Meat and Muscle Biology™

Pork Consumption and Its Relationship to Human Nutrition and Health: A Scoping Review[a]

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Abstract: Pork is a frequently consumed red meat that provides substantial amounts of energy, macronutrients, and micronutrients to the diet. Its role in human nutrition and health is controversial, and a plethora of data exist in the peer-reviewed scientific literature. Therefore, we conducted a scoping review of clinical and population-based studies to assess the effects of pork consumption on human nutrition and health. Results are reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews. Data were extracted from 86 studies, including 16 randomized controlled trials, 1 uncontrolled trial, 7 cohort studies, 4 nonrandomized controlled trials, 4 case-cohort and nested case-control studies, 33 case-control studies, and 21 cross-sectional studies. Intervention studies were conducted in healthy individuals and were short (<1 mo) to moderate (1 to 6 mo) in duration. The effect of pork intake on patients' nutrient status was the most commonly assessed outcome. Most observational studies assessed the effect of pork on cancer incidence, but no studies assessed the effects of pork on cognition or inflammation/oxidative stress. No interventional studies explored diabetes mellitus risk, and only 1 study assessed cancer risk associated with pork consumption. Several micronutrients in pork, including zinc, iron, selenium, choline, thiamin, and vitamins B_6 and vitamin B_{12}, are thought to influence cognitive function, and this may prove to be an exciting area of emerging research. To date, there is a dearth of high-quality randomized controlled trials assessing the effects of pork intake on disease risk factors and outcomes. The scientific literature contains mostly observational studies, a large majority being case-controlled and cross-sectional analyses. Of note, there is a lack of studies examining isolated effects of processed pork intake on human health. Future clinical trials should address the role of pork consumption in health outcomes, intermediate outcomes, and validated biomarkers.

Key words: pork, meat, health policy, scoping review, diet
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Introduction

Pork is a red meat that is consumed frequently across the globe. Cross-sectional analyses of the 2006–2016 United States National Health and Nutrition Examination Survey data sets showed that approximately 19.4%, 16.5%, and 16.1% of adults in the U.S. consume pork, fresh pork, and fresh lean pork, respectively (An et al., 2019). Both pork tenderloin and pork sirloin meet the American Heart Association (2021) Heart Health Checkmark criteria, which means that they contain ≤5 g of fat, ≤2 g of saturated fat, and ≤480 mg of sodium per label serving. A 4-ounce raw, boneless, lean pork chop (top loin) provides approximately 144 kcal of energy, 25.3 g of protein,

3.86 g of fat (1.36 g of saturated fat), and substantial amounts of iron, zinc, selenium, magnesium, phosphorus, potassium, thiamin, riboflavin, niacin, pantothenic acid, choline, and vitamins B_6 and B_{12} to the diet (FoodData Central identifier 168251) (U.S. Department of Agriculture Agricultural Research Service, 2019). Increased lean pork rather than total pork intake was recently associated with improved nutrient intakes of protein, magnesium, potassium, selenium, zinc, phosphorus, thiamin, riboflavin, niacin, and vitamin B_6 and with lesser increases in daily total energy, saturated fat, and sodium intakes among U.S. adults (An et al., 2019). Aside from the effects of pork on nutrient intakes, there is a plethora of scientific evidence regarding the effects of pork intake on human nutrition and health. Recent randomized controlled trials have shown that the addition of lean pork to both the Mediterranean diet and the Dietary Approaches to Stop Hypertension diet does not affect the demonstrated benefits of these diets on established biomarkers of cardiovascular disease (Sayer et al., 2015; Wade et al., 2019). The addition of an average of 3 servings of lean pork to a Mediterranean-style diet pattern in older adults has been suggested to improve cognitive outcomes (Wade et al., 2019). However, evidence on the health effects of pork is heterogenous and in many cases conflicting.

The use of systematic methodologies for reviewing evidence continues to increase in the nutrition science field. Scoping reviews (otherwise known as evidence mapping) are a relatively new and important tool used to systematically characterize the range of research activity in broad topic areas and are used to guide research priority setting and whether evidence is sufficient for systematic reviews and meta-analyses. They are less exhaustive but utilize rigorous systematic and replicable methodologies that allow for a better understanding of the extent and distribution of evidence in a broad area, highlighting where evidence and evidence gaps exist (Hetrick et al., 2010; Althuis and Weed, 2013; Wang et al., 2016). Although scoping reviews are conducted for different purposes compared with systematic reviews, they are still rigorous and transparent in their methodology to ensure trustworthy results (Munn et al., 2018). Purposes for conducting a scoping review may include the following: (1) to identify the types of available evidence in a given field, (2) to clarify concepts and definitions in the scientific literature, (3) to examine how research is conducted on a certain topic or in a certain field, (4) to identify key characteristics or factors related to a concept, (5) to serve as a precursor to systematic review, and/or (6) to pinpoint and analyze knowledge gaps (Arksey and O'Malley, 2005; Anderson et al., 2008; Levac et al., 2010; Peters et al., 2015; Wang et al., 2016; Munn et al., 2018). Scoping reviews are also extremely useful in helping groups prioritize research agendas, particularly when resources are limited and a plethora of heterogenous evidence exists.

Therefore, our research objective was to conduct a scoping review of clinical and population-based studies assessing the effects of pork consumption in relation to human nutrition and health.

Materials and Methods

We created a literature database and performed evidence mapping following methods described elsewhere (Wang et al., 2016). We reported the results according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (Tricco et al., 2018).

Definitions of fresh, processed, and mixed pork

The American Meat Science Association (AMSA) Lexicon for the standardization of various terms used in meat sciences was adopted for these analyses (Seman et al., 2018). Fresh pork was defined as products that met the AMSA standards for "minimal processing," wherein raw, uncooked meat products have not been significantly altered compositionally and contain no added ingredients but may have been reduced in size by fabrication, mincing, grinding, and/or a meat recovery system (Seman et al., 2018). Processed pork was defined as products that met the AMSA standards for "further processing," which entails any process wherein meat products undergo a transformation, beyond minimal processing, containing approved ingredients and may be subjected to a preservation or processing step(s) through the application of salting, curing, fermentation, thermal processing (smoking and/or cooking), batter/breading, or other processes to enhance sensory, quality, and safety attributes. These products may include ready-to-cook and ready-to-eat products (Seman et al., 2018). Mixed pork was defined as a combination of fresh and processed pork.

Literature search and selection

We developed search strategies with the help of university librarians. We searched Ovid Medline from 1946 to present, Embase from 1974 to present, and

Cochrane Central from 1910 to present (Appendix A). No restrictions were set regarding languages or outcome terms. Additional articles were found via reference mining.

After duplicated citations were removed in Endnote, we uploaded titles and abstracts to Rayyan (https://rayyan.qcri.org) for double independent abstract screening. Two independent reviewers screened all abstracts to exclude irrelevant abstracts such as narrative reviews, systematic reviews, case studies, letters to the editor, ecological studies, and conference proceedings or abstracts. We included studies conducted in participants of all ages looking at pork consumption compared with any comparator. Because many study population details were not described in the abstracts, we only excluded those abstracts that clearly stated nonpork primary exposures and outcomes not related to health or nutrition. We then retrieved the full-text articles of all potentially relevant abstracts and performed full-text screening according to our inclusion and exclusion criteria (Table 1). Two reviewers discussed all discrepancies and disagreements during both abstract and full-text screening phases and resolved discrepancies via consensus. If no consensus could be reached, a third reviewer or the entire research team resolved the remaining discrepancies. We recorded the primary reason for exclusion of all full-text articles (Appendix B). Studies in Appendix B were "set aside due to processed meat" if they did not specify whether the processed meat was pork or other meat.

Data extraction

We performed data extraction on all included full-text articles. We extracted information on study characteristics (i.e., study design and sample size), study participant characteristics (i.e., age, health status, and gender), intervention characteristics (i.e., pork source, dose, and form of administration), and a list of analyzed outcomes. Data were extracted by one reviewer and spot checked by a second team member.

We did not perform a risk-of-bias assessment of included studies in the scoping review.

Data analysis and charting

We used one study as our unit of analysis. We treated multiple studies reported in one publication as separate studies in the analysis. To allow for frequency analysis and identification of research gaps, outcomes were classified into categories based on biomarkers and indicators for health outcomes. The outcome categories were cancer, cardiovascular disease risk, diabetes risk, cognitive function, weight status and body composition, nutrient status, inflammation, oxidative stress, and other (Table 2). All other health outcomes that could not be grouped into these predefined outcome categories were grouped into an "other" outcome category.

To summarize the characteristics of the included studies, we conducted descriptive analyses on study design, country, sample size, study population

Table 1. Study eligibility criteria for full-text screening

Parameter	Inclusion Criteria	Exclusion Criteria
Populations of interest	Any human participants	None
Interventions or exposures of interest	Consumption of pork products alone or in combination with other foods/dietary patterns	Articles assessing foods other than pork or dietary patterns not including pork
		Articles that only specify red meat or sausage without identifying pork as a component
		Studies that do not include dietary assessment (i.e., studies using self-report only)
Comparators of interest	Any or no comparator	None
Outcomes of interest	Any health-related outcomes including nutrition deficiency/insufficiency	Food safety outcomesFood allergy outcomes irrespective of measure
		Articles looking singularly at the effect of pork on overall nutrient status
		Hunger and satiety outcomes
Study designs of interest	Any interventional and observational study design	Narrative reviews
		Systematic reviews
		Meta-analyses
		Letters to the editor
		Case studies
		Ecological studies
		Conference proceedings or abstracts

Table 2. List of outcome categories

Outcome Category	Definition
Cancer	Bladder cancer; breast cancer; colorectal cancer; esophageal cancer; gastric cancer; larynx cancer; lung cancer; malignant lymphoma; non-cardia gastric cancer; oral cancer; pancreatic cancer; prostate carcinoma; renal cell carcinoma; thyroid cancer; urinary system cancer; urothelial cancer
Cardiovascular disease risk	Arterial compliance; blood lipids profile; blood pressure; hypercholesterolemia; hypertension
Diabetes risk	Blood/plasma/serum glucose; GDM; insulin status; metabolic syndromes; type 2 diabetes
Cognitive function	Appetite; cognitive function scores; mood
Weight status and body composition	Anthropometrics; body composition; BMI; bone mineral density; muscle mass; obesity; weight
Nutrient status	Iron absorption or status; nitrogen balance; protein metabolites; serum folate; vitamin B12 status; zinc status
Inflammation and oxidative stress	Inflammatory status; monocyte activation markers; muscle inflammation markers; oxidative stress markers
Other	Alcoholic liver diseases; blood urine nitrogen; blood cadmium concentration; blood nitrosamine concentration; body strength; carboxymethyl-lysine; cholesterol gallstones; energy expenditure; Epstein-Barr virus; forearm fracture; gout; glomerular filtration rate; health-related quality of life; hemoglobin; homocysteine; life satisfaction; N-nitrosodimethylamine; pigment gallstones; polymorphisms of vitamin D metabolism genes; urinary PhIP

BMI = body mass index; GDM = gestational diabetes mellitus; PhIP = 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine.

characteristics, health outcome categories assessed in the studies, and funding source.

To visualize gaps in research, we created bubble plots (a type of weighted scatterplot) grouping studies by health outcome, study design, and pork category (fresh pork, processed pork, and mixed sources).

Results

We screened a total of 1,967 abstracts identified through literature searches in the Medline, Cochrane, and Embase databases. A total of 318 full-text articles were retrieved for full-text screening. After excluding 194 articles (see Appendix B for exclusion reasons), we included 126 studies (published in 124 articles) for data extraction. Of these 126 articles, we set aside 40 (see Appendix B for exclusion reasons).

We included 85 studies (in 83 publications) in the final scoping review (Lubin et al., 1981; Lakritz et al., 1982; Miller et al., 1983; Hislop et al., 1986; Kaul et al., 1986; Kune et al., 1987; Steineck et al., 1988; Olsen et al., 1989; Kneller et al., 1991; Richardson et al., 1991; Swanson et al., 1992; Abe et al., 1993; Yu et al., 1993; Goldbohm et al., 1994; Lohsoonthorn and Danvivat, 1995; Wilkens et al., 1996; Ambrosone et al., 1998; Bode et al., 1998; Takashima et al., 1998; Kidd et al., 1999; Smit et al., 1999; Sung et al., 1999; Breslow et al., 2000; Matsuo et al., 2001; Baech et al., 2003; Hu et al., 2003; Markaki et al., 2003; Nomura et al., 2003; Chiu and Gapstur, 2004; Toporcov et al., 2004; Brink et al., 2005; Radosavljević et al., 2005; Sakauchi et al., 2005; Milias et al., 2006; Pitsavos et al., 2006; Rubio et al., 2006; Sato et al., 2006; Xu et al., 2006; Dosil-Díaz et al., 2007; Hu et al., 2007a; 2007b; Leidy et al., 2007; Li et al., 2007; Brunt et al., 2008; Borawska et al., 2009; Campbell and Tang, 2010; Gilsing et al., 2012; McArthur et al., 2012; Murphy et al., 2012; Semba et al., 2012; Celada et al., 2013; Egeberg et al., 2013; Nolan-Clark et al., 2013; Pierre et al., 2013; Murphy et al., 2014; Poomphakwaen et al., 2014; Samman et al., 2014; Wang et al., 2014; Yazawa et al., 2014; Gong et al., 2015; Zou et al., 2015; Angelo et al., 2016; Charlton et al., 2016; Khorosh et al., 2016; Beals et al., 2017; Gong et al., 2017; Harrold et al., 2017; Hu et al., 2017; Kehlet et al., 2017; Martínez-Sánchez et al., 2017; Park et al., 2017; Song et al., 2017; Vulcan et al., 2017; Bartáková et al., 2018; Torres-Sánchez et al., 2018; Tricco et al., 2018; Xu et al., 2018; Gacek and Wojtowicz, 2019; Saliba et al., 2019; Sheng et al., 2019; Sneyd and Cox, 2020; Wedekind et al., 2020; American Heart Association, 2021). These included 16 randomized controlled trials, 1 uncontrolled trial, 7 cohort studies, 4 nonrandomized controlled trials, 4 case-cohort and nested case-control studies, 33 case-control studies, and 20 cross-sectional studies. Figure 1 outlines each stage of the literature search and selection process.

Study characteristics

Many studies investigated the effects of pork consumption on various outcome categories. Figure 2 shows the cumulative frequency of studies published every 5 y from 1988 to 2020. As shown in Figure 2, there was a significant increasing trend in the number of publications reporting cancer outcomes from 1988

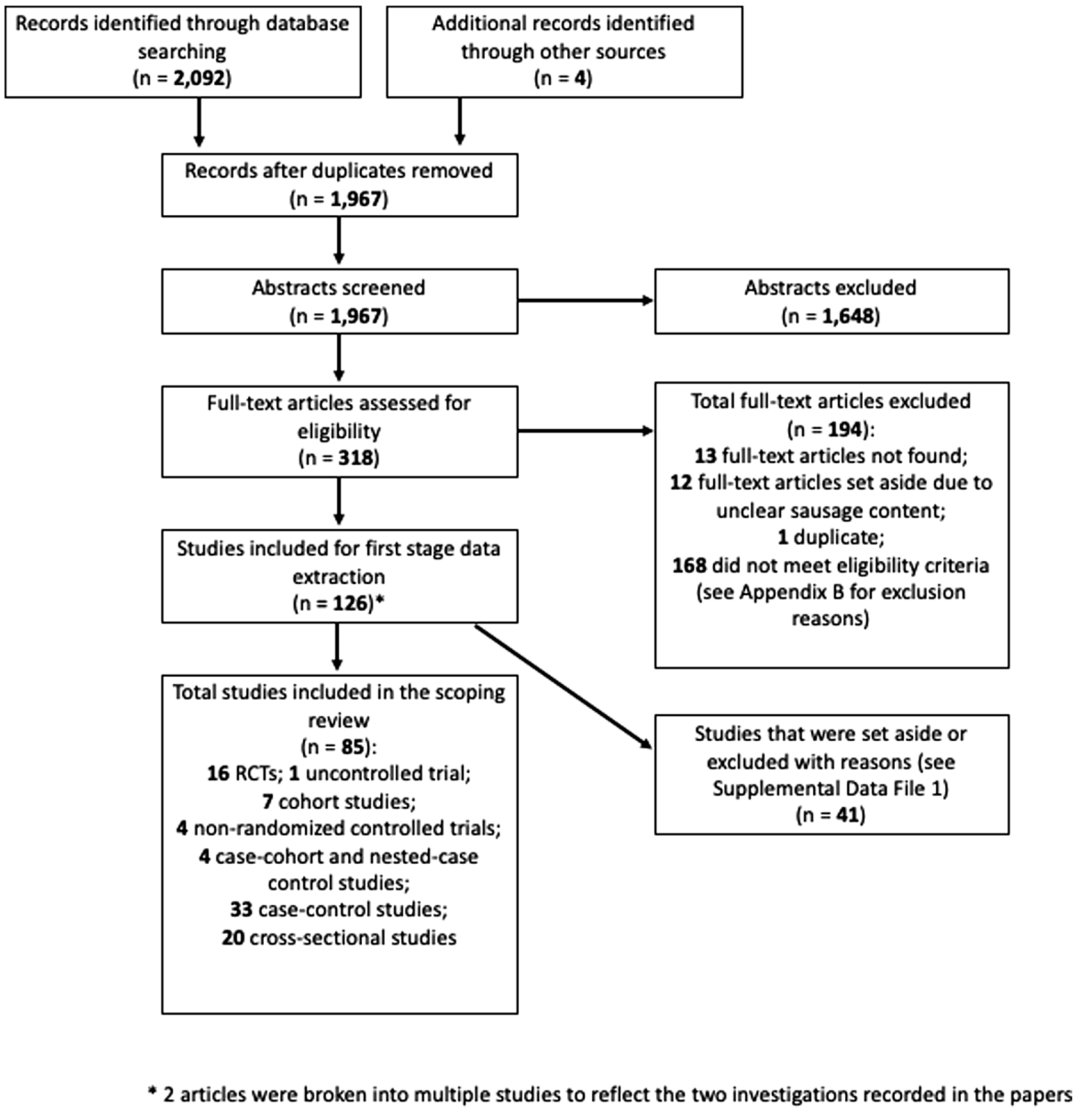

Figure 1. Literature search and study selection process. RCT = randomized controlled trial.

to 2020. Meanwhile, the number of publications reporting cardiovascular disease risk and nutrient status outcomes experienced a steady increase. The research published in other outcome categories, including diabetes mellitus risk factors, weight status and body composition, cognitive function, and inflammation and oxidative stress, emerged at the beginning of the 21st century and has increased since then.

Interventional studies

Among the 85 included studies, 21 were interventional studies (Table 3). Of these, 76.19% were randomized control trials, 19.05% were nonrandomized control trials, and 4.76% were uncontrolled trials. Of the included interventional studies, the average participant's mean age was 39.51 y (range, 1.49 to 82.69 y). Most studies had a duration of 1 to 6 mo (52.38%); 28.57% of studies were >1 mo in duration, whereas only 3 studies were longer than 6 mo. Within the 4 pork intervention categories, 28.57% were exclusive fresh meat, 14.29% provided only processed meat, 38.10% were mixed pork sources, and the other studies (19.05%) did not specify pork category. The majority of funding sources came from industry (33.33%) and mixed sources (38.10%). One-third of the interventional studies were conducted in Europe, 28.57% in North America, and 23.81% in Oceania. Only a few articles were from China (9.52%) and other Asian countries (4.76%). Nutrition status was the most frequently studied outcome among interventional studies, followed by weight status and body composition (28.57%) and cardiovascular heart disease risk (28.57%). Some

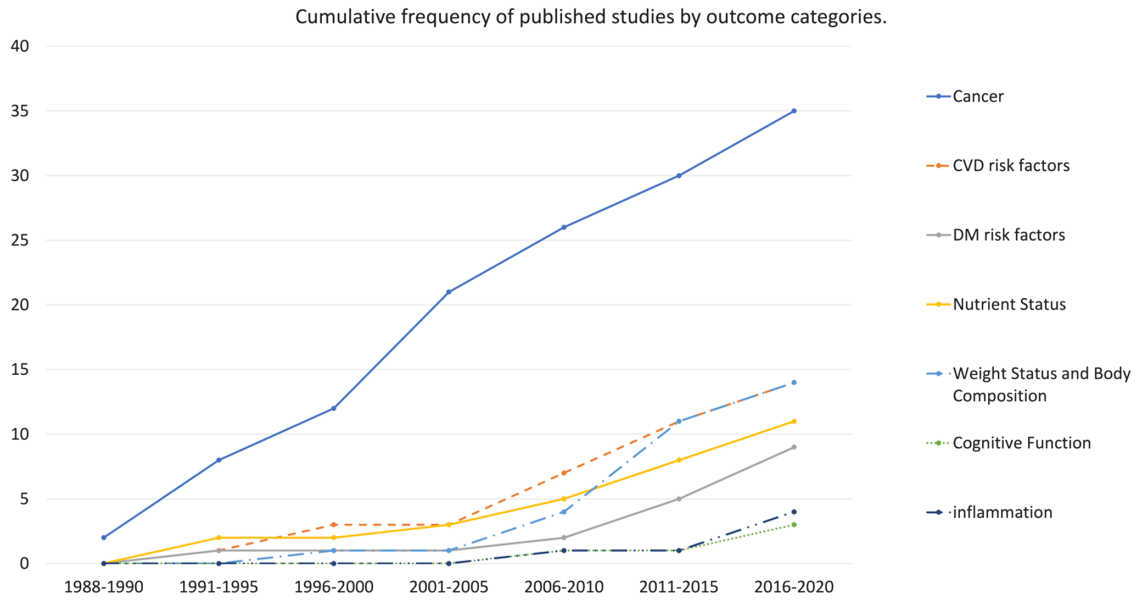

Figure 2. Cumulative frequency of published studies by outcome categories. CVD = cardiovascular disease; DM = diabetes mellitus.

Table 3. Summary of study characteristics of interventional studies

Characteristic	Interventional Study (N = 21)
Design	
Randomized controlled trial	16 (76.19)
Non–randomized controlled trial	4 (19.05)
Uncontrolled trial	1 (4.76)
Sample size, n (range)	42.86 (1–180)
Mean age, y (range)[a]	39.51 (1.49–82.69)
Intervention duration	
<1 mo	7 (33.33)
1–6 mo	11 (52.38)
6–12 mo	2 (9.52)
≥1 y	1 (4.76)
Pork category	
Fresh meat only	6 (28.57)
Mixed	8 (38.10)
Processed meat only	3 (14.29)
Not specified	4 (19.05)
Baseline health status	
100% healthy	19 (90.48)
Generally healthy[b]	0 (0.00)
With disease condition[c]	2 (9.52)
Not reported	0 (0.00)
Funding source	
Academic	0 (0.00)
Government	0 (0.00)
Industry	7 (33.33)
Nonprofit	1 (4.76)
Mixed sources	8 (38.10)
Not reported	5 (23.81)
Region	
North America	6 (28.57)
South America	0 (0.00)
China	2 (9.52)
Other Asia	1 (4.76)
Oceania	5 (23.81)
Europe	7 (33.33)
Outcome categories[d]	
Cancer	1 (4.76)
Cardiovascular disease risk factors	7 (33.33)
Diabetes mellitus risk factors	6 (28.57)
Nutrient status	10 (47.62)
Weight status and body composition	9 (42.86)
Cognitive function	3 (14.29)
Inflammation and oxidative stress	4 (19.05)
Other	6 (28.57)

Data are presented as *n* (%) unless indicated otherwise.

[a]Mean age represents the average of the reported mean age for each included study. The median age was used if the mean age was not reported. The midpoint of the reported age range was used if neither mean age nor median age was reported. One study did not report mean age, median age, or age range.

[b]Generally healthy: ≤20% of the population have diseases.

[c]With disease conditions: >20% of the population have diseases.

[d]Some studies examined multiple outcomes, which generates percentages that sum to >100%.

studies focused on inflammation (14.29%), cancer (4.76%), and cognitive function (4.76%), whereas 38.1% studied other outcomes. Only 3 interventional studies isolated effects of processed pork intake.

Observational studies

A total number of 64 observational studies were included. Most were cross-sectional studies and case-control studies (82.81%). Cohort studies (17.19%) include prospective and retrospective cohort studies, case-cohort studies, and nested case-control studies (Table 4). The average participant's mean age was 53.7 y. About half of the included studies specified the type of pork exposure. For instance, 15.62% reported fresh pork as the only exposure, 9.38% reported processed pork exposure only (i.e., bacon, ham, and other processed pork product), and 25% reported mixed exposure of fresh and processed pork. More than half of the included studies reported the funding source. Of these, 7.81% were supported by multiple funding resources. As for studies reporting a single funding source, government funding was the most common (29.69%), followed by nonprofit (9.38%) and industry (6.25%) funding. Included studies were conducted across the globe, with 32.81% conducted in North American countries, 26.56% in European countries, and 20.31% in China. No cohort studies were identified as being conducted in the South America region or the Oceania region. The most commonly reported outcome was cancer (60.9%), followed by cardiovascular disease risk factors (10.93%) and weight status and body composition outcome (7.81%). Cancer and weight status and body composition were the only 2 outcomes reported in cohort studies. Only 6 case-control and 6 cross-sectional studies isolated effects of processed pork intake, with the large majority focusing on cancer incidence.

Identifying research gaps related to study design and pork categorization

Figure 3 shows the differences in outcome categories explored by interventional studies and observational studies. Nutrient status outcomes were the most frequently explored in interventional studies. These included nutrient status biomarkers for protein/amino acids, folate iron, vitamin B_6, vitamin B_{12}, and zinc. We did not find studies assessing pork's contribution to selenium or thiamin status. Cancer outcomes were the most frequently explored in observational studies. Very few observational studies explored inflammation, oxidative stress, or cognitive function associated with pork consumption. Only one interventional study assessed the role of pork intake with cancer outcomes. As expected, sample sizes were much larger for observational studies compared with interventional studies.

Figure 4 shows the differences in health outcomes reported by categorization of pork as fresh pork, processed pork, and mixed pork sources. Studies that included fresh pork as the main exposure of interest reported on almost all outcome categories, with the largest number of fresh pork studies reporting on cancer risk. Studies that included processed pork as the main exposure of interest primarily reported on cancer risk, with 1 study reporting on weight status and body composition and 1 study reporting on cardiovascular disease risk. Studies that included mixed pork sources as the main exposure of interest reported on all outcomes, and cancer was the most frequently investigated outcome. Figure 5 shows differences in cancer outcome sites reported by categorization of pork as fresh pork, processed pork, and mixed pork sources. Cancers of the gastrointestinal tract were frequent sites to be assessed across observational studies.

Discussion

Scoping reviews are a replicable, systematic, and evidence-based approach used to identify, collect, and evaluate the characteristics of the existing peer-reviewed literature. Here, we highlight research gaps and opportunities for systematic reviews in relation to the effects of pork consumption on human nutrition and health. The scientific literature contains mostly observational studies, a large majority being case-controlled and cross-sectional analyses. To date, there are a dearth of high-quality randomized controlled trials assessing effects of pork intake on disease risk factors and outcomes. The effect of pork intake on patients' nutrient status was the most assessed outcome. No interventional studies explored diabetes mellitus risk, and only 1 study assessed cancer risk associated with pork consumption. The single "cancer risk" intervention sought to investigate whether cured meat modulates biomarkers of cancer risk and whether specific agents can suppress cured meat–induced preneoplastic lesions in rats and associated biomarkers in rats and humans. Data from this study suggest that the addition of calcium carbonate to the diet or α-tocopherol to cured meat may reduce colorectal cancer risk associated with cured meat intake among observational studies (Pierre et al., 2013). Along the same lines, regular consumption of biopeptides contained in dry-cured ham but absent in cooked ham were shown to impair platelet and monocyte activation and levels of plasmatic P-selected, monocyte chemoattractant protein-1 and interleukin-6 in healthy subjects (Martínez-Sánchez et al., 2017). Surprisingly, there was a dearth of observational studies and absence of

Table 4. Summary of study characteristics of observational studies

Characteristic	Combined (N = 64)	Cross-Sectional and Case-Control Studies (n = 53)	Cohort Studies[a] (n = 11)
Number of studies	64 (100)	53 (82.81)	11 (17.19)
Sample size, mean (range)	7,851 (46–64,539)	4,456 (46–56,237)	24,205 (3,500–64,539)
Mean age, y[b]	53.71	53.44	54.92
Follow-up duration, y			
2–5	NA	NA	1 (9.09)
5–10	NA	NA	3 (27.27)
10–15	NA	NA	4 (36.36)
≥15	NA	NA	3 (27.27)
Pork category			
Fresh meat only	10 (15.62)	8 (15.09)	2 (18.18)
Mixed	16 (25.00)	13 (24.53)	3 (27.27)
Processed meat only	6 (9.38)	6 (11.32)	0 (0.00)
Not specified	32 (50.00)	26 (49.06)	6 (54.55)
Baseline health status			
100% healthy	NA	NA	3 (27.27)
Generally healthy[c]	NA	NA	2 (18.18)
With disease conditions[d]	NA	NA	3 (27.27)
Not reported	NA	NA	3 (27.27)
Funding source			
Academic	1 (1.56)	1 (1.89)	0 (0.00)
Government	19 (29.69)	15 (28.30)	4 (36.36)
Industry	4 (6.25)	4 (7.55)	0 (0.00)
Nonprofit	6 (9.38)	4 (7.55)	2 (18.18)
Mixed sources	5 (7.81)	4 (7.55)	1 (9.09)
Not reported	29 (45.31)	25 (47.17)	4 (36.36)
Region			
North America	21 (32.81)	19 (35.83)	2 (18.18)
South America	2 (3.12)	2 (3.77)	0 (0.00)
China	13 (20.31)	12 (22.64)	1 (9.09)
Other Asia	8 (12.50)	6 (11.32)	2 (18.18)
Oceania	3 (4.69)	3 (5.66)	0 (0.00)
Europe	17 (26.56)	11 (20.75)	6 (54.55)
Outcome categories[e]			
Cancer	39 (60.94)	29 (54.72)	10 (90.91)
Cardiovascular disease risk factors	7 (10.94)	7 (13.21)	0 (0.00)
Diabetes mellitus risk factors	3 (4.96)	3 (5.66)	0 (0.00)
Nutrient status	1 (1.56)	1 (1.56)	0 (0.00)
Weight status and body composition	5 (7.81)	4 (7.55)	1 (9.09)
Cognitive function	0 (0.00)	0 (0.00)	0 (0.00)
Inflammation and oxidative stress	0 (0.00)	0 (0.00)	0 (0.00)
Other	12 (18.5)	12 (22.64)	0 (0.00)

Data are presented as *n* (%) unless indicated otherwise.

[a]Cohort studies include prospective cohort study, retrospective cohort study, case-cohort study, and nested case-control study.

[b]Mean age represents the average of reported mean age for each included study. The median age was used if the mean age was not reported. The midpoint of the reported age range was used if neither mean age nor median age was reported. Fifteen studies did not report mean age, median age, or age range.

[c]Generally healthy: ≤20% of the population have diseases.

[d]With disease conditions: >20% of the population have diseases.

[e]Some studies examined multiple outcomes, which generates percentages that sum to >100%.

NA = not applicable.

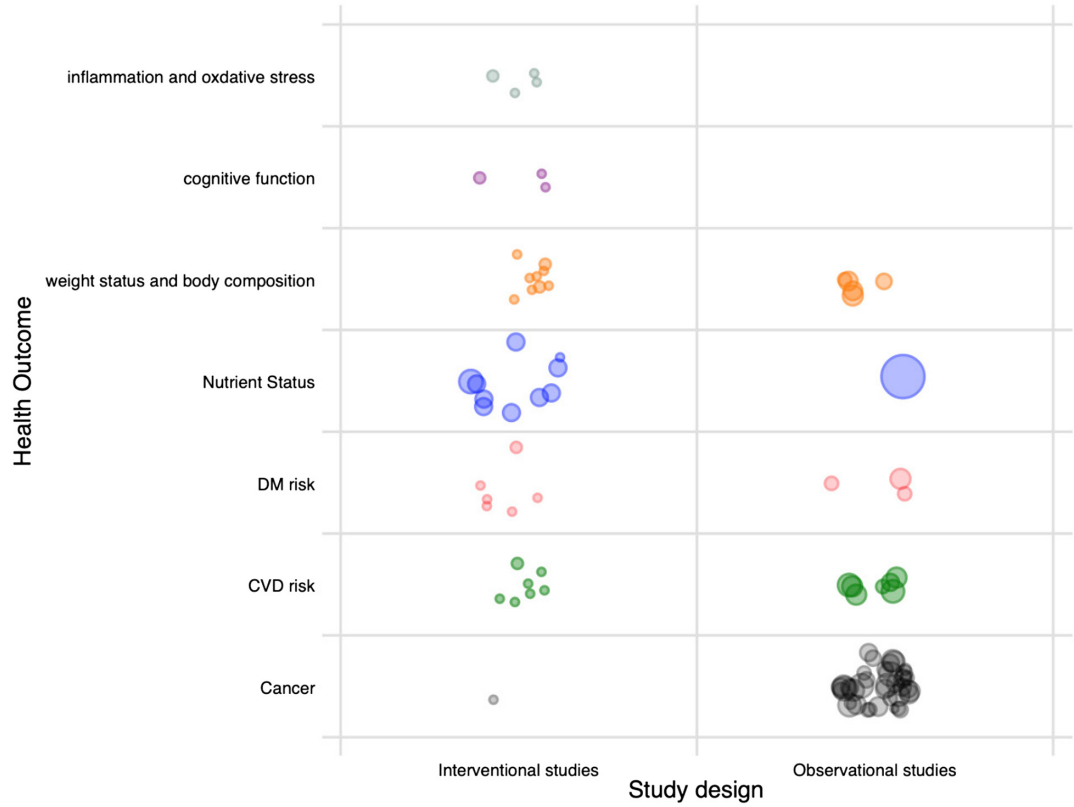

Figure 3. Bubble plot of health outcome categories by study design. Each bubble in the figure represents one study, and the size of the bubble is proportional to the study sample size. CVD = cardiovascular disease; DM = diabetes mellitus.

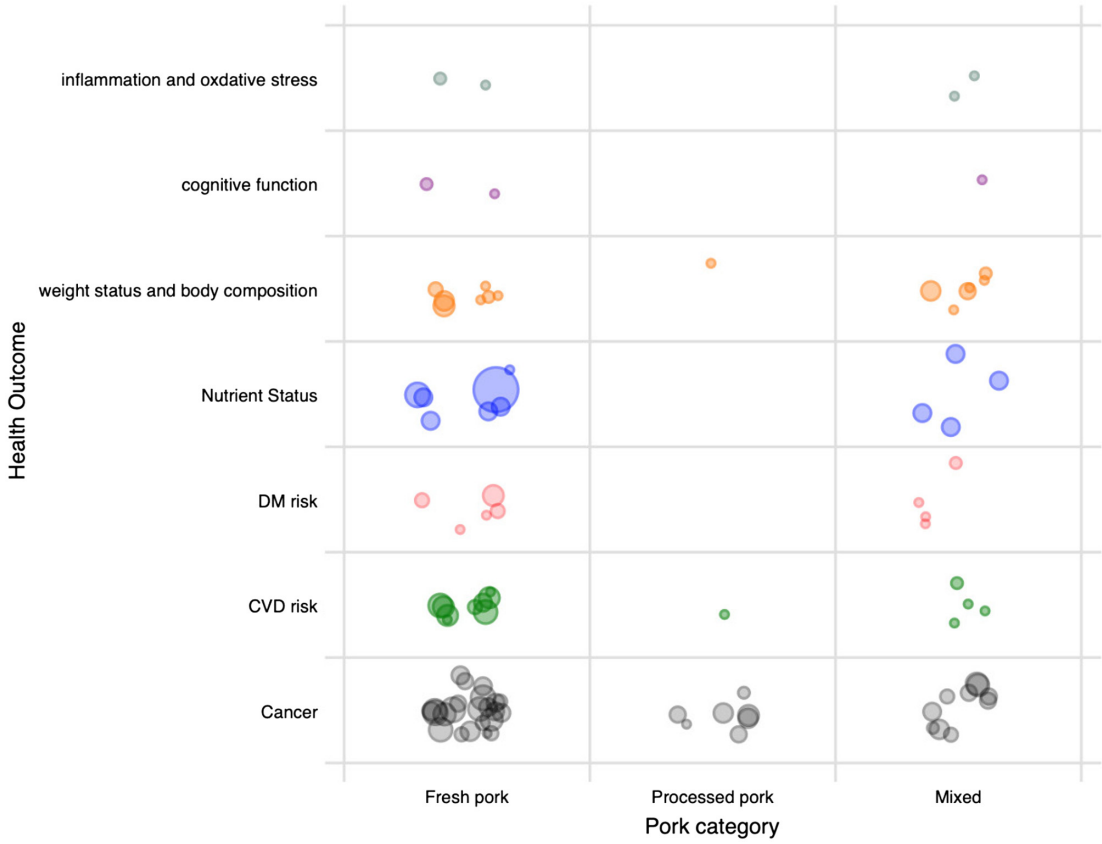

Figure 4. Bubble plot of health outcome categories by pork categorization. Each bubble in the figure represents one study, and the size of the bubble is proportional to the study sample size. Categories specified as "other" were not included in this bubble plot. CVD = cardiovascular disease; DM = diabetes mellitus.

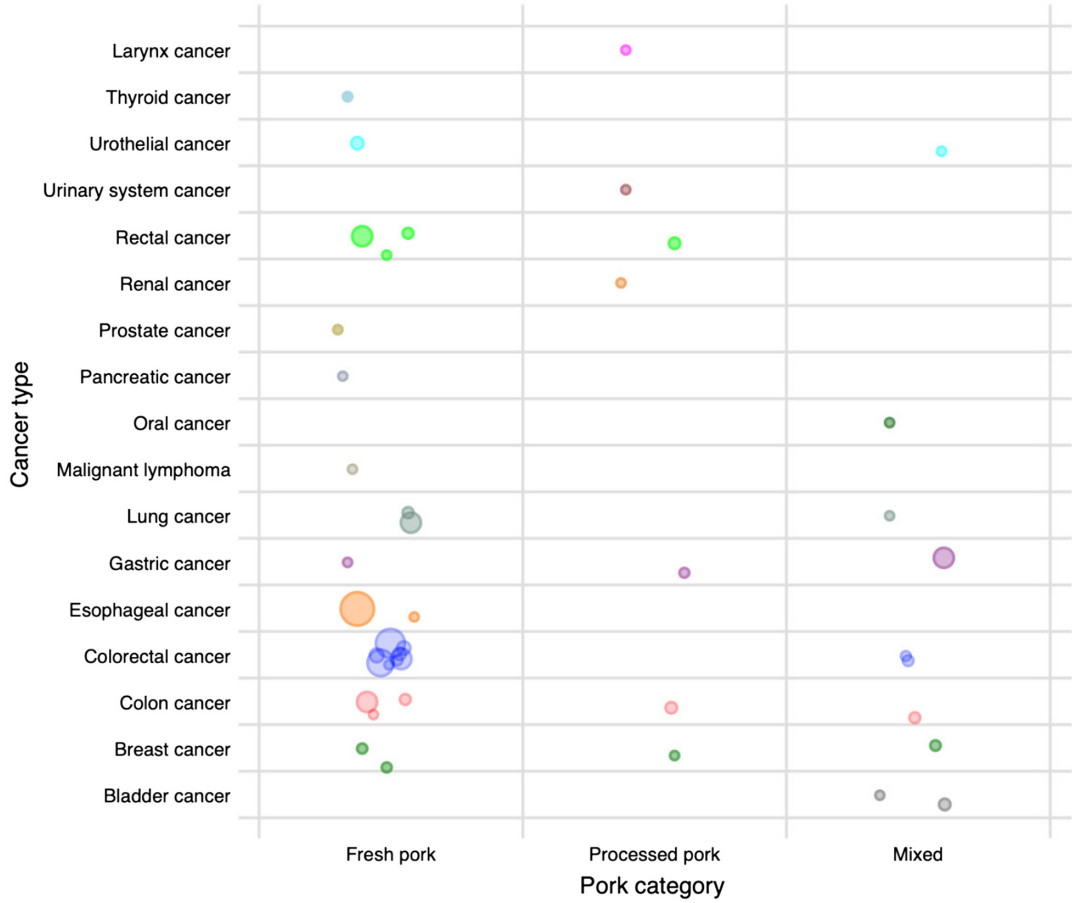

Figure 5. Bubble plot of cancer outcome sites by pork categorization. Each bubble in the figure represents one study, and the size of the bubble is proportional to the study sample size.

prospective cohort studies that examined the role of processed pork on cancer incidence and other health outcomes. Many food frequency questionnaires (FFQ) used in observational analyses are currently not able to quantify intake of fresh and processed pork. This is an important research gap that needs to be addressed among FFQ and when designing future observational research.

Although rural Chinese toddlers consuming fortified cereal had higher vitamin B_{12} levels in one study, those receiving 50 g of pork per day had higher cognitive scores (Sheng et al., 2019). However, a separate quasi-experimental study did not find any advantages of pork versus chicken on cognitive function in healthy older adults, suggesting that the type of dietary protein during aging may not impact cognitive function (Charlton et al., 2016). The inclusion of 2 to 3 weekly servings of fresh, lean pork in the Mediterranean diet was shown to lead to improved cognitive performance over a 24-wk period, as indicated by higher processing speed performance and emotional role functioning. The Mediterranean diet, which is rich in high-selenium foods such as seafood and nuts, has been associated with a lower risk of age-related cognitive decline (Scarmeas et al., 2006; Hardman et al., 2016). Several micronutrients in pork, including zinc, iron, selenium, choline, thiamin, and vitamins B_6 and vitamin B_{12}, are thought to influence cognitive function and may prove to be an exciting emerging area of research. Future prospective cohort investigations could greatly help in the design of larger, long-duration randomized clinical trials that assess outcomes (e.g., Alzheimer's dementia incidence).

Most observational studies assessed the effect of pork on cancer incidence, followed by cardiovascular disease, weight status and body composition, type 2 diabetes, and nutrient status. No prospective cohort studies assessed the effects of pork on cardiovascular disease, type 2 diabetes, cognition, inflammation/oxidative stress, or nutrient status.

Our study has several strengths and weaknesses. The main strength of this review is the thorough, systematic search strategy and detailed analysis of characteristics reported in the included studies. This review is

limited by the availability of manuscripts to online searches in the English language. Another limitation important to note is that scoping reviews do not typically include quality (risk of bias) appraisal of included studies, and therefore there can be substantial amounts of poor-quality research. Observational studies failed to indicate whether the AMSA lexicon for "minimal processing and "further processing" was adopted, in the same way we categorized products as "fresh" or "processed" pork. The inability of current FFQ to distinguish between fresh and processed pork poses additional major limitations to our analyses.

Conclusions

Few conclusions can be drawn from studies evaluating the effects of pork on human nutrition and health. Several micronutrients in pork, including zinc, iron, selenium, choline, thiamin, and vitamins B_6 and vitamin B_{12}, are thought to influence cognitive function, and this may prove to be an exciting area of emerging research. To date, there is a dearth of high-quality randomized controlled trials assessing the effects of pork intake on disease risk factors and outcomes. The scientific literature contains mostly observational studies, a large majority being case-controlled and cross-sectional analyses. Of note, there is a lack of studies examining isolated effects of processed pork intake on human health. Future clinical trials should address the role of pork consumption in health outcomes, intermediate outcomes, and validated biomarkers.

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Appendices

Appendix A. Search Strategies

A1. Medline

Database: Ovid MEDLINE(R) <1946 to December Week 5 2020>

Search Strategy:

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1 exp Pork Meat/ (172)

2 ("Boston butt" or Loin or Pancetta or Collops or Gammon or Bacon or Sausage or Charcuterie or Terrines or Galantines or Pates or Confit or Jamon or Feijoada or Bakkwa or Charsiu or Lechan).af. (10575)

3 pork.af. (8253)

4 2 or 3 (17988)

5 diet.mp. or exp Diet/ (486323)

6 4 and 5 (1902)

7 1 or 6 (2051)

8 limit 7 to (english language and humans) (1022)

A2. EmBase

Embase

Session Results

. . . . . .

No.,Query,Results

#10, #8 NOT #9, 905

#9, #8 AND [medline]/lim, 1445

#8,"#7 AND [english]/lim AND [humans]/lim",2350

#7,"#1 OR #6",5405

#6,"#4 AND #5",2544

#5,"'diet'/exp OR diet",776986

#4,"#2 OR #3",25289

#3,"pork",11334

#2,"'boston butt' OR loin OR pancetta OR collops OR gammon OR bacon OR sausage OR charcuterie OR terrines OR galantines OR pates OR confit OR jamon OR feijoada OR bakkwa OR charsiu OR lechan",15043

#1,"'pork'/exp",3373

A3. Cochrane Central

Database: EBM Reviews - Cochrane Central Register of Controlled Trials <December 2020>, Global Health <1910 to 2021 Week 04>

Search Strategy:

1 exp Pork Meat/ (0)

2 ("Boston butt" or Loin or Pancetta or Collops or Gammon or Bacon or Sausage or Charcuterie or Terrines or Galantines or Pates or Confit or Jamon or Feijoada or Bakkwa or Charsiu or Lechan).af. (10058)

3 pork.af. (22967)

4 2 or 3 (29840)

5 diet.mp. or exp Diet/ (363335)

6 4 and 5 (2885)

7 1 or 6 (2885)

8 limit 7 to (english language and humans) [Limit not valid in CCTR,Global Health; records were retained] (2166)

9 limit 8 to ("review" or "review literature" or "review of reported cases" or review, academic or review, multicase or review, tutorial) [Limit not valid in Global Health; records were retained] (2001)

10 8 not 9 (165)

Appendix B. Excluded articles with reasons for exclusion

First Author (Year)	Title	Reason for Exclusion
Alves-Santos (2018)	Dietary patterns and their association with adiponectin and leptin concentrations throughout pregnancy: a prospective cohort	Pork cannot be isolated
Anonymous (1994)	Dietary and other risk factors of ulcerative colitis. A case-control study in Japan. Epidemiology Group of the Research Committee of Inflammatory Bowel Disease in Japan	Set aside due to processed meat
Armstrong (1998)	Nasopharyngeal carcinoma in Malaysian Chinese: salted fish and other dietary exposures	Pork cannot be isolated
Aro (1994)	Factors affecting the selenium intake of people in Transbaikalian Russia	No human subjects
Asakura (2014)	Estimation of food portion sizes frequently consumed by children 3-6 y old in Japan	No health outcome
Baker (1986	Urine mutagenicity as an indicator of exposure to dietary mutagens formed during cooking of foods	No exposure of interest
Balder (2005)	Dietary patterns associated with male lung cancer risk in the Netherlands Cohort Study	Pork cannot be isolated
Barth (2001)	Food intake of patients with atopic dermatitis	No outcome of interest
Beals (2016)	Anabolic sensitivity of postprandial muscle protein synthesis to the ingestion of a protein-dense food is reduced in overweight and obese young adults	No exposure of interest
Bingham (1996)	Does increased endogenous formation of N-nitroso compounds in the human colon explain the association between red meat and colon cancer?	Pork cannot be isolated
Bingham (1996)	Does increased endogenous formation of N-nitroso compounds in the human colon explain the association between red meat and colon cancer?	Duplicate
Butler (2006)	Prospective study of dietary patterns and persistent cough with phlegm among Chinese Singaporeans	Pork cannot be isolated
Campbell (1999)	Effects of an omnivorous diet compared with a lactoovovegetarian diet on resistance-training-induced changes in body composition and skeletal muscle in older men	Pork cannot be isolated
Caselli (2014)	Test-based exclusion diets in gastro-esophageal reflux disease patients: a randomized controlled pilot trial	Pork cannot be isolated
Celada (2014)	Omega-3 enriched frankfurters and pâtés intake decrease TXA2 level and N-6/N-3 in volunteers at increased cardiovascular risk: a placebo-controlled study	Abstract only
Cempaka (2019)	Dysregulated iron metabolism-associated dietary pattern predicts an altered body composition and metabolic syndrome	Pork cannot be isolated
Chan (2004)	Postprandial glucose response to Chinese foods in patients with type 2 diabetes	Pork cannot be isolated
Charlton (2011)	Pork, beef and chicken have similar effects on acute satiety and hormonal markers of appetite	No outcome of interest
Chatzivagia (2019)	Nutrition transition in the post-economic crisis Greece: assessing the nutritional gap of food insecure individuals. A case-control study	Pork cannot be isolated
Chen (2020)	The risk of urinary tract infection in vegetarians and non-vegetarians: a prospective study	Pork cannot be isolated
Coates (2009)	Regular consumption of n-3 fatty acid-enriched pork modifies cardiovascular risk factors	Pork cannot be isolated
Coelho Nde (2015)	Dietary patterns in pregnancy and birth weight	Pork cannot be isolated
Cui (2007)	Dietary patterns and breast cancer risk in the Shanghai Breast Cancer Study	Pork cannot be isolated
Cuparencu (2020)	The anserine to carnosine ratio: an excellent discriminator between white and red meats consumed by free-living overweight participants of the PREVIEW study	PDF not found
Davidson (1999)	Comparison of the effects of lean red meat vs lean white meat on serum lipid levels among free-living persons with hypercholesterolemia: a long-term, randomized clinical trial	Pork cannot be isolated
de Gavelle (2018)	Patterns of protein food intake are associated with nutrient adequacy in the general French adult population	No outcome of interest
Deneo-Pellegrini (2015)	Meat consumption and risk of squamous cell carcinoma of the lung: a case-control study in Uruguayan men	Pork cannot be isolated
Di Pietro (2007)	Breast cancer in southern Brazil: association with past dietary intake	Pork cannot be isolated
Dixon (2004)	Dietary patterns associated with colon and rectal cancer: results from the Dietary Patterns and Cancer (DIETSCAN) Project	Pork cannot be isolated
Dolara (1984)	Urinary mutagens in humans after fried pork and bacon meals	No exposure of interest

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Endoh (2015)	Interactions between psychological stress and drinking status in relation to diet among middle-aged men and women: a large-scale cross-sectional study in Japan	Pork cannot be isolated
Erhardt (2002)	Alcohol, cigarette smoking, dietary factors and the risk of colorectal adenomas and hyperplastic polyps–a case control study	No exposure of interest
Erkkila (2014)	Effect of fatty and lean fish intake on lipoprotein subclasses in subjects with coronary heart disease: a controlled trial	Pork cannot be isolated
Etemadi (2017)	Mortality from different causes associated with meat, heme iron, nitrates, and nitrites in the NIH-AARP Diet and Health Study: population based cohort study	Pork cannot be isolated
Favero (1998)	Diet and risk of breast cancer: major findings from an Italian case-control study	Set aside due to processed meat
Flynn (1982)	Dietary "meats" and serum lipids	PDF not found
Franceschi (1999)	The role of energy and fat in cancers of the breast and colon-rectum in a southern European population	Set aside due to processed meat
Franceschi (1995)	Influence of food groups and food diversity on breast cancer risk in Italy	Set aside due to processed meat
French (1994)	Food intake and physical activity: a comparison of three measures of dieting	No exposure of interest
Friedenberg (2010)	Population-based survey: body mass index at age 18 is strongly predictive of adulthood obesity	Abstract only
Fung (2004)	Dietary patterns, meat intake, and the risk of type 2 diabetes in women	Pork cannot be isolated
Gacek (2014)	Individual differences as predictors of dietary patterns among menopausal women with arterial hypertension	Set aside due to processed meat
Giles (1994)	Dietary factors and the risk of glioma in adults: results of a case-control study in Melbourne, Australia	Pork cannot be isolated
Giovannucci (1994)	Intake of fat, meat, and fiber in relation to risk of colon cancer in men	Pork cannot be isolated
Gorder (1986)	Dietary intake in the Multiple Risk Factor Intervention Trial (MRFIT): nutrient and food group changes over 6 y	Pork cannot be isolated
Guallar-Castillon (2013)	The Southern European Atlantic Diet is associated with lower concentrations of markers of coronary risk	Pork cannot be isolated
Gunasekeera (2016)	Treatment of Crohn's disease with an IgG4-guided exclusion diet: a randomized controlled trial	No outcome of interest
Hansen (2015)	A long-term fatty fish intervention improved executive function in inpatients with antisocial traits and a history of alcohol and drug abuse	Pork cannot be isolated
Hansen (2014)	Fish consumption, sleep, daily functioning, and heart rate variability	Pork cannot be isolated
Hansen (2014)	Reduced anxiety in forensic inpatients after a long-term intervention with Atlantic salmon	Pork cannot be isolated
Hartung (1980)	Relation of diet to high-density-lipoprotein cholesterol in middle-aged marathon runners, joggers, and inactive men	PDF not found
Harvala (2019)	Hepatitis E virus in blood donors in England, 2016 to 2017: from selective to universal screening	No outcome of interest
Hebert (1998)	The effect of dietary exposures on recurrence and mortality in early stage breast cancer	Pork cannot be isolated
Heningburg (2015)	Nutritional intake assessment in patients with urolithiasis: a decision impact analysis	Pork cannot be isolated
Henry (2002)	Brief communication: energy and protein intake in a sample of hospitalized elderly in Hong Kong	No outcome of interest
Hernandez (2015)	An estimation of the carcinogenic risk associated with the intake of multiple relevant carcinogens found in meat and charcuterie products	No human subjects
Hobbs (2018)	Associations between red and processed meat consumption and cardiometabolic risk markers among British adults	Pork cannot be isolated
Hogan (2012)	Effects of protein quantity and source (animal versus plant) on indices of mood and fed-state large neutral amino acids and tryptophan profile	PDF not found
Houston (1997)	Lifestyle and dietary practices influencing iron status in university women	Pork cannot be isolated
Hunninghake (2000)	Incorporation of lean red meat into a National Cholesterol Education Program Step I diet: a long-term, randomized clinical trial in free-living persons with hypercholesterolemia	Pork cannot be isolated
Ifejika (2016)	Swipe out Stroke: Feasibility and efficacy of using a smart-phone based mobile application to improve compliance with weight loss in obese minority stroke patients and their carers	Study protocol
Ishizuka (1993)	Influence of meals and night shifts on health	Pork cannot be isolated

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Jacobson (1983)	Increased excretion of malonaldehyde equivalents in the urine after consumption of cooked, stored meats	PDF not found
Jacques (1992)	Effects on plasma lipoproteins and endogenous sex hormones of substituting lean white fish for other animal-protein sources in diets of postmenopausal women	Pork cannot be isolated
Jakic (2010)	Are lipoprotein disturbances in chronic hemodialyzed patients only renal failure related?	Abstract only
Jonsson (2016)	Diet in 1-year-old farm and control children and allergy development: results from the FARMFLORA birth cohort	No outcome of interest
Jung (2010)	The influence of dietary patterns on acne vulgaris in Koreans	No outcome of interest
Kassier (2016)	Colon cancer and the consumption of red and processed meat: An association that is medium, rare or well done?	an review article
Kato (1987)	Per capita foods/nutrients intake and mortality from gastrointestinal cancers in Japan	Set aside due to processed meat
Kato (1987)	Relationship between westernization of dietary habits and mortality from breast and ovarian cancers in Japan	Set aside due to processed meat
Kiefer (2005)	Eating and dieting differences in men and women	No outcome of interest
Kim (2017)	Red meat and chicken consumption and its association with high blood pressure and obesity in South Korean children and adolescents: a cross-sectional analysis of KSHES, 2011-2015	Pork cannot be isolated
Kimura (2007)	Meat, fish and fat intake in relation to subsite-specific risk of colorectal cancer: the Fukuoka Colorectal Cancer Study	Pork cannot be isolated
Kjaerheim (1998)	The role of alcohol, tobacco, and dietary factors in upper aerogastric tract cancers: a prospective study of 10,900 Norwegian men	Pork cannot be isolated
Kocic (1997)	Diet and breast cancer	PDF not found
Komorniak (2019)	What are the diets of patients before bariatric surgery?	Pork cannot be isolated
Lacaille (2000)	Responses of plasma lipoproteins and sex hormones to the consumption of lean fish incorporated in a prudent-type diet in normolipidemic men	Pork cannot be isolated
Landi (2019)	Daily meat consumption and variation with aging in community-dwellers: Results from Longevity Check-Up 7 + project	Pork cannot be isolated
Lang (2018)	Impact of individual traits, saturated fat, and protein source on the gut microbiome	Pork cannot be isolated
Langsetmo (2010)	Dietary patterns in Canadian men and women ages 25 and older: relationship to demographics, body mass index, and bone mineral density	Pork cannot be isolated
Lankinen (2009)	Fatty fish intake decreases lipids related to inflammation and insulin signaling–a lipidomics approach	Pork cannot be isolated
Larsson (2006)	Processed meat consumption, dietary nitrosamines and stomach cancer risk in a cohort of Swedish women	Pork cannot be isolated
Lee (2005)	Breast cancer and dietary factors in Taiwanese women	Pork cannot be isolated
Levi (1998)	Food groups and risk of oral and pharyngeal cancer	Pork cannot be isolated
Levi (2000)	Food groups and oesophageal cancer risk in Vaud, Switzerland	Set aside due to processed meat
Levi (1999)	Food groups and colorectal cancer risk	Set aside due to processed meat
Li (2016)	Effects of dietary protein source and quantity during weight loss on appetite, energy expenditure, and cardio-metabolic responses	Pork cannot be isolated
Li (2015)	Prospective cohort study of cured meat intake and asthma symptom score in the EGEA study	PDF not found
Li (2007)	Dietary mutagen exposure and risk of pancreatic cancer	Pork cannot be isolated
Li (2016)	Effects of dietary protein source and quantity on glycemic control in energy-restricted overweight and obese adults	PDF not found
Lin (2010)	Red meat and heterocyclic amine intake, metabolic pathway genes, and bladder cancer risk	Abstract only
Lindqvist (2009)	Herring (*Clupea harengus*) intake influences lipoproteins but not inflammatory and oxidation markers in overweight men	Pork cannot be isolated
Lindqvist (2007)	Herring (*Clupea harengus*) supplemented diet influences risk factors for CVD in overweight subjects	Pork cannot be isolated
Linseisen (2002)	Meat consumption in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts: results from 24-hour dietary recalls	No outcome of interest

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Liu (2019)	Fat from dairy foods and 'meat' consumed within recommended levels is associated with favourable serum cholesterol levels in institutionalised older adults	Pork cannot be isolated
Lizcano (2020)	The impact of lean pork meat consumption on cardiovascular risk	Non-English study
Lyon (1993)	Dietary intake as a risk factor for cancer of the exocrine pancreas	Pork cannot be isolated
Ma (2000)	Zinc and copper intakes and their major food sources for older adults in the 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII)	No outcome of interest
Magee (2005)	Associations between diet and disease activity in ulcerative colitis patients using a novel method of data analysis	No outcome of interest
Manara (2013)	Is gout still the rich and dissolute men's disease? Results from the KING study of the Italian Society for Rheumatology (SIR)	Abstract only
Mannisto (2005)	Dietary patterns and breast cancer risk: results from three cohort studies in the DIETSCAN project	Pork cannot be isolated
Martin (2016)	Maternal dietary patterns are associated with lower levels of cardiometabolic markers during pregnancy	Pork cannot be isolated
McArthur (2011)	Inclusion of pork meat in the diets of young women reduces snack food consumption and increases fruit and vegetable intakes	No outcome of interest
McKay (2015)	Whole eggs enhance antioxidant activity when combined with energy dense, cooked breakfast foods	PDF not found
McNaughton (2011)	An energy-dense, nutrient-poor dietary pattern is inversely associated with bone health in women	Pork cannot be isolated
Minami (1993)	Female systemic lupus erythematosus in Miyagi Prefecture, Japan: a case-control study of dietary and reproductive factors	Pork cannot be isolated
Miyake (2018)	Dietary patterns and depressive symptoms during pregnancy in Japan: baseline data from the Kyushu Okinawa Maternal and Child Health Study	Pork cannot be isolated
Miyake (2011)	Maternal dietary patterns during pregnancy and risk of wheeze and eczema in Japanese infants aged 16–24 mo: the Osaka Maternal and Child Health Study	Pork cannot be isolated
Montoro Garcia (2016)	Dry-cured ham, its effects on human blood pressure and cardiovascular risk: a clinical study	Abstract only
Moon (2015)	Application of instrumental neutron activation analysis to assess dietary intake of selenium in Korean adults from meat and eggs	No human subjects
Mozaffarian (2006)	Dietary fish and n-3 fatty acid intake and cardiac electrocardiographic parameters in humans	No outcome of interest
Mrazova (2020)	The effect of consumption of pork enriched by organic selenium on selenium status and lipid profile in blood serum of consumers	No exposure of interest
Mubiru (2017)	Exposure assessment of epoxy fatty acids through consumption of specific foods available in Belgium	No outcome of interest
Nagao (2012)	Meat consumption in relation to mortality from cardiovascular disease among Japanese men and women	Pork cannot be isolated
Narasaki (2020)	Phosphatemic index is a novel evaluation tool for dietary phosphorus load: a whole-foods approach	PDF not found
Nestel (1976)	Effect of dietary polyunsaturated pork on plasma lipids and sterol excretion in man	PDF not found
Nielsen (2018)	Protein from meat or vegetable sources in meals matched for fiber content has similar effects on subjective appetite sensations and energy intake-a randomized acute cross-over meal test study	No outcome of interest
Nicklas et al. (1995)	Impact of meat consumption on nutritional quality and cardiovascular risk factors in young adults: the Bogalusa Heart Study	Pork cannot be isolated
No author (2017)	Foodomics application: analysis of dietary components of the DASH diet pre and post consumption	PDF not found
Norrish (1999)	Heterocyclic amine content of cooked meat and risk of prostate cancer	No outcome of interest
O'Connor (2018)	Adopting a Mediterranean-style eating pattern with different amounts of lean unprocessed red meat does not influence short-term subjective personal well-being in adults with overweight or obesity	Pork cannot be isolated
O'Connor (2018)	A Mediterranean-style eating pattern with lean, unprocessed red meat has cardiometabolic benefits for adults who are overweight or obese in a randomized, crossover, controlled feeding trial	Pork cannot be isolated
Okubo (2019)	Hardness of the habitual diet and its relationship with cognitive function among 70-year-old Japanese elderly: findings from the SONIC Study	No outcome of interest

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Oliveira (2010)	Adherence to the Southern European Atlantic Diet and occurrence of nonfatal acute myocardial infarction	Pork cannot be isolated
Olsen (2020)	Nutritional status in patients with inflammatory rheumatic diseases (IRD)	Pork cannot be isolated
Omura (1987)	Geographical distribution of cerebrovascular disease mortality and food intakes in Japan	Ecological study
Ouellet (2008)	Dietary cod protein reduces plasma C-reactive protein in insulin-resistant men and women	Pork cannot be isolated
Ouellet (2007)	Dietary cod protein improves insulin sensitivity in insulin-resistant men and women: a randomized controlled trial	Pork cannot be isolated
Palacios (2018)	A lean pork-containing breakfast reduces hunger and glycemic response compared with a refined carbohydrate-containing breakfast in adults with prediabetes	Pork cannot be isolated
Parada (2017	Grilled, barbecued, and smoked meat intake and survival following breast cancer	Pork cannot be isolated
Park (2017)	Unprocessed meat consumption and incident cardiovascular diseases in Korean adults: the Korean Genome and Epidemiology Study (KoGES)	Pork cannot be isolated
Patterson (1988)	Food choices and the cancer guidelines	Pork cannot be isolated
Pestitschek (2013)	Selenium intake and selenium blood levels: a novel food frequency questionnaire	Pork cannot be isolated
Petermann-Rocha (2020)	Diet-quality and its association with cardiovascular diseases and cancer incidence and all-cause mortality: a prospective cohort study from UK Biobank	Pork cannot be isolated
Plagens-Rotman (2016)	Odds ratio analysis in women with endometrial cancer	Pork cannot be isolated
Porter Starr (2019)	Impact on cardiometabolic risk of a weight loss intervention with higher protein from lean red meat: combined results of 2 randomized controlled trials in obese middle-aged and older adults	Pork cannot be isolated
Pu (2000)	Prostate cancer in Taiwan: epidemiology and risk factors	Set aside due to processed meat
Pupillo (2018)	Amyotrophic lateral sclerosis and food intake	Set aside due to processed meat
Pupillo (2017)	Amyotrophic lateral sclerosis and food intake in Italy	Set aside due to processed meat
Radosavljevic (2004)	Non-occupational risk factors for bladder cancer: a case-control study	PDF not found
Rahman (2007)	Dietary factors and cognitive impairment in community-dwelling elderly	Pork cannot be isolated
Ramadass (2017)	Faecal microbiota of healthy adults in south India: comparison of a tribal & a rural population	Pork cannot be isolated
Ramel (2012)	Effects of two different types of fast food on postprandial metabolism in normal and overweight subjects	Pork cannot be isolated
Reeves (2017)	A service evaluation of adult patients given advice to reduce intake of dietary vasoactive amines	Pork cannot be isolated
Robbins (2014	Association of egg consumption and calcified atherosclerotic plaque in the coronary arteries: the NHLBI Family Heart Study	No exposure of interest
Rodriguez (2006)	Meat consumption among Black and White men and risk of prostate cancer in the Cancer Prevention Study II Nutrition Cohort	Pork cannot be isolated
Rothman (2019)	Nutritional status and food intake of women residing in rural and urban areas of Lesotho	Pork cannot be isolated
Salgado (2011)	Association of dietary factors and development of inflammatory bowel disease (IBD) in Rio de Janeiro, Brazil	Abstract only
Sarcinelli (2003)	Dietary and reproductive determinants of plasma organochlorine levels in pregnant women in Rio de Janeiro	No outcome of interest
Schlegel-Zawadzka (2002)	Comparative analysis of zinc status, food products' frequency intake and food habits of 11-year-old healthy children	No outcome of interest
Seely (1985)	Relation between pork consumption and cirrhosis	PDF not found
Sharma (2013)	Contribution of meat to vitamin B12, iron and zinc intakes in five ethnic groups in the USA: implications for developing food-based dietary guidelines	Pork cannot be isolated
Shi (2018)	Association between dietary patterns, cadmium intake and chronic kidney disease among adults	Pork cannot be isolated
Shi (2011)	Dietary pattern and weight change in a 5-year follow-up among Chinese adults: results from the Jiangsu Nutrition Study	Pork cannot be isolated
Shin (2018)	Identifying dietary patterns associated with mild cognitive impairment in older Korean adults using reduced rank regression	Pork cannot be isolated

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Shin (2007)	Empirically derived major dietary patterns and their associations with overweight in Korean preschool children	Pork cannot be isolated
Shulten (2009)	The role of diet in the management of gout: a comparison of knowledge and attitudes to current evidence	Pork cannot be isolated
Smigielski (2013)	The effect of selected lifestyle factors and diet on mortality of men with documented physical fitness in the city of Lodz	Pork cannot be isolated
Sone (1998)	Comparison of diets among elderly female residents in two suburban districts in Chiang Mai Province, Thailand, in dry season–survey on high- and low-risk districts of lung cancer incidence	Pork cannot be isolated
Song (2004)	A prospective study of red meat consumption and type 2 diabetes in middle-aged and elderly women: the women's health study	Pork cannot be isolated
Stajic (2016)	Impact of dietary habits and mental health on nutritional status of adolescents	PDF not found
Stefa ska (2016)	The effectiveness of a weight loss diet in a group of overweight and obese women with recurrent depressive disorders	Pork cannot be isolated
Sturtzel (2018)	Effects of an enhanced iron dense foods offering in the daily meals served in geriatric institutions on measures of iron deficiency anemia	Pork cannot be isolated
Su (2015)	Trends in dietary cholesterol intake among Chinese adults: a longitudinal study from the China Health and Nutrition Survey, 1991-2011	No outcome of interest
Tamae (2018)	The associations of reactive oxygen metabolites and biological antioxidant potentials with related factors among youth	Pork cannot be isolated
Tan (2010)	Energy expenditure does not differ, but protein oxidation rates appear lower in meals containing predominantly meat versus soy sources of protein	Pork cannot be isolated
Teng (2014)	Food sources of protein and risk of incident gout in the Singapore Chinese health study	Pork cannot be isolated
Varraso (2007)	Prospective study of cured meats consumption and risk of chronic obstructive pulmonary disease in men	Pork cannot be isolated
Velie (2005)	Empirically derived dietary patterns and risk of postmenopausal breast cancer in a large prospective cohort study	Pork cannot be isolated
Villar (2017)	Sodium consumption patterns according to sociodemographic characteristics in an Ecuadorian population: results from the Latin American study of nutrition and health (ELANS)	No exposure of interest
Vincent (2017)	Herring and chicken/pork meals lead to differences in plasma levels of TCA intermediates and arginine metabolites in overweight and obese men and women	Pork cannot be isolated
Vitariusova (2010)	Food intake, leisure time activities and the prevalence of obesity in schoolchildren in Slovakia	No outcome of interest
Voon (2011)	Is there an influence of dietary habits on breast density as seen on digital mammograms?	Pork cannot be isolated
Vulcan (2017)	Intake of different types of red meat, poultry, and fish and incident colorectal cancer in women and men: results from the Malmö diet and cancer study	Abstract only
Wade (2020)	Can we modify the Mediterranean diet for non-Mediterranean populations Results from two randomised controlled trials	Abstract only
Wang (2013)	Joint association of dietary pattern and physical activity level with cardiovascular disease risk factors among Chinese men: a cross-sectional study	Pork cannot be isolated
Willett (1990)	Relation of meat, fat, and fiber intake to the risk of colon cancer in a prospective study among women	Pork cannot be isolated
Wu (1999)	Food sources of weight, calories, and three macro-nutrients - NAHSIT 1993-1996	No outcome of interest
Wytiaz (2015)	Foods provoking and alleviating symptoms in gastroparesis: patient experiences	No outcome of interest
Xu (2018)	Dietary patterns, dietary lead exposure and hypertension in the older Chinese population	Pork cannot be isolated
Xu (2017)	Dietary pattern, serum magnesium, ferritin, C-reactive protein and anaemia among older people	Pork cannot be isolated
Yan (1989)	Epidemiological studies of nasopharyngeal cancer in the Guangzhou area, China. Preliminary report	Pork cannot be isolated
Yaw (2014)	Diet and physical activity in relation to weight change among breast cancer patients	Abstract only
Yu (2016)	Food groups consumed by infants and toddlers in urban areas of China	No outcome of interest
Zhang (2019)	The Japanese dietary pattern is associated with longer disability-free survival time in the general elderly population in the Ohsaki Cohort 2006 Study	Pork cannot be isolated
Zhang (2016)	Association between dietary patterns and blood lipid profiles among Chinese women	Pork cannot be isolated

(*Continued*)

First Author (Year)	Title	Reason for Exclusion
Zhang (2015)	Dietary patterns and their associations with general obesity and abdominal obesity among young Chinese women	Pork cannot be isolated
Zhang (2015)	Dietary patterns and their associations with childhood obesity in China	Pork cannot be isolated
Zhang (2012)	Dietary inclusion of salmon, herring and pompano as oily fish reduces CVD risk markers in dyslipidaemic middle-aged and elderly Chinese women	Pork cannot be isolated
Zhang (2010)	Inclusion of Atlantic salmon in the Chinese diet reduces cardiovascular disease risk markers in dyslipidemic adult men	Pork cannot be isolated
Zhang (2000)	Intakes of fruits, vegetables, and related nutrients and the risk of non-Hodgkin's lymphoma among women	Pork cannot be isolated
Zhang (1999)	Dietary fat and protein in relation to risk of non-Hodgkin's lymphoma among women	Pork cannot be isolated
Zhen (2018)	Dietary pattern is associated with obesity in Chinese children and adolescents: data from China Health and Nutrition Survey (CHNS)	Pork cannot be isolated
Zheng (1998)	Well-done meat intake and the risk of breast cancer	No outcome of interest
Zhou (2016)	Higher-protein diets improve indexes of sleep in energy-restricted overweight and obese adults: results from 2 randomized controlled trials	Pork cannot be isolated