isolating meat within a dietary pattern, future studies should focus on investigating single meat categories, cognitive outcomes should be measured consistently across all studies to enhance the interpretation of findings and present the most rigorous and conclusive results.

Due to emerging research in this area, future research should aim to explore the gut microbiome and inflammation markers (Oluwagbemigun *et al.*, 2024), epigenetics and diet (Grootswagers *et al.*, 2024) and brain imaging to improve prediction of longitudinal cognitive

outcomes (Pike *et al.*, 2022). This could potentially give a deeper insight into the mechanisms to gain an improved understanding of the processes and the association between the consumption of meat and cognitive decline and dementia risks. Additionally future studies should focus on the preparation and cooking methods of meat to allow translation of evidence into practice.

5.6 Practical Implications

It has been highlighted that an increased intake of processed meat is a risk factor for many non-communicable diseases that increase the risk for poorer cognitive outcomes and dementia (Liang *et al.*, 2024).

While this review does not present definitive evidence on high meat consumption increasing the risk of cognitive decline and dementia, and while there is some potential evidence of a protective effects of leaner meats, it should be highlighted the potential need for a balanced intake of meat. Potentially a less frequent consumption of red meat and a reduction in the intake of processed meat, in line with publications by World Health Organization (World Health Organization, 2023b) and SACN (Public Health England, 2011).

This review potentially underscores the need for more targeted public health guidance and recommendations on differentiating between the different types of meat and their outcomes, particularly as some individuals restrict all meat from their diet based on health-related values as found in a recent review by Valli *et al.* (2019).

This could be accomplished through nutrition education programmes and public health campaigns to educate, inform and give guidance on ways of reducing processed meat consumption. As some populations might be more susceptible of incorporating a large amount of processed meats and red meats into their diets, particularly the younger generation (Marino, *et al.*, 2021), there is a potential need for targeted intervention.

Additionally due to the pathway of cognitive decline and dementia, nutrition education on achieving a balanced diet should be a targeted intervention for individuals that are at an increased risk of CVD, in addition to children from a young age. Encouraging the adoption of a lifestyle that reduces intake, through improved nutrition education, improved food labelling

and the use of different cooking methods to optimise the prevention and management of the disease through diet.

6 Conclusion

There are a substantial number of reviews that explore the associations between dietary patterns and cognitive outcomes and neurodegenerative diseases, however there are a lack of reviews that investigate the association of meat consumption with risk of cognitive decline and dementia. Overall, this systematic review provides an extensive exploration of the current studies within this area on the association of meat consumption and cognitive outcomes, including dementia.

Despite recent studies and their investigations on this topic, findings were inconsistent and varied between studies, with numerous no associations found. Although several of the studies in this review do indicate some evidence that certain meats, particular processed meats may increase risk of poorer cognitive outcomes, including dementia and AD. Whilst red meat and poultry intake might be protective of such outcomes, it is difficult to draw a firm conclusion.

Methodological difficulties and differences within studies such as their observational design, the measure of cognitive outcomes and the inability to isolate meat consumption within a diet, obscures the ability to draw such conclusions. Emphasising the various difficulties within the dietary studies in this review to provide conclusive, clear and reliable dietary advice on meat consumption to the population.

Further research is needed using intervention studies and large cohort studies with long follow-up times. Future research should focus on recruiting participants prior to middle-age due to the progression and development of cognitive impairment and dementia, with consistent standards used for measuring cognitive outcomes. Additionally, advancing research to incorporate studies that explore the connection with the microbiome, cooking methods used, the use of brain imaging and epigenetics with meat consumption to further advance knowledge in this area.

Given the current prevalence of dementia and the negative consequences of such disease on individuals and the healthcare system, in addition to longer life expectancies, it is essential to focus future research within this area. Gaining a clear understanding on the role of individual foods and their particular significance on managing the disease and its progression, reflecting and supporting current public health priorities.

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8. Appendices

Appendix A: Newcastle-Ottawa assessment scale for cohort studies

CODING MANUAL FOR COHORT STUDIES

SELECTION

1) Representativeness of the Exposed Cohort

Item is assessing the representativeness of exposed individuals in the community, not the representativeness of the sample of women from some general population. For example, subjects derived from groups likely to contain middle class, better educated, health oriented women are likely to be representative of postmenopausal estrogen users while they are not representative of all women (e.g. members of a health maintenance organisation (HMO) will be a representative sample of estrogen users. While the HMO may have an under-representation of ethnic groups, the poor, and poorly educated, these excluded groups are not the predominant users of estrogen).

Allocation of stars as per rating sheet

2) Selection of the Non-Exposed Cohort

Allocation of stars as per rating sheet

3) Ascertainment of Exposure

Allocation of stars as per rating sheet

4) Demonstration That Outcome of Interest Was Not Present at Start of Study

In the case of mortality studies, outcome of interest is still the presence of a disease/incident, rather than death. That is to say that a statement of no history of disease or incident earns a star.

COMPARABILITY

1) Comparability of Cohorts on the Basis of the Design or Analysis

A maximum of 2 stars can be allotted in this category

Either exposed and non-exposed individuals must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the relative risk for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

There may be multiple ratings for this item for different categories of exposure (e.g. ever vs. never, current vs. previous or never)

Age = ☆ , Other controlled factors = ☆

OUTCOME

1) Assessment of Outcome

For some outcomes (e.g. fractured hip), reference to the medical record is sufficient to satisfy the requirement for confirmation of the fracture. This would not be adequate for vertebral fracture outcomes where reference to x-rays would be required.

- a) Independent or blind assessment stated in the paper, or confirmation of the outcome by reference to secure records (x-rays, medical records, etc.) ☆
- b) Record linkage (e.g. identified through ICD codes on database records) ☆
- c) Self-report (i.e. no reference to original medical records or x-rays to confirm the outcome)
- d) No description.

2) Was Follow-Up Long Enough for Outcomes to Occur

An acceptable length of time should be decided before quality assessment begins (e.g. 5 yrs. for exposure to breast implants)

3) Adequacy of Follow Up of Cohorts

This item assesses the follow-up of the exposed and non-exposed cohorts to ensure that losses are not related to either the exposure or the outcome.

Allocation of stars as per rating sheet

Appendix B: Newcastle-Ottawa assessment scale for cross-sectional studies

Newcastle-Ottawa Scale adapted for cross-sectional studies

Selection:

1. Representativeness of the sample:
 - a. Truly representative of the average in the target population. * (all subjects or random sampling)
 - b. Somewhat representative of the average in the target group. * (non-random sampling)
 - c. Selected group of users/convenience sample.
 - d. No description of the derivation of the included subjects.
2. Sample size:
 - a. Justified and satisfactory (including sample size calculation). *
 - b. Not justified.
 - c. No information provided
3. Non-respondents:
 - a. Proportion of target sample recruited attains pre-specified target or basic summary of non-respondent characteristics in sampling frame recorded. *
 - b. Unsatisfactory recruitment rate, no summary data on non-respondents.
 - c. No information provided
4. Ascertainment of the exposure (risk factor):
 - a. Vaccine records/vaccine registry/clinic registers/hospital records only. **
 - b. Parental or personal recall and vaccine/hospital records. *
 - c. Parental/personal recall only.

Comparability: (Maximum 2 stars)

1. Comparability of subjects in different outcome groups ~~on the basis of~~ design or analysis. Confounding factors controlled.
 - a. Data/ results adjusted for relevant predictors/risk factors/confounders e.g. age, sex, time since vaccination, etc. **
 - b. Data/results not adjusted for all relevant confounders/risk factors/information not provided.

Outcome:

1. Assessment of outcome:
 - a. Independent blind assessment using objective validated laboratory methods. **
 - b. Unblinded assessment using objective validated laboratory methods. **
 - c. Used non-standard or non-validated laboratory methods with gold standard. *
 - d. No description/non-standard laboratory methods used.
2. Statistical test:
 - a. Statistical test used to analyse the data clearly described, appropriate and measures of association presented including confidence intervals and probability level (p value). *
 - b. Statistical test not appropriate, not described or incomplete.

Cross-sectional Studies:

Very Good Studies: 9-10 points

Newcastle-Ottawa Scale adapted for cross-sectional studies

Good Studies: 7-8 points

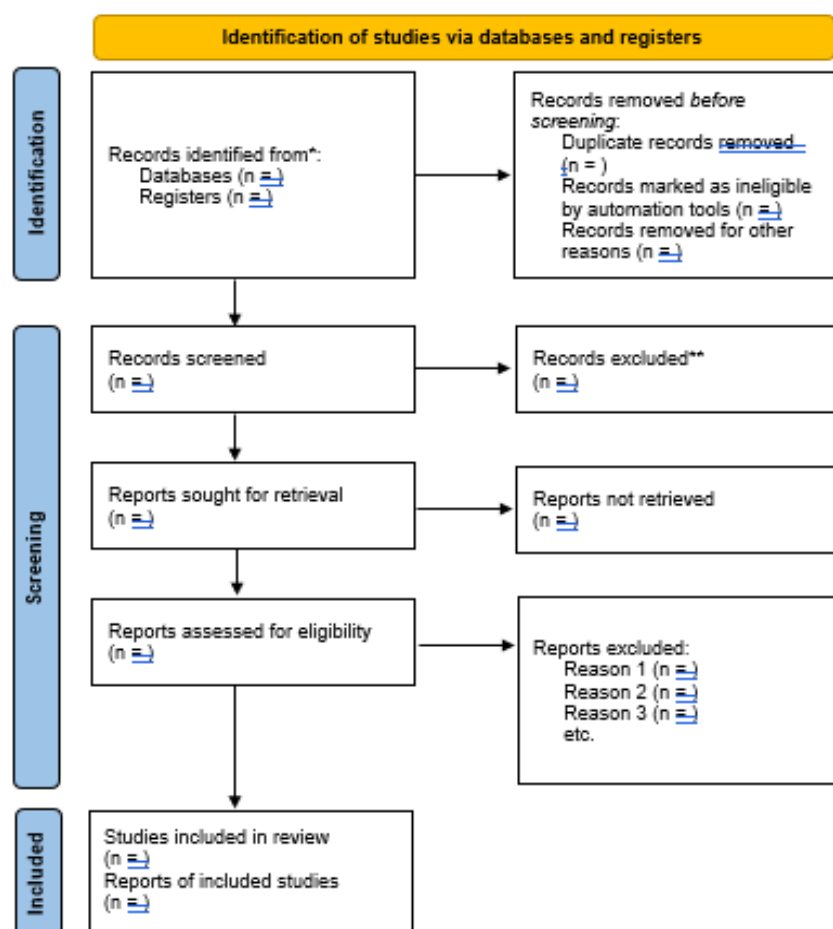
Satisfactory Studies: 5-6 points

Unsatisfactory Studies: 0 to 4 points

This scale has been adapted from the Newcastle-Ottawa Quality Assessment Scale for cohort studies to provide quality assessment of [cross-sectional](#) studies¹.

Appendix C: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only





PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
	23b	Discuss any limitations of the evidence included in the review.	
	23c	Discuss any limitations of the review processes used.	
	23d	Discuss implications of the results for practice, policy, and future research.	
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
Competing interests	26	Declare any competing interests of review authors.	
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	