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Universitat Autònoma de Barcelona

Values and preferences about meat consumption: synthesis and integration in dietary guideline recommendations

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DOCTORAL THESIS

Claudia Valli

Supervisors: Dr. Pablo Alonso Coello, Dr. Montserrat Rabassa Bonet

Tutor: Dr. Xavier Bonfill Cosp

Barcelona, February 2023

NutriRECS

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Thesis report as a compendium of publications presented by Claudia Valli to apply for a PhD from the Autonomous University of Barcelona and conducted under the supervision of Dr. Pablo Alonso Coello and Dr. Montserrat Rabassa Bonet.

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Contents

ABSTRACT

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Background

There is a range of different factors, health and non-health related, influencing peoples' values and preferences about meat consumption. The identification and incorporation of people's values and preferences in dietary guideline development process ensures that recommendations will be more easily accepted, implemented, and adhered to by those intended to benefit from the guidelines.

Objectives

The objective of this thesis is to develop a methodological process to identify, synthesise, evaluate, and integrate evidence on people's meat values and preferences in the formulation of recommendations for dietary guidelines.

Methodology

This thesis work is presented as a compendium of three articles, published in peer-reviewed journals.

In the first study, we conducted a mixed-methods systematic review in order to identify peoples' health-related values and preferences regarding meat consumption. This evidence was used to inform an international guideline panel for the formulation of meat recommendations.

In the second study, we conducted a cross-sectional explanatory sequential mixed-methods study to assess people's values and preferences about meat consumption, and specifically their willingness to modify their intake when informed of the potential cancer risks associated with meat consumption.

In the third study, we conducted a mixed-methods systematic review in order to investigate to what extent environmental concerns may influence meat consumption behaviours, as the environmental impact of meat is a highly debatable subject and health is not the only aspect people consider.

Results

In the first study, we included 41 studies and found that people are attached to meat and are unwilling to change their behaviour. Participants' willingness to change meat consumption was generally low. People considered meat an essential component of a healthy diet, enjoyed eating meat, felt that meat is a part of

their traditions, and believed they lack the knowledge and cooking skills to prepare an adequate meal without meat.

In the second study, 304 participants participated in the survey, seven agreed to participate in the semi-structured interviews and, eight in the follow-up assessment. We observed that, when informed about the cancer incidence and mortality risks of meat consumption, most respondents were not willing to reduce their intake, and men were appreciably less willing to reduce meat consumption.

In the third study, we included 70 studies and found that regardless of people's general beliefs about meat and its impact on the environment, most people were unwilling to change their meat consumption, and, among those who did already reduce their meat intake in the past, environmental concerns were not always the main reasons but often a contributory factor among others.

Conclusions

People are highly attached to meat consumption and wish to maintain their dietary habits, regardless of the potential harmful impact that meat might have on their health and/or the environment. Organizations developing dietary guidelines should ensure that their recommendations consider this type of evidence. This thesis provides a methodological basis for obtaining, evaluating, and integrating peoples' values and preferences in the context of FBDGs.

RESUMEN

Antecedentes

Existe una gama de diferentes factores, relacionados con la salud y otros aspectos, que influyen en los valores y preferencias de las personas sobre el consumo de carne. La identificación e incorporación de los valores y preferencias de las personas en el proceso de desarrollo de las guías alimentarias asegura que las recomendaciones sean más fácilmente aceptadas y cumplidas por aquellos que se beneficiarán de las pautas.

Objetivos

El objetivo de esta tesis es desarrollar un proceso metodológico para identificar, sintetizar, evaluar e integrar evidencia sobre los valores y preferencias relacionadas con el consumo de carne, en la formulación de recomendaciones para guías alimentarias.

Métodos

Este trabajo de tesis se presenta como un compendio de tres artículos publicados en revistas revisadas por pares.

En el primer estudio, realizamos una revisión sistemática de métodos mixtos para identificar los valores y preferencias relacionados con la salud de las personas con respecto a la ingesta de carne. Esta evidencia se utilizó para informar al panel de la guía para la elaboración de recomendaciones sobre la carne.

En el segundo estudio, realizamos un estudio transversal explicativo secuencial de métodos mixtos con el objetivo de evaluar los valores y preferencias de las personas sobre el consumo de carne y, específicamente, su disposición a modificar su ingesta cuando se les informa sobre los posibles riesgos de cáncer asociados con el consumo de carne.

En el tercer estudio, llevamos a cabo una revisión sistemática de métodos mixtos para investigar en qué medida las preocupaciones ambientales pueden influir sobre el consumo de carne, ya que el impacto ambiental de la carne es un tema muy discutible y la salud no es el único aspecto que las personas consideran cuando eligen consumir carne.

Resultados

En el primer estudio, incluimos 41 estudios y descubrimos que las personas están arraigadas a la carne y no están dispuestas a cambiar su comportamiento alimentario. La disposición de los participantes a cambiar la ingesta de carne fue generalmente baja. Las personas consideraban que la carne era un alimento saludable y esencial, disfrutaban comiendo carne, sentían que la carne era parte de sus tradiciones y creían que carecían del conocimiento y las habilidades culinarias para preparar una comida adecuada sin carne.

En el segundo estudio, 304 participantes participaron en la encuesta, siete aceptaron participar en la entrevista semiestructurada y ocho en la evaluación de seguimiento. Observamos que, cuando se les informó sobre la incidencia de cáncer y los riesgos de mortalidad de la ingesta de carne, la mayoría de los encuestados no reduciría su consumo y los hombres estaban considerablemente menos dispuestos a reducir la ingesta de carne que las mujeres.

En el tercer estudio, incluimos 70 estudios y encontramos que, independientemente de las creencias generales de las personas sobre la carne y su impacto en el medio ambiente, la mayoría no estaba dispuesta a cambiar su ingesta de carne y, entre aquellos que ya redujeron su consumo de carne en el pasado, las preocupaciones ambientales no siempre fueron las principales razones, pero a menudo fue un factor contribuyente entre otros.

Conclusiones

Las personas están muy arraigadas al consumo de carne y desean mantener sus hábitos alimentarios independientemente del potencial factor de riesgo que la carne pueda tener sobre su salud y/o el medio ambiente. Las organizaciones que desarrollan guías alimentarias deben asegurarse de que sus consideren este tipo de evidencia. Esta tesis proporciona una base metodológica para obtener, evaluar e integrar los valores y preferencias de las personas en el contexto de las guías alimentarias.

RESUM

Antecedents

Hi han diferents factors, relacionats amb la salut i altres aspectes, que influeixen en els valors i les preferències de les persones sobre la ingesta de carn. La identificació i incorporació dels valors i preferències de les persones en el procés d'elaboració de les guies alimentàries garanteix que les recomanacions siguin més fàcils d'acceptar i complir per part dels que pretenen beneficiar-se de les directrius.

Objectius

L'objectiu d'aquesta tesi és desenvolupar un procés metodològic per sintetitzar, avaluar i integrar evidència sobre les valors i les preferències de les persones relacionat amb la ingesta de carn, en la formulació de recomanacions per a les guies alimentàries.

Mètodes

Aquest treball de tesi es presenta com un compendi de tres articles publicats en revistes revisades per parells.

En el primer estudi, vam realitzar una revisió sistemàtica de mètodes mixtos per identificar els valors i les preferències relacionades amb la salut de les persones pel que fa a la ingesta de carn. Aquesta evidència es va utilitzar per informar al panel de la guia per a l'elaboració de recomanacions de carn.

En el segon estudi, vam dur a terme un estudi seqüencial explicatiu transversal de mètodes mixtos amb l'objectiu de avaluar la voluntat de les persones de modificar la seva ingesta quan s'informava dels possibles riscos de càncer associats a la ingesta de carn.

En el tercer estudi, vam realitzar una revisió sistemàtica de mètodes mixtos per investigar fins a quin punt les preocupacions ambientals poden influir en els comportaments de consum de carn, ja que l'impacte ambiental de la carn és un tema molt discutible i la salut no és l'únic aspecte que la gent té en compte a l'hora d'escollir el consum de carn.

Resultats

En el primer estudi, vam incloure 41 estudis i vam trobar que la gent està arrelada a la ingesta de carn i no està disposada a canviar el seu comportament alimentari. La voluntat dels participants de canviar la ingesta de carn va ser generalment baixa. La gent considerava la carn com un aliment saludable i essencial, li agrada

menjar carn, considerava que la carn forma part de la seva tradició i creia que no té els coneixements i les habilitats de cuina per preparar un àpat adequat sense carn.

En el segon estudi, 304 participants van participar en l'enquesta, set van acceptar a participar en l'entrevista semiestructurada i vuit en l'avaluació de seguiment. Vam observar que quan se'ls va informar sobre la incidència de càncer i el risc de mortalitat associats a la ingesta de carn, la majoria dels enquestats no reduirien la seva ingesta i els homes estaven considerablement menys disposats a reduir la ingesta de carn que les dones.

En el tercer estudi, vam incloure 70 estudis i vam trobar que, independentment de les creences generals de la gent sobre la carn i el seu impacte en el medi ambient, la majoria no estava disposada a canviar la seva ingesta de carn i, entre els que ja van reduir la seva ingesta de carn en el passat, les preocupacions ambientals no sempre van ser les raons principals, sinó que sovint van ser un factor que contribuïa entre d'altres.

Conclusions

Les persones estan molt arrelades al consum de carn i volen mantenir els seus hàbits alimentaris independentment del potencial factor de risc que la carn pugui tenir sobre la seva salut i/o el medi ambient. Les organitzacions que desenvolupen guies alimentàries han d'assegurar-se que les recomanacions considerin aquest tipus d'evidència. Aquesta tesi proporciona una base metodològica per obtenir, avaluar i integrar els valors i les preferències de les persones en el context de les guies alimentàries.

1. INTRODUCTION

1. INTRODUCTION

1.1 Diet and health

A healthy diet throughout life is key for the overall health of each individual (1). People's diet is defined by the dietary pattern individuals adhere to, which in turn is composed by the foods they eat and, the food components and nutrients the foods are made of (2). Foods are therefore essential to people's health, whereas food components and the corresponding included nutrients are necessary for meeting the appropriate nutrient requirements (2). Recognizing and understanding this interdependent relation between dietary patterns, foods, foods' components and nutrients, is essential in developing appropriate dietary guidelines (2).

In the past, nutritional related health problems were mainly associated with undernutrition and nutrition deficiencies, and, for this reason, nutritional epidemiological studies mostly followed a single nutrient approach by focusing on the quantities of individual nutrients that people should consume to achieve a healthy nutrition state. Nowadays, instead, the nutrition related complications are influenced mainly by chronic diseases, as a result of a complex interaction between the food or food groups intake and other determinants affecting the overall diet quality, shifting the focus more towards dietary patters and foods consumed, if single nutrients intake (2).

There is a large body of evidence showing the beneficial health effects of a proper diet, as it promotes healthy pregnancy outcomes (3); supports normal growth (4) and healthy development and ageing (5); helps to maintain a healthy body weight (6); it prevents and treat mental health disorders, such as depression and anxiety (7) and, it reduces the risk of chronic diseases (8).

The world, however, faces an alarming nutrition situation with 88% of countries suffering between two to three serious forms of malnutrition (9) including: acute and/or chronic undernutrition, micronutrient deficiencies, obesity and diet-related diseases (including type II diabetes, cardiovascular diseases and certain types of cancer) (10).

The prevalence of chronic conditions and the number of deaths related to noncommunicable diseases has increased over time (11). According to the Global Burden of Disease Collaborative Network, in 2019, it was estimated that chronic conditions caused almost 42 million deaths worldwide (11) and, in the Global Burden of Diseases, Injuries, and Risk Factors Study 2017, it was estimated that one in five deaths worldwide - mainly related to cardiovascular diseases and cancers - can be attributed to an unhealthy diet (8).

As food plays a vital role in supporting health and in response to the increased prevalence of chronic diseases (8), more recent experimental studies have investigated how food and nutrition interventions - named as well "food is medicine" interventions- can prevent, manage, treat and in some cases even cure illnesses (12).

This emerging body of evidence highlights even more the key role that food and nutrition play in individuals' health, and suggests how food and nutrition interventions, if implemented on a broader scale, may improve the overall health of the general population (12). For this reason, several scientific communities including the American Society for Nutrition, strongly support these "food is medicine" interventions, highlighting their effectiveness in response to serious health conditions affected by diet (13-15).

Nevertheless, in the clinical encounter, clinicians normally do not emphasize much on the role that nutrition might play on their patient's health (16). Lack of time at the clinical consultations, insufficient nutrition training as well as the lack of consistent and trustworthy nutritional evidence, makes it challenging for clinicals to provide appropriate nutritional counselling (17).

In response to, one hand, the large evidence on nutrition as an important contributor to human health and, to the other hand, the lack of consistent and trustworthy nutrition evidence, public health bodies and organizations have placed healthy nutrition amongst their priorities and are developing food-based dietary guidelines aimed at improving diet quality for better health, prevention of diet-related diseases, and reduction of the burden of malnutrition (18,19).

1.2 Food-based dietary guidelines

1.2.1. Definition of food-based dietary guidelines

Food-based dietary guidelines (FBDGs) -also known as dietary guidelines- provide advice on foods, food groups and dietary patterns in order to promote healthy eating and prevent noncommunicable diseases (20). The Food and Agriculture Organization of the United Nations (FAO) describes them as guidelines that "*provide context-specific advice and principles on healthy diets and lifestyles which are rooted on sound evidence and respond to a country's public health and nutrition priorities, food production and consumption patterns, sociocultural influences, food composition data, and accessibility, among other factors. Typically, FBGDs propose a set of recommendations in terms of foods, food groups and dietary patterns to provide the required nutrients to promote overall health and prevent chronic diseases*" (10). A concisely and shorter definition was provided by the European Food Safety Authority (EFSA), describing the FBDGs as "*science-based recommendations in the form of guidelines for healthy eating*" (21).

FBDGs translate nutritional guidelines (e.g., recommended sugar daily intake) into dietary messages for consumers, by using nontechnical language, enabling individual consumers to compose their daily diet based on the recommended food groups, in the suggested proportions for a healthy diet (22). Overall, FBDGs are key for guiding and facilitating the formulation of a wide range of policies and programmes about food and nutrition, health, agriculture and nutrition education. Therefore, they represent a unique opportunity to favourably impact diets and the food system, from production to consumption (23).

Usually, FBDGs are developed for the general healthy population, whereas separate guidelines are developed for population sub-groups with specific nutritional needs, such as pregnant, lactating omen and the elderly (23). More recently, there is an increasing number of studies suggesting the need of shifting form the traditional population-based recommendation to individualized recommendations (24,25). This new perspective of "personalized nutrition" aims to provide targeted nutritional advice, founded in evidence-based science to individuals, considering information on individual characteristics to promote dietary behaviour change that may result in measurable health benefits (24,25).

FBDGs should be country-specific and should consider aspects related to the context to which they apply, including: the practicality of implementation, the local foods, access and availability of foods, and the social-economic situation of a given country (20). Moreover, dietary guidelines should include brief and easy to understand messages, that are based on the most recent and highest-quality evidence available (20-22). The messages reported should be, therefore, simple and, include graphics about local foods, food groups and lifestyle choices (22,26).

Herforth et al. 2019 provided a global review of existing FBDGs and assessed differences and similarities of recommended healthy dietary behaviours across the globe and established which FBDG included key messages aligned with the World Health Organization (WHO) recommendations. Although this review found several common messages across countries aligned with the WHO recommendations (to consume a variety of foods; to consume some foods in higher proportion than others; to consume fruits and vegetables, legumes, and animal-source foods; and to limit sugar, fat, and salt), recommendations on dairy, red meat, fats and oils, and nuts varied considerably. In the case of meat, for instance, the differences across countries might be related to the different consumption levels in each country. In some populations (e.g., Guatemala) with low consumption levels, meat intake is recommended to avoid anaemia, whereas, in other populations with high levels of meat intake (e.g., the Netherlands), a reduction of meat consumption is recommended to reduce health related risks and environmental sustainability (27).

Different graphical representations of FBDGs exist, for example, they can be presented as plates or food pyramids, food pots, rainbows, spin tops, or oyster shell. (22,28). Three examples of existing guidelines are provided below in **Figure 1, 2** and **3**. Typically, each country can decide which graphic to use that it is most representative for the population, as well as the number of recommendations, its indented target group, and the food groups to be displayed following the national health and nutrition agenda (28). Guidelines and specifically FBDGs are an excellent tool to stay up to date, they help reducing unjustified variability in clinical practice, promote knowledge transfer, as they translate scientific evidence to clinical practice in the form of recommendations, facilitate decision-making process of health decisions, and ultimately improve the use of resources (29,30).

Figure 1. Spain Healthy Eating Pyramid (19)

Figure 2. Israel Rainbow guideline (31)

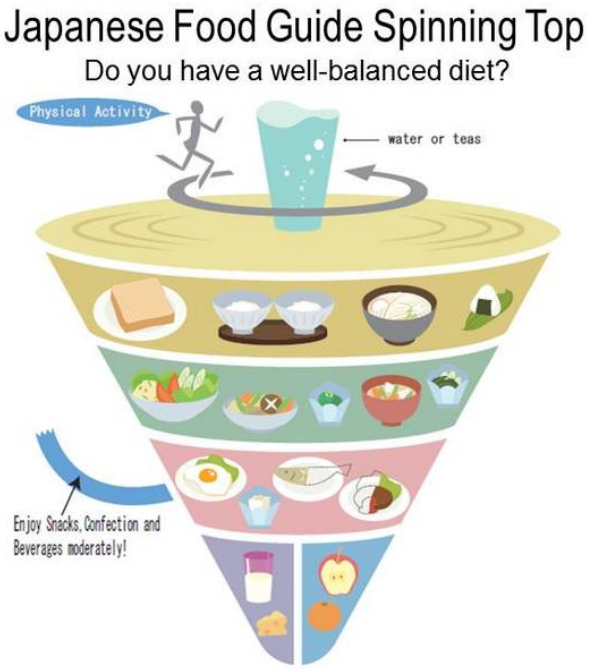

Figure 3. Japan Spinning-top guideline (32)

FBDGs are therefore of key importance for the general public, as well as for health professionals, when faced with clinical scenarios of uncertainty for making an informed health decision, by providing evidence-based dietary recommendations. These guidelines have the potential to influence dietary advice given by health professionals to patients, the public's dietary choices, as well as food labelling and research priorities (33,34).

Currently, there are 20,390 references indexed in MEDLINE related to FBDG published between 1960 and 2022 (MEDLINE search, via PubMed). The interest aroused by FBDG can be clearly reflected in the increase in the number of publications related to dietary guidelines, in recent decades (**Figure 4**).

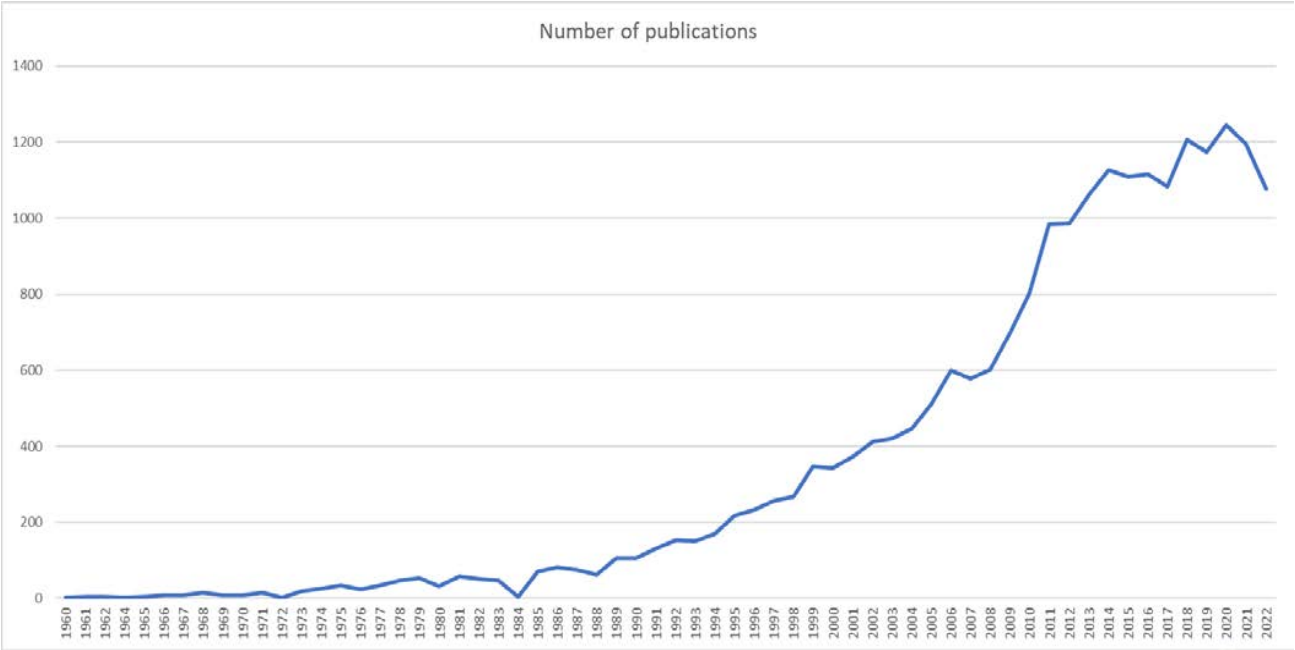

Figure 4. Number of publications related to dietary guidelines indexed in MEDLINE (via PubMed).

1.2.2 Development of food-based dietary guidelines

In general, FBDGs are developed by a guideline development working group composed by interdisciplinary teams, including members with expertise in different areas (35,36). Depending on the institution or organization developing the guideline, suggested and included members can range from the food science and nutrition field to the agriculture and food industry (35,36). According to the FAO, the working group should include representatives of agriculture, health, food science, nutritional science, consumers, food industry, communications, and anthropology (35). Other organizations suggest and/or require the inclusion of other technical experts, such as for example, epidemiologists, experts on processes and methods for developing evidence-based guidelines, or health economists. (36). Although members of the guideline's development working group are generally invited through the launching a public call for experts (37,38), each organization establishes its own approach for selecting the members, that may or may not be explicitly reported in their methods.

With regard to the process for developing FBDGs, the overall process of developing FBDGs has changed over time, and it varies depending on the countries, institutions and/or organizations developing the guideline (21,39-41). A 9-step structured process for developing FBDGs was first proposed in 1998 by a collaboration between WHO and FAO (39). After approximately 10 years, EFSA - under the request of the European Commission - provided a scientific opinion on the process for developing FBDGs (21). EFSA proposed a 7-step approach including the identification of: 1) diet-health relationships, 2) country specific diet-related health problems, 3) nutrients of public health concern, 4) foods relevant for food-based dietary guidelines and 5) food patterns, and 6) testing of food based dietary guidelines and finally 7) development of graphical representations of the FBDGs (21).

The process for developing optimal dietary guidelines is continuously evolving, in fact, as an example, FAO and other national guidelines organizations (e.g., Swedish and Brazilian FBDGs) are currently revising the overall methodology for developing FBDGs to ensure that the dietary recommendations take into account the associated environmental impact (42). Despite the differences in terms of number of steps and the timing, generally, dietary guideline development includes: a) identification and formulation of the research questions, b) the creation of the working group and panel composition, c) search and selection of scientific evidence, d) formulation of recommendations, and e) dissemination.

Table 1 below provides an overview of the first developed FBDGs processes, and some of the most recent ones. The first ever proposed approach by FAO/WHO collaboration reports following a nine steps approach described in a published World Declaration and Plan of Action for Nutrition (39), the WHO currently follows a three steps approach, which is described in a published handbook for guideline development (36, 43) and finally, the U.S. Department of Agriculture (USDA) 2020-2025 dietary guideline reported following a five steps approach, described in a published Scientific Report of the 2020 dietary guidelines (41).

Table 1. Overview of FBDGs overall approach

	FAO/WHO (39)	**WHO** (36,43)	**USDA** (41)
1	Working group should be formed, including representatives of agriculture, health, food science, nutritional science, consumers, food industry, communications, and anthropology.	**Planning.** Defining the scope, identifying funding and potential contributors, and preparing a planning proposal. Formulation of key questions to be addressed by the guideline, following the PICO format (P: population; I: intervention or exposure, C: comparator and, O: outcome).	**Identify the scientific questions.** Identify topics and supporting scientific questions to be examined. HHS and USDA propose that scientific questions for the new guideline should be based on relevance, importance, potential federal impact, and by avoiding duplications.
2	Appropriate technical focal points provide material on nutrition-related diseases, and on food availability and food intake patterns in the country. Members of the working group are invited to suggest nutritional objectives.	**Development.** It involves retrieving, synthesizing, and evaluating the evidence. Based on the evidence and other considerations, recommendations are formulated, and the guideline is written.	**Appoint the advisory committee.** Appoint a Dietary Guidelines Advisory Committee. HHS and USDA request nominations for the Dietary Guidelines Advisory Committee (Committee) and select the Committee through launching a call of experts.
3	Working group identifies, through full discussion, a set of major nutrition-related health problems for which dietary guidelines could be useful. Working group also evaluates the general food production and supply situation by considering current practices, subsidies and other governmental policies and problems, to see if FBDG can be implemented under the present situation.	**Publishing and updating.** It involves designing the guideline format and layout; creating derivative products for various end users, translate the guidelines to other languages, and disseminating to the target audience.	**Advisory Committee reviews scientific evidence.** Advisory Committee reviews scientific evidence on nutrition and health across the life span, discusses its evidence review during public meeting, considers public comments as it reviews the evidence and develops its scientific reports, and finally submits s scientific report to the secretaries of HHS and USDA.
4	Set of draft "food-based guidelines" are formulated.		**Develop the Dietary Guidelines.** HHS and USDA work together to develop the Dietary Guidelines. Each edition of the Dietary Guidelines builds upon the preceding edition, with the scientific justification for revisions informed by the scientific report of the new Dietary Guidelines Advisory Committee, and

			consideration of public and Federal agency comments.
5	Background/back-up statements for each "food-based guidelines" are prepared, and each statement is circulated to all working group members.		**Implement the Dietary Guidelines.** Implement the Dietary Guidelines through Federal programs. HHS and USDA release the updated Dietary Guidelines and work with Federal, state, and local partners to implement the new edition.
6	Working group or committee meets again and each background statement is critically reviewed and revised. Wording of guideline statements is pilot tested with consumer groups, revised as needed, and carefully checked.		
7	Background statements are finalized, synthesized, and sent to interest groups in the country for comment (possibly also to international advisers).		
8	Working group meets again to consider changes, in view of the comments received.		
9	Working group secretary puts together draft of final report; working group concludes draft, adopts, publishes, and disseminates final report, and implementation begins.		

Abbreviations: FAO= Food and Agriculture Organization of the United Nations; WHO= World Health organization; USDA= U. S. Department of Agriculture; HHS= Health and Human Services.

1.2.3 Systematic reviews informing food-based dietary guidelines

Systematic reviews are an important methodological approach for the identification, evaluation, and synthesis of evidence collected, according to pre-specified eligibility criteria in order to answer a specific research question (44,45). According to evidence-based medicine (EBM) principles, not all evidence is the same and, the quality and the amount of evidence available varies (46). An evidence pyramid was created to visually describe the hierarchy of the different types of evidence, placing systematic review evidence at the top of the pyramid, as the highest quality but less common type of evidence (46).

Systematic reviews are conducted in order to support informed decision-making processes about an intervention, diagnostic test, prognostic factor or any other health or healthcare related topic by providing an up-to-date summary of the state of research knowledge on the topic of interest (44). In addition, systematic reviews aim to minimize bias by following methods explicitly reported previously in a protocol (44).

A definition of a systematic review by the Institute of Medicine is "a *scientific investigation that focuses on a specific question and that uses explicit, planned scientific methods to identify, select, assess, and summarize the findings of similar but separate studies, and can help clarify what is known and not known about the potential benefits and harms of drugs, devices, and other healthcare services*" (47).

The methodological approach followed by Cochrane – an organization whose mission is to promote evidence-based informed decision making – is considered the gold standard of systematic review development. Good quality systematic reviews should follow methods outlined in the Cochrane Handbook for systematic review development (44) and, should adhere to a set of standards agreed across other communities of guidelines developers and systematic reviews methodologists (48), including: adherence to the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement for reporting of systematic reviews and meta-analyses (49), as well as to the Standards for Systematic Reviews produced by the Institute of Medicine (47), and finally, the quality of the individual studies as well as the overall quality of the evidence produced should be assessed following the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (50).

There are different types of systematic reviews. They can be either quantitative, qualitative or mixed methods. The main difference is the type of studies and evidence that will be considered eligible and therefore the type of results that will be produced. For quantitative or meta-analysis systematic reviews, quantitative studies -for example randomized controlled trials of treatment effects - will be considered eligible and the quantitative results – pooled estimates or meta-analysis - will be presented in graphical and tabular formats, for qualitative systematic reviews, qualitative studies such as cross-sectional studies conducting focus groups discussions will be included, and findings will be presented as narrative themes synthesis, for mixed-methods systematic reviews both types of studies will be included in which typically, both components will be presented as narrative and in tables (51).

Among guidelines' development groups, there is high consensus that guidelines should be based on systematic review evidence (47,48,52,53). Overall, systematic reviews can assist members of a guideline panel in formulating recommendations by facilitating a similar interpretation of a comprehensively collected and rigorously assessed body of evidence (53); this will lead to the development of guidelines through a systematic and transparent approach (48).

Systematic reviews have been established as the preferred approach also in the context of dietary guidelines development (38, 54), as they can inform through a systematic and transparent approach guideline panels about the health effects of the consumption of specific foods.

However, the nutrition field faces few more methodological challenges for the application of good quality systematic reviews (45). In face of the scarce availability of randomized controlled trials in nutrition, dietary guidelines rely often on observational studies results, which are at potentially higher risk of bias (54,55). There are several examples of cohort studies and randomized controlled studies showing inconsistent results (54,56); for instance, cohorts' studies showed that people who consumed a diet rich in antioxidants (i.e., beta-carotene, vitamin A, vitamin C, vitamin E, selenium) had a lower risk for developing cardiovascular disease and cancer (57), whereas a Cochrane systematic review and meta-analysis of 78 RCTs (n = 296,707) revealed no evidence to support antioxidant supplements for primary or secondary prevention (58). These inconsistencies demonstrate that relying on observational studies may result in misleading inferences and less trustworthy recommendations (56).

In order to overcome these challenges and strengthen the credibility of dietary recommendations, it is suggested that systematic reviews of the nutritional literature should consider observational studies separately from randomized trials (56), risk of bias of included studies should be assessed with the Cochrane Risk-of-Bias tool and the ROBINS-I tools respectively (54) and, the certainty (quality) of the pooled estimates should be assessed independently from the meta-analyses evidence (56).

Finally, as nutritional epidemiological studies are at higher risk of bias mostly due to validity and reliability of dietary measures, prevalent-user designs, inappropriate comparators, and residual confounding (55), a standardised format for conducting and reporting nutritional research study is crucial to mitigate such limitation (59). For this reason, the Strengthening Reporting of Observational Studies in Epidemiology (STROBE) initiative proposed a set of recommendations for improving the quality of reporting for Nutritional epidemiology, called STROBE-nut (59). The STROBE-nut guideline consists in a checklist including 24 recommendations. The use of this checklist is highly recommended to ensure and improve clarity, completeness and, transparency of research reports and ultimately increase the overall quality (59).

1.2.4 Trustworthiness of food-based dietary guidelines

International groups, including the Institute of Medicine (60), the WHO (36), and the Guidelines International Network (GIN) (48), over the years, have established a set of standards for the development of trustworthy and good quality guidelines. These standards include: transparency details on guideline development and funding explicitly reported, management of conflicts of interest, a multidisciplinary guideline group composition with methodological expertise and including patient and community members, use of systematic reviews and meta-analysis, certainty assessment of the evidence and rating the strength of

recommendations, clear articulation of recommendations and, external review by a full spectrum of stakeholders (e.g., scientific and clinical experts, patients and community representatives) (60).

Despite the high consensus on the methodological approach for guidelines development, many clinical practice guidelines (CPGs) still lack of methodological robustness and quality (61). A previous systematic review of clinical guidelines showed that that although the quality of CPGs has increased over time, according to the AGREE instrument evaluation, quality scores have remained moderate to low (61).

Similarly, in the context of nutrition and health, previous evaluations reported several methodological limitations in the development of dietary guidelines (62-68). In a recent overview of reviews of studies assessing the quality of nutritional guidelines using the AGGREE tool, it was found that the overall quality of FBDGs varied and had not improved over time (66). The main limitations reported were related with stakeholder involvement including lack of transparency in the formation of the guideline working group and the panel composition (69); lack of reporting of conflicts of interest (69); rigor of development, applicability, and editorial independence of the guideline (66).

In another review investigating the methods used for synthesizing the evidence and grade the recommendations in FBDGs, it was found that only a minority of FBDGs conducted systematic reviews specifically for the guideline, and that the methods used to conduct the evidence reviews were poorly reported (65). In addition, none of the recommendations were graded based on their strength, using a consensus approach or through a more structured process, such as GRADE (65).

Another limitation referred to the lack of involvement of patients or patients' representatives and community members in the development of the recommendations; for example, many guidelines related to sugar consumption did not describe how they obtained the values and preferences of their target population and those guidelines that did, did not explicitly report the process they followed (62).

1.3. People's values and preferences integrated in food-based dietary guidelines

1.3.1 Food choices and food culture

On a daily basis, people need to choose from a wide range of foods and, their choices are influenced by the interaction of many different factors (70), including biological, psychological, social, cultural, and historical influences (71,72). Food choice is broad term that comprehend a series and complex dynamics and decisions that ultimately determine people's food behaviours in relation to what they buy, cook, eat and store (73).

As defined by the Food Standards Agency, food choice is "*the selection of foods for consumption, which results from the competing, reinforcing, and interacting influences of a variety of factors. These range from sensory, physiological, and psychological responses of individual consumers to interactions between social, environmental, and economic influences including the variety of foods and food industry activities to promote them*" (74). Regarding environmental influences for example, and specifically nutritional claims about what might improve or harm peoples' well-being, over the past two decades, people have been and are constantly exposed to numerous nutrition related messages through different information sources, ranging from scientific research publications to social media posts and news (75).

What people eat, why they eat it and under which circumstances, defines overall peoples' food culture (76). Food culture is an overarching and comprehensive concept underpinned by peoples' values and preferences as well as the context of structure and norms in which food is formed and consumed (77). Although the concept of food culture is not broadly used in nutrition research, it has existed since the mid-1980s (77), and, it was defined by the American ethnologist Lucy Long as "*the practices, attitudes, and beliefs as well as the networks and institutions surrounding the production, distribution, and consumption of food*" (77).

With respect to red and processed meat, the image and culture around meat consumption suffered an important shift in the past decades. In light of recent studies showing an association between consumption of unprocessed red meat and processed meat and undesirable health consequences, such as all-cause mortality, cardiovascular mortality, and stroke (78-83), most dietary guidelines suggest limited consumption of meat (84-86).

In addition, although, some authors have questioned the current consensus because of the weaknesses of the epidemiological signals and the lack of clear causal associations (87-90), the image of meat has changed not only under the lens of health concerns, but also because of the claimed environmental impact of meat production. Meat production is considered as a major source of anthropogenic greenhouse gas emissions and freshwater depletion, that ultimately favour global warming and environmental degradation (91,92).

Overall, the emerging evidence and the ongoing debate about the potential health and environmental impact of meat have shaped the food culture and the image around meat. Therefore, in order to develop appropriate

food-based dietary guidelines, it is fundamental to follow, investigate and understand people's current values and preferences that ultimately shape their food choices.

1.3.2. Values and preferences concepts and definitions

According to a literature research study investigating the theoretical concept of values and preferences (93), the term "value" refers to the extent to which something is considered desirable or undesirable, whereas "preference" for one thing over another demonstrates that the former is valued more than the latter (93). Values are therefore not measurable entities, but instead are inferred by the individuals' preferences and for these reasons are often used as synonymies (93).

In the nutrition field, the concept of "people's values and preferences" over the years became increasingly popular; however, till today there is no agreed term nor definition. In the published research literature, the terms "values", "predispositions ", "preferences", "attitudes", "goals", "likes vs. dislikes", and "beliefs" are often used interchangeably. Although there is not a proposed nor agreed definition within the context of dietary guidelines, several studies have referred to the overall concept "values and preferences" in relation to food by providing different explanations. Studies report it as either: individuals' predisposition to either favour (like) or not favour (dislike) a specific food (94); individuals' despondency or pleasure to consume certain foods (95); peoples' reasons for eating or not specific foods (96-98); people's willingness to pay for specific foods (99,100); or as people's willingness to change their dietary behaviour (101). With regard to willingness to change, our group has reported it as either individuals' willingness stop, reduce, or increase the consumption of a specific food (102).

Similarly, the equivalent concept used in the context of clinical practice guidelines, referring to patients' perspective, has not reached an agreed definition either. However, many terms that are interchangeably used for referring to patients values and preference have been coined by different organizations within the field of CPGs development. For example, GIN refers to "patient and caregiver preferences and concerns" (103), whereas within the AGREE II tool the overarching concept is defined as the "views and preferences of the target population (patients, public, etc.) (104). One of the most common terms seen in the literature, is the term "values and preferences of the patients", which was proposed by the GRADE working group (105) and defined as " an overarching term that includes patients' perspectives, beliefs, expectations, and goals for health and life ". Furthermore, it also referred, more precisely, to "the processes that individuals use when considering the potential benefits, risks, costs, and inconveniences of the management options in relation to one another" (106,107).

Finally, more recently, with the development of the Evidence to Decision (EtD) frameworks -tools that help panel members and people in making an informed decision through a structured and transparent approach in the context of health care decisions including recommendations -the concept "patients values and

preferences" has been specified as the importance of the outcomes or health states of interest (108,109), according to which, preferences for or against an intervention are determined by the importance given to the outcomes of interest (110).

1.3.3. Importance and scope of integrating peoples' values and preferences in food-based dietary guidelines

The consideration of patients' preferences in the clinical setting is a concept that forms part of the practice of evidence-based medicine since the late 90s (111). This consists of integrating people's preferences in the decision-making process at the time of choosing between different options and/or treatments (111).

As a matter of fact, one of the three fundamental principles on which the EBM approach is based on, states that "*evidence alone is never sufficient to make a clinical decision*" (112). In addition to clinicians' expertise in understanding the patient dilemma (from a clinical, social, and economic perspective) and in identifying the best evidence to suggest the appropriate treatment, the values and preferences of the patient should also be considered and guide the decision about the treatment options available (113). According to the EBM, "d*ecision makers must always trade off the benefits and risks, burden, and costs associated with alternative management strategies and, in doing so, consider their patients' unique predicament and values and preferences*" (113).

Over the last decades, patients' perspective and their participation in medical care has become of central importance in many public health initiatives, programs, and interventions (113-120). In the same way, in the context of CPGs, patients' perspectives as well as their involvement during the guideline development process has been gradually integrated in the overall guideline development process (118,119,121,122-127).

Several reasons have been reported for incorporating patient values and preferences in the development of guidelines (110,119), but mostly importantly, it is suggested that recommendations that consider the values of the target population may be more easily accepted and therefore implemented and adhered to (110). Further motives for incorporating patient values and preferences in guideline include: 1) ethical considerations related to patients' increased willingness of being active participants in the decision-making process (119, 128-130); 2) in case of lack of evidence and/or uncertain results, decisions are driven by patient's preferences (131); 3) preferences can vary regardless of the evidence and related certainty (132-134); 4) more options with similar or equal effectiveness may co-exist (135), and finally, 5) patient preferences and motivation for treatment can positively affect treatment outcomes in randomized controlled trials in musculoskeletal medicine (136).

Likewise, in the context of dietary guidelines, the integration of people's values and preferences in the development of recommendations in strongly advocated (30). According to FAO, FBDGs should "*provide context-specific advice and principles on healthy diets and lifestyles, which are rooted on sound evidence, and*

respond to a country's public health and nutrition priorities, food production and consumption patterns, sociocultural influences, food composition data, and accessibility, among other factors" (10). The consideration of the dietary habits and socio-cultural and religious preferences of the target population is strongly recommended by several other health organizations, suggesting that the integration of people's values and preferences will increase the recommendations to be culturally acceptable and implementable (10,21,41).

Despite the increased awareness regarding the importance of following healthy lifestyles and how diet can strongly contribute to health, compliance, and adherence to recommended lifestyles and/or dietary behaviours is not guaranteed (137,138). According to the Healthy Eating Index (HEI), for Americans ages 2 and older, HEI-2015 scores indicate that intakes are not consistent with recommendations for a healthy dietary pattern (139). Another study assessing the compliance with 4 healthy lifestyle recommendations - including "consuming 5 fruits and vegetables per day" - conducted in 164,940 adult participants in the 2000 National Behavioural Risk Factor Surveillance System, found that only 3% of the U.S. adults surveyed followed all 4 modifiable lifestyle characteristics (140). These results showed that regardless of the advocacy and publicity on the importance of diet to health, people continued with their current consumption (137,138). This could be explained by the lack of considerations of socioeconomic, cultural, and political factors, as well as people's values and preferences that ultimately influence people's food choices (138,141).

Peoples' food values and preferences are decisive for individual's dietary intake and dietary behaviour, thus, tailoring public health messages and dietary recommendations accordingly may improve overall compliance as well (56). This will also improve the quality of the diet of the individuals and, consequently, contribute to the overall health and quality of life (137,138). In addition, offering alternative dietary pattern options tailored to people's values and preferences may increase the likelihood of long-term success of maintaining a healthy dietary pattern (30). Overall, the evaluation and integration of the target population values and preferences may improve the quality of dietary guidelines and their relevance to end-users, especially patients and community members (56)

1.3.4. Methods on how to obtain the public's food values and preferences and integrate them in food-based dietary guidelines

Over the years, with the increased recognition of needing to consider people's perspective in health research, several health and guidelines organizations have proposed several frameworks for the identification and integration of peoples' perspective (130,142,143). However, currently there is no standardized method on how to obtain people's values and preference and on how to incorporate them in the development of FBDGs.

Guidelines organizations may adopt a variety of methods to involve the public and consider their values and preferences in the development of a guideline, as stated by the GIN: "*there is definitely not a one size-fits-all*

approach" (144). GIN has developed a specific toolkit describing the different approaches for patient and public involvement in guidelines (145). Depending on the communication flow between the guideline organization and the public involved, we can distinguish three main categories of strategies: 1) consultation - information is collected from patients and the public, 2) participation - information is exchanged between the public and other guideline developers- and 3) communication - information is communicated to patients and the public. **Figure 5** describes overall goals and examples of methods used for each of these three categories. However, it is also common to combine different strategies across these three categories to have a more comprehensive involvement (145).

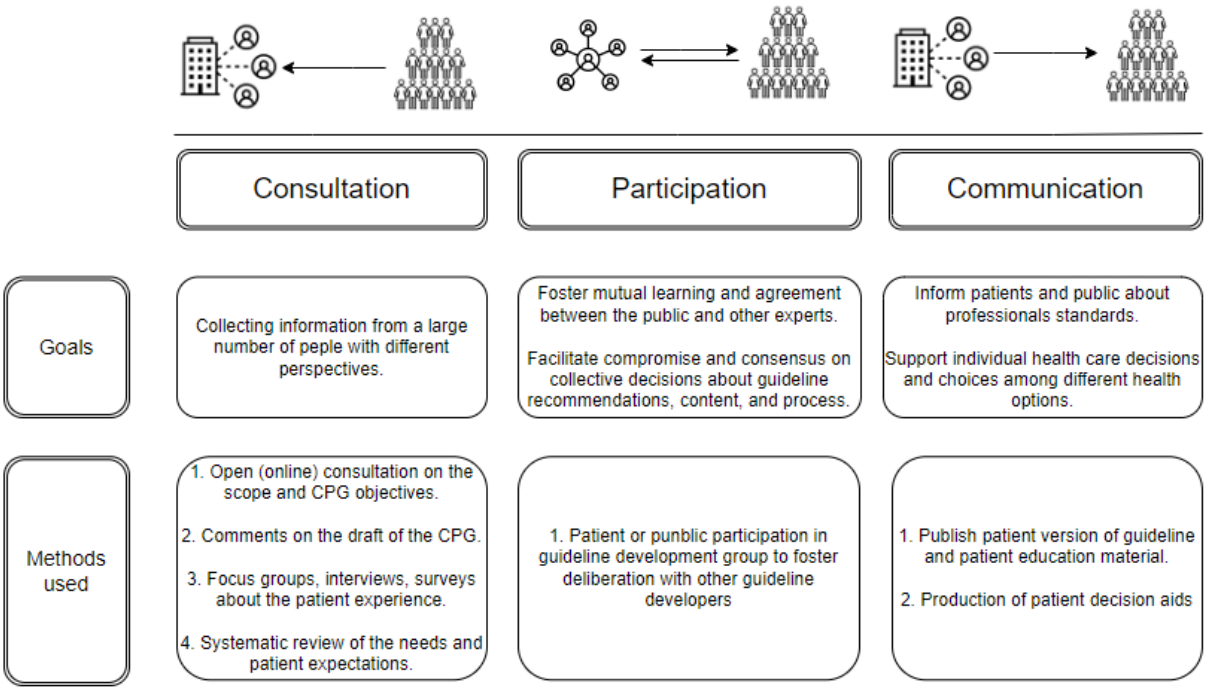

Figure 5. Strategies and methods to involve patients in the development of clinical practice guidelines, adapted from the G-I-N Public Toolkit table, p. 15 (145).

A systematic review on CPGs incorporating patients' values and preferences found that despite the majority of included guidelines suggested including patients' perspective in the development process, guidance on how to implement it was limited (provided by the 47.5% of included studies) (146). The methods reported were mainly regarding how to identify and recruit patients or patient's representative and how to obtain their values and preferences (sources of patients' perspective). For the latter, the most frequently reported sources for patients' views were: i) the consultation with patients or their representatives; ii) considering the judgement provided by the guideline panel; iii) the development of original (de novo) research; iv) conducting of systematic reviews of relevant evidence (146).

An international cross-sectional survey conducted in 2018, described how guideline developers identify, incorporate and report patient preferences (147). This study found that many guideline developers used a combination of different approaches to identify patient's' preferences but mostly by engaging patients as panellists and by extracting patient's preferences from published research (147). Similarly, different approaches to incorporate patient's preferences were identified, the most frequently reported were the use of patient preferences to generate recommendations, specify treatment preferences, or establish guideline questions (147). Finally, regarding the methods on how to report and describe patients' preferences in their guideline, a smaller number of organizations explicitly reported the identified preferences or how they influenced the formulation of recommendations. Patients' preferences were implicitly reported in the formulation of guideline recommendations, questions, or point of- care communication tools (147).

In our setting, a recent systematic review assessing the methodological quality of Spanish dietary guidelines (published between 2007 and 2019), found that many of the FBDGs did not report how they sought the values and preferences of their target population, nor they obtained value and preference data to inform any food-based dietary recommendations (148). However, in the past decade, published dietary guidelines and relevant health organizations such as the FAO and WHO highlighted the importance of customizing the dietary recommendations based on the values and preferences of the individuals (10,36).

In the USDA 2020-2025 dietary guideline, one of the four general formulated guidelines for 'nutrition and health across the lifespan' states the following: "*Customize and Enjoy Food and Beverage Choices to Reflect Personal Preferences, Cultural Traditions, and Budgetary Considerations*". This guideline aims to provide a framework to assist people in making informed healthy dietary choices in respect to their individual needs, personal preferences, as well as the foodways of the diverse cultures in the United States and including budgetary considerations (149). However, no guidance is provided with respect to how and through which methodological approach people's values and preference can be obtained and incorporated in the development of dietary recommendations. The investigation and development of specific methods to incorporate dietary diversity including food preferences has been suggested by the USDA guideline working group for the updated guideline as stated in the future directions section of the technical report of the overall guideline process (150).

According to the WHO handbook for guideline development, values and preferences data of the target population for which the recommendations are intended for can be either quantitative (e.g., utilities of different health states) or qualitative (e.g., interviews transcripts) and a systematic review is considered a first approach to synthesize peoples' values and preferences (36,56). Moreover, although the lack of consensus and refinement on the best methodological process, mixed-methods systematic reviews are becoming an important and common approach that can provide a more complete and comprehensive view

on a specific phenomenon of interest with; a first guidance was provided by the Joanna Briggs Institute (JBI) Mixed Methods Review Methodology Group (151). On the other hand, in case of lack of data in the published literature, observational studies (both quantitative and qualitative) have also shown to be an efficient strategy to capture the values and preferences of the public (36). Conducting a survey or interviewing the stakeholders who will be affected by the guideline may provide valuable data about the importance they place on the benefits and harms of an intervention or treatment (36,56). Finally, when primary data are not available and cannot be collected, as an alternative approach, members of the guideline working group can provide inputs to inform the discussion, although the insights that can be provided will not accurately describe the perspectives of people affected by a recommendation and therefore, should be considered cautiously (36).

The most important question to consider is about how people seem to value the health outcomes linked with an intervention, and how much variation across populations exists. This will determine the strength of the recommendation (50, 152,153). When there is significant uncertainty or heterogeneity around people's values and preferences, a conditional recommendation is more likely to be warranted (36), on the other hand, high concordance of peoples' values and preference will strengthen the degree of the recommendation (154,155).

1.3.5. Barriers and potential facilitators of integrating people's' values and preferences

The inclusion of people's values and preferences in the development of guidelines can be challenging. Different studies have highlighted the barriers and facilitators for the identification and integration of people's values and preferences (147,156-158). Challenges were mainly related to the resources needed and the processes to be followed to involve impatiens (147). The most common barriers were: the difficulty in identifying patients of diverse characteristics (147), the resources needed for including patients values and preferences (147,156,157), the workload expected by the patients (158), as well as the possibility of facing divergent opinions between patients and professionals (157). Other important barriers include the difficulties for patients in understanding the medical terminology (156), uncertainty among the participants about the roles and objectives of their participation in the process (157) and, difficulty of assessing the contribution patients make to the decision-making process is not only seen in guideline development but in other decision-making processes as well (156).

A series of potential facilitators have also been identified to overcome these challenges. The most common reported facilitators were training and support (147,157,158). Training for patients refereed to providing patients with seminars and/or workshop to tutor them regarding scientific and technical aspects, whereas training for clinicians referred to train them in understanding patients' preferences and conducting research to capture and use patient preferences. Support consisted in providing assistance by telephone and/or email

to patients' participants. The active involvement of patients in all phases of guideline development was also seen as a potential facilitator (157), although some organizations found it challenging (147). Other facilitators included clarifying the role and objective of patients' involvement (157,158), involving a group of patients rather than a single patient (158) and finally, involving researchers with qualitative methodology experience and skills in obtaining patients preferences (147).

1.4 NutriRECS initiative

1.4.1 NutriRECS group

The Nutritional Recommendations (NutriRECS) working group began in the year 2017 as an informal collaboration of people with an interest in addressing the limitations and challenges of developing evidence-based dietary and nutritional recommendations. NutriRECS is an international and independent group with clinical, nutritional, and public health content expertise, skilled in the methodology of systematic reviews and practice guidelines, which are unencumbered by institutional constraints and conflicts of interest (159).

1.4.2 NutriRECS aim and overall approach

NutriRECS aim is to produce trustworthy dietary and nutritional guideline recommendations based on the values, attitudes and preferences of patients and community members, by following a systematic and transparent approach through the GRADE system (160). NutriRECS is based on six main cornerstones: application, integration, dissemination, growth, education, and advancement (**Figure 6**) (159):

1. **Application** of the best systematic review and practice guideline methods to investigate the association of dietary patterns, food, and nutrients with health outcomes (e.g., cardiovascular disease).
2. **Integration** of patient and community values, attitudes, and preferences into guideline recommendations.
3. **Dissemination** of NutriRECS work via open-access, user-tested evidence summaries and decision aids for clinicians, patients, and members of the community.
4. **Growth** in the number of well-trained experts in nutritional guideline methodology worldwide.
5. **Education** of clinicians, policymakers, patients, and members of the public in the principles and practice of evidence-based nutrition.
6. **Advancement** in the methodology of systematic reviews, meta-analysis, and practice guideline development in nutrition.

Figure 6. NutriRECS cornerstones

1.4.3 NutriRECS methods

NutriRECS group developed and published - in the *BMC Medical Research Methodology Journal* - a specific protocol including the methods for the development of trustworthy dietary and nutritional recommendations (56) (**Annex 2A**). Briefly, based on the eight standards set by the Institute of Medicine (29) and the Appraisal of Guidelines for Research & Evaluation Instrument (AGREE II) (104), NutriRECS proposes a nine steps approach underpinned by the GRADE methodology, to move from the formulation of the health research question to the formulation of dietary recommendations, informed by systematic reviews of the best available evidence (56). **Figure 7** illustrates step-by-step the NutriRECS methods.

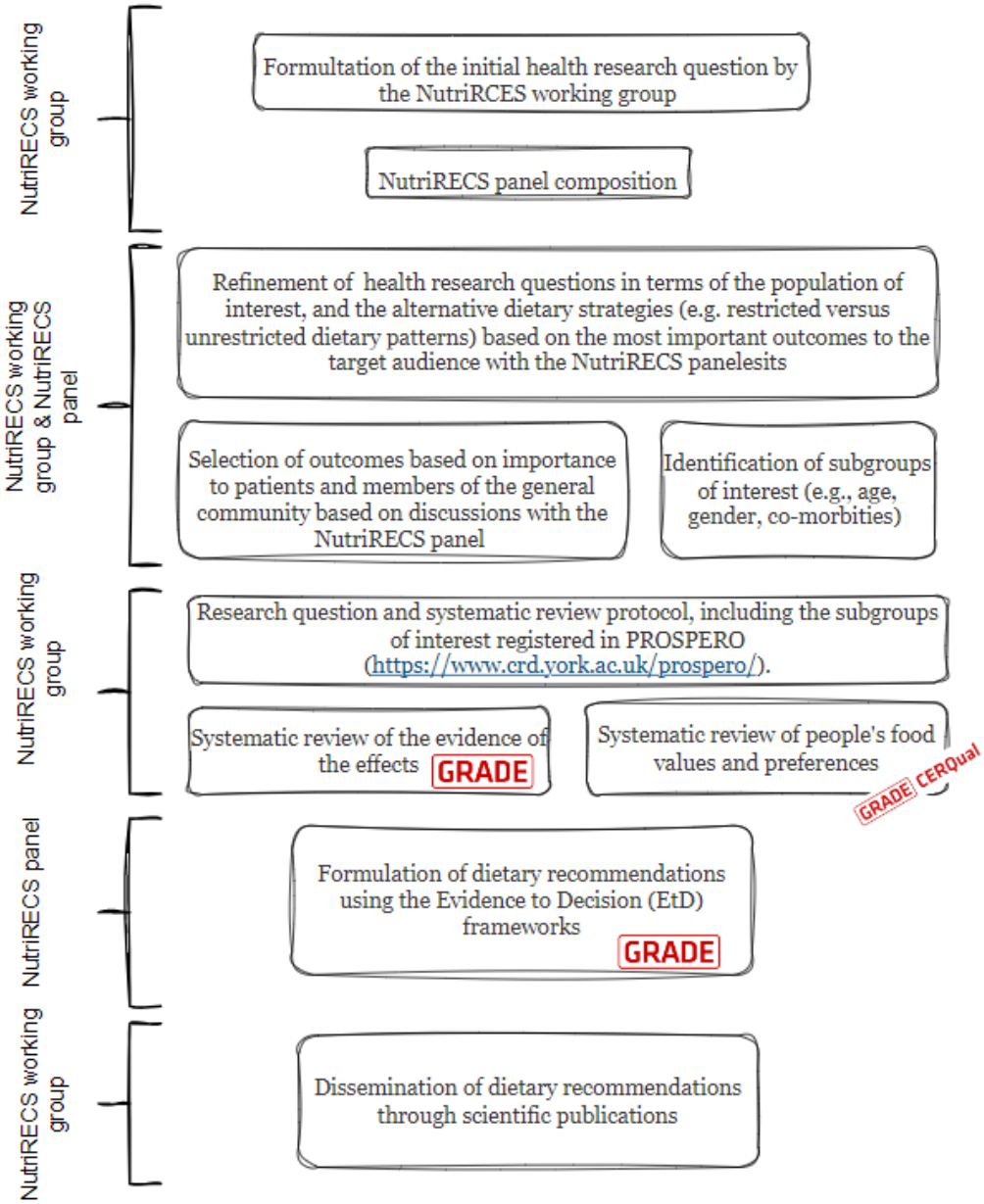

Figure 7. NutriRECS methods

1.4.4. NutriRECS red and processed meat project

The first project selected by the NutriRECS working group was about red and processed meat consumption and, the guideline panel was composed through a very strict and transparent approach including screening and reporting on panel members previous intellectual public positions, eating habits, and funding over the previous three years. The initial research question was formulated as follows:

"Among adults, what is the impact of dietary patterns higher in red and processed meat versus diets lower in red and processed meat intake (replacement with fish, white meats or vegetarian or vegan diet) on the risk of outcomes important to patients and community members (i.e., overall and cardiovascular mortality, cancer, weight, quality of life, satisfaction with diet, type II diabetes, and cardiovascular outcomes [fatal and non-fatal coronary heart disease, non-fatal stroke, non-fatal myocardial infarction, major adverse cardiac events (MACE)]) and on factors that may have a causal relation to cardiovascular outcomes (hypertension and cholesterol), or other adverse outcomes (haemoglobin)?"

In order to provide a rigorous estimate on the balance of the health benefits and risks of eating red and processed meat, we performed four parallel systematic reviews, addressing the following: clinical (161) and observational evidence (81) on the effect of red and processed meat on cancer and cardiometabolic outcomes, observational studies on the effect of red and processed meat on cancer outcomes (82), and the effect of red and processed meat dietary patterns on cardiometabolic and cancer outcomes (83). In addition, we conducted a mixed-methods systematic review to identify people's values and preferences regarding meat and their willingness to change their consumption (91) (Study 1 of the thesis). This information was important in order to consider the balance of benefits and harms from the perspective of the population that is affected by the recommendations. On the basis of these reviews, a guideline panel, supported by the NutriRECS working group, developed recommendations for red and processed meat and health outcomes (162) (**Annex 2B**).

1.5. Justification

1.5.1. Justification of the topic of the thesis

This thesis is part of the NutriRECS red and processed meat project, and it contributed by providing evidence on people's values and preferences about meat consumption for the formulation of meat recommendations (162).

Peoples' food values and preferences and, therefore, their food choices are influenced by a wide range of factors that can be classified as rational decisions - for example, health conscious or sustainable food choices - or unconscious decisions that are part of peoples' inner beliefs and culture that cannot be easily changed (71,72). Investigating people's food values and preferences, whether they are dictated by a rational decision

or unconsciously, is essential to better understand what factors and determinants influence their choices and, therefore, what is their predisposition towards a potential dietary change.

To produce dietary recommendations that are likely to be effective, we need to be able to make valid predictions about the consequences of the proposed recommendations, and for this, we need a better understanding of peoples' food choices determinants. Therefore, the identification and incorporation of people's values and preferences in dietary guideline development process ensures that recommendations will be more easily accepted, implemented, and adhered to by those intended to benefit from the guidelines.

With respect to red and processed meat consumption, most dietary guidelines suggest limited consumption of meat, because of the reported association with cancer (84-86) and other adverse health outcomes, such as all-cause mortality, cardiovascular mortality, and stroke (78-83). However, limited information exists regarding how much people value meat in their diet in relation to their health and, their willingness to reduce meat consumption in the face of these undesirable health effects. Moreover, health is not the only aspect that people consider when consuming meat; other aspects - for example, the climate impact of meat that has become a highly discussed topic - can influence how people value meat in their diet. All these factors, health and non-health related, play an important part in people's meat choices.

In addition, despite the fact that the incorporation of peoples' values and preferences in the FBDG is increasingly advocated, it is unclear what are the most appropriate methods that dietary guideline development organizations should follow. In fact, in the case of FBDGs, it is unknown what it is recommended, nor which approach has been used, if any. Currently, there is no guidance nor consensus on the most appropriate methods to be followed, to ensure the inclusion of the public perspective in the elaboration of dietary recommendations.

Finally, there is no current and standard definition of people's values and preferences in the context of FBDG, and for the development of this thesis, we used the term "values and preferences" referring as to what people are inclined to do (people's actions) in terms of food choices and behaviours. In the same way, we used the term "people" referring to the general population, for who the meat recommendations developed by the NutriRECS group are intended for.

1.5.2. Justification of the studies undertaken for this thesis

This thesis is articulated in three studies on the synthesis and integration of people's meat values in the development of dietary recommendations for meat consumption. The three studies followed a mixed-methods approach by combining both, quantitative and qualitative methods, to ensure a comprehensive representation of the investigated topic.

Although, the methodological approach on how to conduct quantitative and qualitative systematic reviews is well established - thanks to the methodological advances of the Cochrane collaboration and the JBI Collaboration (44,151)-, there is no consensus on the most appropriate approach regarding the synthesis, integration, and the certainty assessment of mixed-methods scientific evidence. Therefore, we attempted to refine and propose a robust methodological approach for mixed-methods systematic reviews.

Rationale for the first study

Carrying out a mixed-methods systematic review on people's values and preferences about meat consumption will produce new knowledge on people's preferences about meat and their willingness to accept and follow meat recommendations. This evidence can then be used to inform FBDGs panels for the elaboration of meat recommendations.

The incorporation of the public perspective is especially relevant in situations where the balance between the benefits and risks of a recommendation is very uncertain and debatable. In this type of situation, the decision depends a lot on the context of the individuals receiving the recommendation and their perspectives.

Considering the increased debate around the allegedly harmful health impacts of meat intake, peoples' health-related values and preferences are fundamental in the development of meat recommendations.

Rationale for the second study

In our first study, we found that reasons for meat consumption varied and that people's willingness to change their meat consumption in the face of health concerns was generally low (96). However, in most of the included studies, participants were not presented with the possible adverse health consequences of meat consumption in ways that captured the current evidence and its uncertainty, and therefore we could not make an overall conclusion on what people would be willing to do when informed.

We therefore developed and conducted a cross-sectional explanatory sequential mixed-methods study, in order to evaluate adults' values and preferences regarding unprocessed red meat and processed meat intake. Specifically, we aimed to assess people' willingness to change their intake in the face of possible undesirable health consequences based on the dose–response meta-analysis systematic reviews of meat and cancer risk (82).

To increase the trustworthiness of the study we first developed and published a protocol reporting the overall methodology to allow others to replicate our investigation (**Annex 2C**). Additionally, we conducted a pilot study in the general community in Nova Scotia and Prince Edward Island, Canada in order to collect feedback on the study's procedures and improve the study's implementation. In parallel to our implementation,

another centre in Poland - as part of the NutriRECS working group - conducted the same study following the protocol methodology (97).

Rationale for the third study

Individuals' food choices are influenced by a wide range of factors. Health is not the only aspect people consider when choosing to consume meat; other factors such as concern for the environmental impact of meat (production and distribution) can influence people's meat choices and thus its consumption (96). This was also showed in our second study (102) in which, included participants, who had previously reduced their meat intake (prior to their participation in the study), reported to have reduced their meat consumption manly due to the environmental concerns and animal welfare rather than health concerns.

We therefore conducted a mixed-methods systematic review to further investigate to what extent environmental concerns may influence meat consumption behaviours. In addition, based on the methodological learning experiences acquired through Study 1, in this study, we attempted to improve and better define the methodological approach to be followed for mixed-methods systematic reviews.

2. OBJECTIVES

2.OBJECTIVES

2.1. Overall objective

Develop the methodological process to synthesise, evaluate and integrate evidence on people's food values and preferences, specifically on meat consumption, in the formulation of recommendations on meat for dietary guidelines.

2.2. Specific objectives

1. Identify, synthetize, and evaluate the quantitative evidence on people's values and preferences related to meat consumption.

2. Identify, synthetize, and evaluate the qualitative evidence on people's values and preferences related to meat consumption.

3. Conduct a de novo mixed-methods study to identify, describe and synthetize current people's values and preferences on meat consumption.

4. Synthetize, evaluate, and integrate evidence on values and preferences into the Evidence to Decision (EtD) frameworks for the development of meat recommendations for NutriRECS guidelines.

2. METHODS

3.METHODS

This PhD thesis, which is presented as a compendium of publications, is based on three studies: 1) a mixed-methods systematic review of people's health related values and preferences regarding meat intake; 2) a cross-sectional explanatory sequential mixed-methods study on peoples' health related values and preferences regarding meat; and 3) a mixed methods systematic review of peoples' values and preferences about meat consumption in view of the potential environmental impact of meat.

The methods of the thesis are those corresponding to the methods of these three studies.

3.1. Study 1: "Health-related values and preferences regarding meat consumption: a mixed-methods systematic review"

3.1.1. Design

Mixed-methods systematic review on people's health related values and preferences on meat intake. We registered the protocol in PROSPERO (CRD42018088854) (163) and adhered to the PRISMA statement (49).

Before beginning each aspect of the review process, we conducted calibration exercises in which reviewers assessed the same articles and discussed any disagreement, leading to a clarification and a common understanding of criteria and process. Pairs of reviewers conducted the different steps of the review; in cases of disagreement, reviewers reached consensus with assistance from a third reviewer.

3.1.2. Data sources and search strategy

We designed and conducted a search in MEDLINE (via PubMed), EMBASE (via Ovid), Web of Science (Institute for Scientific Information), Centre for Agriculture and Biosciences Abstracts (via CABI), International System for Agricultural Science and Technology, and Food Science and Technology Abstracts from inception to June 2019. We combined search terms related to meat consumption, consumer behaviour, and values and preferences with the controlled vocabulary from each database. We did not restrict our search by publication status, language, or date of publication. We also reviewed reference lists of the included articles, and relevant systematic reviews.

3.1.3. Inclusion criteria

We included studies exploring health-related values and preferences on meat consumption, if more than 80% of participants were adults (aged ≥18 years). We considered quantitative (cross-sectional design), qualitative (interviews, focus groups), and mixed-methods studies. We included only studies conducted in Europe, Australia, Canada, the United States, and New Zealand.

We excluded studies that focused on meat alternatives (for example, cultured, in vitro, functional products, or genetically modified), types (for example, organic), quality (composition, sensory quality or palatability factors, or origin),safety (for example, food handling, chemical hazards or contamination, or storing or preserving), industry (for example, market research to inform or meet consumers' demands), consumption trends, and specific populations (for example, cancer survivors or pregnant women). After calibration, reviewers independently screened titles and abstracts of all retrieved references. Subsequently, reviewers independently reviewed the full text of articles, deemed potentially eligible during title and abstract screening.

3.1.4 Data extraction

We used two ad hoc data extraction forms for quantitative and qualitative research. Teams of reviewers independently abstracted information from each study, including study identification, objectives or research questions, population characteristics, design and methods, risk of bias or methodological limitations, and findings. For quantitative studies, we used an adapted version of the GRADE approach to assess risk of bias of studies on importance of outcomes or values and preferences (110).

We considered five items grouped in three domains: selection of participants, missing outcome data, and measurement instruments' validity. We rated studies as having high risk of bias if the measurement instrument was not validated or was unclear, and as having moderate risk if it was validated but two or more items had high risk of bias. For qualitative studies, we used the Critical Appraisal Skills Pro-gramme (CASP) qualitative research checklist, which consists of the following items: aim of the research, qualitative methodology appropriateness, research design, ap-propriate recruitment strategy, data collection, investigator and participants' relationship, ethical issues, data analysis, findings, and value of the research (164). We rated studies as having "serious methodological limitations" if more than two items had serious concerns and as having "moderate methodological limitations" if they had two items with serious concerns.

3.1.5. Data synthesis

We synthesized results from studies using a four-step approach that involved simultaneous quantitative and qualitative data collection and analysis. First, we selected a few eligible articles per study design, identified key themes, and coded them in categories. Second, we used these categories to design ad hoc data extraction forms. Third, using an iterative process, we compared the key themes of the categories identified across all studies and developed analytic themes. Fourth, we applied the critical meta-narrative synthesis to transform the quantitative data into qualitative data (165,166). For the last step, we used four systematic profiles and several critical questions, to extract the identified narratives and to guide our synthesis of data.

We synthesized and narratively reported the findings according to participants' meat consumption. We defined those who consumed meat as omnivores and analysed them separately from persons who typically avoided meat, whom we defined as vegetarians, including lacto-ovo vegetarians or low-meat consumers.

3.1.5.1 Certainty of evidence

For quantitative studies, we assessed the certainty of evidence for each review finding, according to GRADE domains (risk of bias, imprecision, inconsistency, indirect-ness, and publication bias) (50, 167). For qualitative studies, we assessed the certainty of evidence according to GRADE-CERQual (Confidence in the Evidence from Reviews of Qualitative Research) domains (methodological limitations, relevance, coherence, and adequacy) (168). Findings were initially considered as high certainty and were downgraded (from high to very low) by one or more levels, if serious or several minor or moderate concerns were detected in one or more domains.

3.2. Study 2: "Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study"

3.2.1. Design and setting

Cross-sectional explanatory sequential mixed-methods study that included a quantitative assessment through an online survey, a qualitative inquiry through semi-structured interviews, and a follow-up assessment through a telephone survey. Our team conducted the study in Spain between November 2020 and March 2021, based on a previously published study protocol where further details on the methods are provided (169). The report followed STROBE guidelines (170).

3.2.2. Study population

People learned about this study thorough the Cochrane website and Twitter, where we published all Information related to the study, eligibility criteria, contact information of the researcher carrying out the study, and the related link to access the online survey. People interested in participating, completed the online consent form, and accessed to the survey. Respondents included adults between 18 and 80 years of age who currently consume URM and/or PM. We excluded adults who had active cancer; those who have suffered a major cardiovascular event such as: stroke, angina, myocardial infarction, heart failure, symptomatic peripheral arterial disease, as well as pregnant women, and those unwilling or unable to provide informed consent.

3.2.3. Recruitment strategy and sample size

3.2.4 Questionnaire and study procedures

The questionnaire was first developed and reviewed by experts on the topic to ensure the validity of the included items in the questionnaire; secondly, we pilot-tested it in English in a convenience sample of participants (98). On the basis of the pilot study, our team modified the questionnaire, performed a translation into Spanish - one researcher translated the survey that was reviewed and confirmed by a second researcher-, and finally, we developed an online version that we tested in 34 Spanish participants to establish clarity and understanding. Based on the findings of the pre-testing, we refined the survey to improve face and content validity.

The questionnaire addressed participants' demographic characteristics, their medical history, and meat consumption beliefs and behaviours, as well as including a direct choice exercise. This exercise presented scenarios tailored to each individual's weekly meat consumption and included, based on a prior systematic reviews and dose-response meta-analysis, the best estimates of the risk reduction of overall lifetime cancer incidence and cancer mortality associated with a decrease of (unprocessed red meat) URM and/or processed meat (PM) consumption (82).

In order to keep the presentation understandable and assimilable, we decided to focus only on cancer and thus, we omitted possible cardiovascular effects. The scenarios also presented the corresponding certainty of the evidence for the potential risk reductions. The questionnaire was tailored to participants' individual meat consumption (i.e., after they had stated their mean consumption, subsequent questions referred to those prior responses) and participant's willingness to change their meat intake (those unwilling to change responded to additional questions regarding whether higher quality evidence or a larger effect would change their willingness).

The questionnaire was structured following a conditional formatting, allowing respondents to skip certain questions based on their answers to other questions. The more unwilling to change, the more questions were presented to participants; thus, in case of expressing unwillingness to stop and/or reduce, participants would move to the next question following the logic reported in **figure 8**, whereas in case of a positive response, participants would skip to the next cancer scenario and then type of meat. This logic of questions was applied for both types of meat (URM and PM) and for both cancer incidence and cancer mortality scenarios.

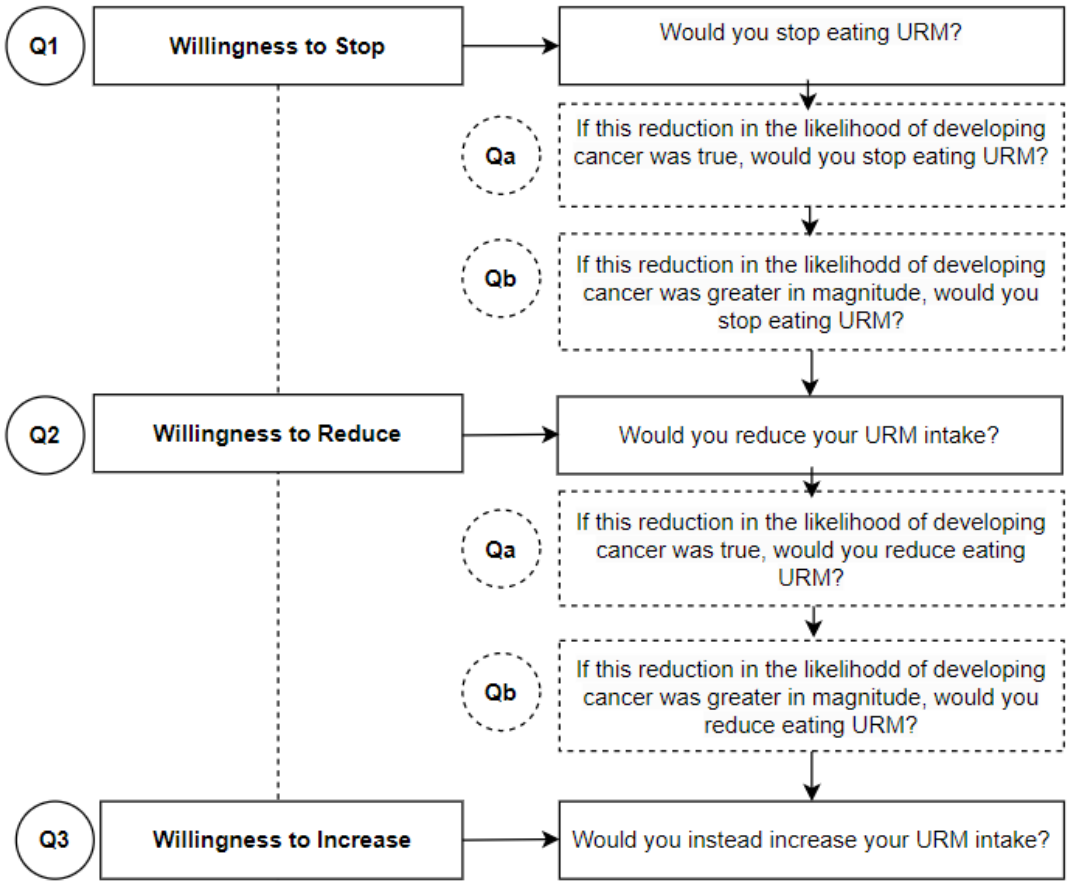

Figure 8. Questions framework for the direct-choice cancer incidence exercise for unprocessed red meat.

Abbreviations: URM= unprocessed red meat; Q1=Question 1; Q2=question2; Q3=Question3; Qa=Question a; Qb=Question b.

Q1-Q2-Q3: Willingness to stop, reduce and increase meat intake was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes).

Qa: Willingness to stop and reduce meat intake with higher certainty was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes).

Qb: Willingness to stop and reduce processed meat consumption with a larger risk reduction was formulated as a multiple-choice question.

This logic of questions was applied for both types of meat and for both cancer incidence and cancer mortality scenarios.

* For the mortality scenarios “developing cancer” was changed into “dying from cancer”.

Two additional questions invited respondents to participate in a semi-structured interview and the follow up assessment at 3 months. If respondents agreed to participate in the semi-structured interviews, we arranged a meeting (through a secured Skype/Zoom call or by telephone) in which we reviewed and discussed their answers from the online survey and asked additional questions addressing their motives to change or continue with their current URM and/or PM consumption. At 3 months after the online survey, we conducted

follow-up interviews via email and/or phone and asked the participants who agreed to be contacted if they had made any changes in their meat consumption.

3.2.5. Data synthesis and analysis

3.2.5.1. Quantitative analysis

All statistical analyses were performed using RStudio (version 1.2.5033) (171). Data were checked for normal distribution using the Kolmogorov-Smirnov test. An independent samples t-test (normal distribution) or a Mann-Whitney U test (non-normal distribution) was used to assess the difference between two groups. For categorical variables, differences between groups were analysed by chi-square test. Missing values were excluded from the analysis.

We described participants' demographic and medical history information as well as meat consumption behaviours using mean ± standard deviation or as median and inter-quartile-range (IQR), and number (percentage). Because the data were not normally distributed, we presented participants' willingness to stop, reduce and increase meat consumption in the face of undesirable cancer as medians and IQR. We performed separate logistic regression analysis for each dependent variable to explore the determinants of participants willingness to change meat consumption in the direct choice scenarios. The dependent variables were the choice (unwilling versus willing) to stop and reduce eating URM and/or PM in the face of cancer incidence risks as well as cancer mortality risks. The team identified independent variables sex, age, level of education, occupational status and religious belief a priori as known potential confounders and were included in each statistical model. Linear regression was not performed as planned in the protocol because the assumption of linearity was violated. We calculated the number and percentage of participants who made any changes in their meat consumption at three months of follow-up.

3.2.5.2 Qualitative analysis

After collecting the data and transcribing the semi-structured interviews, we conducted an iterative, thematic analysis, using constant comparison within and across the transcripts of study's participants by following a six-step approach (i.e., familiarising with the data, generating initial codes, searching for themes, reviewing the themes, defining, and naming themes and producing the final report) (172).

3.2.5.3. Integrating qualitative and quantitative analyses

We conducted a sequential analysis of the quantitative and qualitative components of the data. We analysed each dataset separately and then, at the end of the study, listed the findings from each component of our study and draw meta-inferences. Findings of interest from both data sets were compared and contrasted for convergence (whether findings from each data set agree), complementarity (whether findings offer complementary information on the same issue), dissonance (appear to contradict each other) and "silence"

(a particular finding could only be explored in one data set) (173). The integrated data were presented using a joint display (173), which presents each theme from the qualitative analyses according to the proportion obtained from the relevant online survey questions.

3.3. Study 3: "Peoples' values and preferences towards animals' welfare and environmental concerns of meat consumption: A mixed-methods systematic review"

3.3.1. Design

This is a mixed-methods systematic review on people's health related values and preferences regarding meat intake in the face of environmental concerns. We registered the protocol with PROSPERO (CRD42018088854) (163) and adhered to the PRISMA statement (49).

3.3.2. Data sources and search strategy

We designed and conducted an exhaustive search in MEDLINE (via PubMed), EMBASE (via Ovid), Web of Science (Institute for Scientific Information), CAB abstracts (via CABI; Centre for Agriculture and Bioscience), AGRIS (International System for Agricultural Science and Technology), and FSTA (Food Science and Technology Abstracts) from inception to June 2020. We defined search terms related to meat consumption; consumer behaviour; and values, preferences, and attitudes and combined them with relevant terms from the controlled vocabulary from each database. We did not restrict our search by publication status or date of publication. We also reviewed reference lists of the included articles and relevant systematic reviews.

3.3.3. Inclusion criteria

We included studies exploring how environmental values and preferences can in-fluence meat consumption in adults (≥80% of the sample were 18 years or older). If studies did not report the participants' age, we assumed that >80% of the participants were ≥ 18 years old. We included studies that obtained data by qualitative (e.g., inter-views, focus groups), quantitative (e.g., cross-sectional survey), or mixed methods (e.g., both interviews or focus groups and a cross-sectional survey). We included only studies published from 2000 onwards conducted in Europe, Australia, Canada, and the United States (USA) because we considered them a homogeneous set of countries reflecting similar socio-economic characteristics and values. If a study was conducted in multiple countries, including countries that did not fulfil the eligibility criteria, it was included. We excluded experimental/intervention studies and studies focusing on: meat alternatives (e.g., cultured meat, in vitro meat, functional meat products, or genetically modified meat); meat quality (meat composition, sensory quality, and/or palatability factors or origin of meat); meat safety (e.g., food handling, chemical hazards/meat contamination, or storing/preservation of meat); meat industry (e.g., market research to inform or meet consumers' demands); meat consumption trends; and studies focusing on specific populations (e.g., cancer survivors or pregnant women).

Following a calibration exercise, teams of two reviewers independently screened the titles and abstracts of all retrieved references from the search. Subsequently, teams of two reviewers independently reviewed the

full text of articles deemed potentially eligible in the title and abstract screening. In case of disagreement, reviewers reached consensus with the help of a third reviewer.

3.3.4 Data extraction

We used two ad hoc data extraction forms for quantitative and qualitative studies. For mixed-methods studies, the quantitative and qualitative evidence was extracted separately in the corresponding extraction form. After calibration, two reviewers independently abstracted information from each study including: 1) study identification; 2) objectives or research questions; 3) participant characteristics; 4) general design and methods; 5) risk of bias/methodological limitations; and 6) findings. In case of disagreement, reviewers reached consensus with assistance from a third reviewer.

For quantitative studies, we used an adapted version of available GRADE guidance to assess the risk of bias (RoB) of studies on the importance of outcomes on values and preferences (110). We considered five items grouped in three domains: 1) selection of participants; 2) missing outcome data; and 3) the measurement instruments' validity. We rated studies as high risk of bias if the measurement instrument did not have evidence of validity, or it was unclear, and as moderate risk if it was validated but two or more items proved at high risk of bias.

For qualitative studies, we used the Critical Appraisal Skills Programme (CASP) qualitative research checklist to assess the methodological limitations (ML) of the studies, consisting of the appropriateness of the following items: 1) aim of the research; 2) qualitative methodology; 3) research design; 4) recruitment strategy; 5) data collection; 6) researcher and participants relationship; 7) ethical issues; 8) data analysis; 9) summary of findings; and 10) value of the research (164). We rated studies as "serious methodological limitations" if three or more items had serious concerns, as "Moderate methodological limitations" if they had two items with serious concerns, "minor methodological limitations" if one item had serious concerns, and "No or minor concerns" if no items had serious concerns. A pair of reviewers independently assessed RoB/ML; in case of disagreement, they reached consensus with the help of a third senior methodologist.

For mixed-methods studies, we used the mixed methods appraisal tool (MMTA) consisting of the appropriateness of the five following items: 1) use of mixed-methods design, 2) integration of different components of the study, 3) interpretation of qualitative and quantitative components, 4) reporting of inconsistencies between quantitative and qualitative results, and 5) quality criteria of quantitative and qualitative evidence (174).

3.3.5. Data synthesis

We synthesised our findings into narrative forms following an iterative four-step approach that involved simultaneous quantitative and qualitative data collection and analysis. First, we selected two to three eligible

articles per study design, identified key themes, and coded them in different categories. Second, we used these categories to design ad hoc data extraction forms. Third, through an iterative process, we compared the key themes of the different categories identified across all studies, categorised them into different groups depending on the type of population (e.g., women, vegetarians, elderly) and developed analytic themes. Finally, we applied a critical meta-narrative synthesis to transform the quantitative data into qualitative data (165,175,176). For the latter, we used four systematic profiles and several critical questions (e.g., "Modal pro-file" refers to the most occurring different attributes, and therefore if most study participants reported to consume meat, they were described as omnivores) to extract the identified narratives and to guide our synthesis of data) (165). We synthesised and narratively reported the findings according to the identified themes. Within each identified theme, we divided the findings into different subsections (if applicable) according to the following criteria:

- Type of data: whether the findings were from quantitative (e.g., questionnaire) or qualitative (e.g., interview) data sets.
- Previous knowledge/information on the environmental impact of meat: whether the participants had been informed about the environmental impact of meat be-fore being asked about their beliefs, preferences, and/or behaviours.

3.3.5.1 Integrating Qualitative and Quantitative Analyses

We compared the narratively reported findings from the quantitative and qualitative data sets, searching for similarities and differences (177). We integrated them into joint displays, which present findings from both quantitative and qualitative data sets per theme (177-179), and assessed whether findings from each data set agreed, offered complementary information, or contradicted each other (178).

3.3.5.2 Confidence in the evidence

We assessed the confidence in the integrated evidence using the GRADE-CERQual approach (168). This is the most appropriate approach for assessing the extent to which a review finding is a reasonable representation of the phenomenon of interest—in our case the phenomenon of interest was people's values and preferences regarding meat consumption related to environmental impact. Therefore, we assessed the confidence in the evidence considering the following GRADE-CERQual domains: methodological limitations, relevance, coherence, and adequacy, with the exception that we used different appraisal tools for the risk of bias or methodological limitations depending on whether the evidence was quantitative or qualitative as explained above.

To increase consistency and transparency in the overall assessment, we assigned a number value to each of the GRADE-CERQual levels of the concerns as follows: no or very minor concerns were valued as 0; minor concerns as 1; moderate concerns as 2 and serious concerns as 3. Based on the sum of values per domain

and per theme, we judged the overall confidence for all the identified themes as: high confidence (values between 0 and 1); moderate confidence (values between 2 and 4); low confidence (values between 5 and 8); and very low confidence (values between 9 and 12).

4. RESULTS

4.RESULTS

4.1. Study 1: "Health-related values and preferences regarding meat consumption: a mixed-methods systematic review"

4.1.1. Summary of Study 1 results

4.1.1.1 Study selection

The search yielded 19,172 articles, of which 456 were deemed potentially eligible on the basis of title and abstract. We excluded 402 studies. After full-text appraisal, we included 41 quantitative and 13 qualitative studies.

4.1.1.2 Study characteristics

Of the 41 quantitative studies, 21 were conducted in Europe, 11 in the United States, 7 in Australia, 1 in Canada, and 1 in New Zealand. Eighteen studies were done between 1988 and 2009, and 23 were done between 2011 and 2019. Of the 13 qualitative studies, 7 were done in Europe, 3 in the United States, and 3 in Australia. Six were done between 1991 and 2010, and 7 were done between 2011 and 2018. The number of participants ranged from 100 to 22 935 (aged 18 to >65 years) in the quantitative studies and from 19 to 460 (aged 16 to >75 years) in the qualitative studies. Among the included studies, 41 reported data on meat in general, 6 reported data on both meat in general and red meat, and 7 reported data on red meat only.

4.1.1.3 Findings

We identified 2 main themes: reasons for meat consumption (38 quantitative [62 963 participants] and 10 qualitative [419 participants]) and willingness to reduce meat consumption in the face of undesirable health effects (5 quantitative [8983 participants] and 4 qualitative [616 participants]).

Of the quantitative studies, 23 of 38 (60.5%) reporting "reason for meat consumption" and 5 of 5 (100%) reporting "willingness to reduce meat consumption in the face of undesirable health effects" were assessed as having high risk of bias due to lack of validation of the measurement instruments. Of the qualitative studies, 1 of 12 (8.3%) reporting "reason for meat consumption" had serious methodological limitations due to lack of reporting of the investigator and participants' relationship, lack of detail about the data analysis process, and unclear reporting of findings.

4.1.1.3.1 Reasons for meat consumption

4.1.1.3.1.1 Quantitative studies

Nineteen studies reported on reasons for omnivores' meat consumption. Most consumed meat because they enjoyed it, they perceived it as being part of a complete and healthy diet, and they considered it part of their

culture. In addition, lack of food alternatives and lack of cooking skills to prepare a tasty dish without meat were often reported as barriers to reducing meat consumption.

Ten studies reported that, overall, men had a more positive attitude toward meat consumption than women and that they considered meat as part of a healthy diet and their culture. Women were substantially more concerned about health consequences and more frequently avoided eating meat because of health and ethical concerns. Three studies reported inconsistent results on how elderly persons value meat consumption. In 2 studies, these persons noted potential undesirable health consequences and the presence of diet-related diseases as important reasons to reduce meat consumption. Another study, however, reported that older people were no more concerned about health than younger people, with both groups believing that meat was necessary for maintaining health. Seventeen studies reported on reasons for avoiding meat among vegetarians or low-meat consumers. All participants reported health (for example, risk for cancer, heart diseases) as 1 of the main reasons for avoiding meat. Other reasons for avoiding meat included animal welfare or environmental concerns.

The overall certainty of the evidence was rated as low because 20 of 38 (53%) studies proved to be at high risk of bias due to lack of validation of the measurement instruments and likely selectivity of study populations (**Annex 3A**).

4.1.1.3.1.2 Qualitative studies

Three studies reported on the reasons omnivores consume meat: enjoyment, the perception that meat was part of a healthy diet, and the belief that it was part of their culture. Lack of food alternatives and cooking skills to prepare a tasty dish without meat were often mentioned as barriers to reducing consumption. Two studies reported that older people believe that aging is associated with a decline in food intake and thus a reduction in meat consumption, with a particular focus on red meat. Many elderly participants viewed fish as a healthier alternative to red meat and were aiming to regularly incorporate fish into their diet. Most older people believed that people ate too much meat and that it was the cause of the increase the frequency of cancer, high blood pressure, diabetes, and heart disease.

Six studies explored reasons for avoiding meat among vegetarians and low-meat consumers and suggested that motivations for vegetarianism and meat avoidance vary and change over time. Persons might initially avoid meat because of 1 motivation or concern (for example, health) and later integrate other beliefs or reasons to support their behaviour (for example, animal welfare and environmental concerns). For many vegetarians, concern about health (for example, to avoid genetic health problems, such as heart disease) was the primary motivation to stop eating meat, but ethical concerns (for example, animal welfare) were also often reported as a major reason.

The overall certainty of the evidence was rated as low because of methodological limitations due to lack of reporting of the investigator and participants' relationship (8 of 10 [80%] studies), limited information on the data analysis process and the likely selectivity of study populations (3 of 10 [30%] studies), and adequacy concerns (small number of participants) (**Annex 3A**)

4.1.1.3.2 Willingness to change meat consumption in the face of health concerns

4.1.1.3.2.1 Quantitative studies

Five studies evaluated willingness to change meat consumption when faced with health concerns. One study provided participants with a World Health Organization report on the risk for colorectal cancer associated with red meat consumption. Another study provided participants with a fictional newspaper article reporting potentially undesirable health effects of meat consumption, including risk for stroke, heart attack, diabetes, and cancer. In both studies, most participants reported that they would not reduce meat consumption in the future, partially because they mistrusted the information provided. In 1 study, many of the participants believed additives used in the production process were the real health problem rather than the meat consumption itself. Men attached greater importance to possible barriers for reducing meat consumption, considering it as part of a healthy diet and their culture, whereas most women expressed environmental concerns and animal welfare as motivations for reducing meat consumption.

Two additional studies asked participants what changes they would make to improve or maintain their health, and meat reduction was not among the most frequently reported; other dietary or lifestyle changes, such as exercise or eating more fruits and vegetables, were, among 10 options, selected more often. One study that asked what future changes participants would make specifically regarding meat consumption found that most, especially men, had no intention of changing meat consumption. Many participants already believed that they had reduced their meat consumption in the past and did not plan any further reductions.

The overall certainty of the evidence was rated as low because all studies proved to be at high risk of bias due to lack of validation of the measurement instruments, and for indirectness because 3 of 5 (60%) studies did not inform participants about the undesirable health effects of meat consumption and the likely selectivity of populations (**Annex 3B**).

4.1.1.3.2.2 Qualitative studies

Four studies evaluated willingness to change meat consumption in the face of health concerns. Two studies asked participants how they perceived the possibility of changing meat consumption habits to minimize undesirable health effects. Most participants reported that they would not reduce consumption. One study asked participants their opinion about consumption of fewer animal-derived products and consuming more plant-based foods. Participants were concerned about reducing meat consumption because they perceived meat as an important component of a healthy diet. Reasons participants reported not desiring to change

consumption included belief that they already ate small quantities and did not need to reduce further (this reason was more frequently cited when discussing reduction of red meat than other types of meat), that they had already reduced meat consumption in the past, that the consequences of meat consumption were trivial compared with other behaviours (for example, smoking tobacco), and that they did not trust the available scientific information. In another study, participants were presented with nutritional information about lamb meat and then asked about their future meat consumption intentions. Most participants believed they would continue with their current consumption, with the most common reasons being the belief that they needed protein and the enjoyment of eating meat.

The overall certainty of the evidence was rated as low because of methodological limitations due to lack of reporting of the investigator and participants' relationship (3 of 4 [75%] studies), because of concerns in relevance due to not informing participants about the undesirable health effects of meat consumption and the likely selectivity of populations (4 of 4 [100%] studies), and because of adequacy concerns (small number of participants) (**Annex 3B**).

4.1.2. Study 1 publication

Valli C, Rabassa M, Johnston BC, Kuijpers R, Prokop-Dorner A, Zajac J, Storman D, Storman M, Bala MM, Solà I, Zeraatkar D, Han MA, Vernooij RWM, Guyatt GH, Alonso-Coello P; NutriRECS Working Group. **Health-Related Values and Preferences Regarding Meat Consumption: A Mixed-Methods Systematic Review**. *Ann Intern Med*. 2019;171(10):742-755.

Annals of Internal Medicine Journal (2019): impact factor 21.317, first quartile Q1 (Internal Medicine; Medicine (miscellaneous)).

REVIEW

Annals of Internal Medicine

Health-Related Values and Preferences Regarding Meat Consumption

A Mixed-Methods Systematic Review

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Background: A person's meat consumption is often determined by their values and preferences.

Purpose: To identify and evaluate evidence addressing health-related values and preferences regarding meat consumption.

Data Sources: MEDLINE, EMBASE, Web of Science, Centre for Agriculture and Biosciences Abstracts, International System for Agricultural Science and Technology, and Food Science and Technology Abstracts were searched from inception to July 2018 without language restrictions.

Study Selection: Pairs of reviewers independently screened search results and included quantitative and qualitative studies reporting adults' health-related values and preferences regarding meat consumption.

Data Extraction: Pairs of reviewers independently extracted data and assessed risk of bias.

Data Synthesis: Data were synthesized into narrative form, and summaries were tabulated and certainty of evidence was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach. Of 19 172 initial citations, 41 quantitative studies (38 addressed reasons for meat consumption and 5 addressed willingness to reduce meat consumption) and 13 qualitative studies (10 addressed reasons for meat consumption and 4 addressed willingness to reduce meat consumption) were eligible for inclusion. Thirteen studies reported that omnivores enjoy eating meat, 18 reported that these persons consider meat an essential component of a healthy diet, and 7 reported that they believe they lack the skills needed to prepare satisfactory meals without meat. Omnivores are generally unwilling to change their meat consumption. The certainty of evidence was low for both "reasons for meat consumption" and "willingness to reduce meat consumption in the face of undesirable health effects."

Limitation: Limited generalizability of findings to lower-income countries, low-certainty evidence for willingness to reduce meat consumption, and limited applicability to specific types of meat (red and processed meat).

Conclusion: Low-certainty evidence suggests that omnivores are attached to meat and are unwilling to change this behavior when faced with potentially undesirable health effects.

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For author affiliations, see end of text.
This article was published at Annals.org on 1 October 2019.
* For members of the NutriRECS Working Group, see the **Appendix**, available at Annals.org.

People need to choose from a wide range of foods on a daily basis to meet their nutritional requirements (1). Consumption of different foods may yield both desirable and undesirable health effects (2). In light of recent studies showing an association between consumption of unprocessed red meat and processed meat and adverse health consequences, including increased risk for cancer (3), all-cause (4) and cardiovascular mortality (5), and stroke (6), dietary guidelines have generally endorsed limiting meat intake (7–9). However, these guidelines have neglected to identify and incorporate their target populations' values and preferences on meat consumption (10–13), which are major influences on what foods people eat (14–16). Understanding people's health-related values and preferences on meat consumption may improve the trustworthiness of dietary recommendations (17).

Therefore, we conducted a systematic review addressing people's health-related values and preferences on meat consumption. This review was done as part of Nutritional Recommendations and Accessible Evidence Summaries Composed of Systematic Reviews (NutriRECS), an initiative that aims to develop trustworthy nutritional recommendations (18). We performed 4 parallel systematic reviews addressing the following: experimental (19) and observational evidence (20) on the effect of red and processed meat on cancer and cardiometabolic outcomes, observational studies on the effect of red and processed meat on cancer outcomes (21), and the effect of varying red and processed meat dietary patterns on cardiometabolic and cancer outcomes (22). On the basis of these reviews, we developed recommendations for red and processed meat and health outcomes (23).

See also:

Related articles 703, 711, 721, 732, 756
Editorial comment 767

Web-Only
Supplement

METHODS

We registered the protocol with PROSPERO (CRD42018088854) (24) and adhered to the PRISMA

(Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement (25).

Data Sources and Searches

We designed and conducted a search in MEDLINE (via PubMed), EMBASE (via Ovid), Web of Science (Institute for Scientific Information), Centre for Agriculture and Biosciences Abstracts (via CABI), International System for Agricultural Science and Technology, and Food Science and Technology Abstracts from inception to July 2018, and an updated search of MEDLINE and EMBASE through June 2019. We combined search terms related to meat consumption, consumer behavior, and values and preferences with the controlled vocabulary from each database. We did not restrict our search by publication status, language, or date of publication (**Supplement Table 1**, available at Annals.org). We also reviewed reference lists of the included articles and relevant systematic reviews.

Study Selection

We included studies exploring health-related values and preferences on meat consumption if more than 80% of participants were adults (aged ≥18 years). We considered quantitative (that is, cross-sectional design), qualitative (that is, participant interviews, focus groups), and mixed-methods studies. If studies did not report the participants' ages, we assumed that more than 80% were aged 18 years or older. We included only studies done in Europe, Australia, Canada, the United States, and New Zealand because we considered them to be homogeneous countries reflecting similar socioeconomic characteristics and values. We excluded studies that focused on meat alternatives (for example, cultured, in vitro, functional products, or genetically modified), types (for example, organic), quality (composition, sensory quality or palatability factors, or origin), safety (for example, food handling, chemical hazards or contamination, or storing or preserving), industry (for example, market research to inform or meet consumers' demands), consumption trends, and specific populations (for example, cancer survivors or pregnant women).

Before beginning each aspect of the review process, we conducted calibration exercises in which reviewers assessed the same articles and discussed any disagreement, leading to a clarification and a common understanding of criteria and process. After calibration, teams of 2 reviewers independently screened titles and abstracts of all retrieved references. Subsequently, teams of 2 reviewers independently reviewed the full text of articles deemed potentially eligible during title and abstract screening. In cases of disagreement, reviewers reached consensus with assistance from a third reviewer.

Data Extraction and Quality Assessment

We used 2 ad hoc data extraction forms for quantitative and qualitative research (**Supplement Tables 2** and **3**, available at Annals.org). After calibration exercises similar to the ones described earlier, teams of reviewers independently abstracted information from each study, including study identification, objectives or research questions, population characteristics, design and methods, risk of bias or methodological limitations, and findings. In cases of disagreement, reviewers reached consensus with assistance from a third reviewer.

For quantitative studies, we used an adapted version of the GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach to assess risk of bias of studies on importance of outcomes or values and preferences (26). We considered 5 items grouped in 3 domains: selection of participants, missing outcome data, and measurement instruments' validity. We rated studies as having high risk of bias if the measurement instrument was not validated or was unclear, and as having moderate risk if it was validated but 2 or more items had high risk of bias. For qualitative studies, we used the Critical Appraisal Skills Programme qualitative research checklist, which consists of the following items: aim of the research, qualitative methodology appropriateness, research design, appropriate recruitment strategy, data collection, investigator and participants' relationship, ethical issues, data analysis, findings, and value of the research (27). We rated studies as having "serious methodological limitations" if more than 2 items had serious concerns and as having "moderate methodological limitations" if they had 2 items with serious concerns. Reviewers independently assessed risk of bias or methodological limitations. In cases of disagreement, reviewers reached consensus with assistance from a third reviewer.

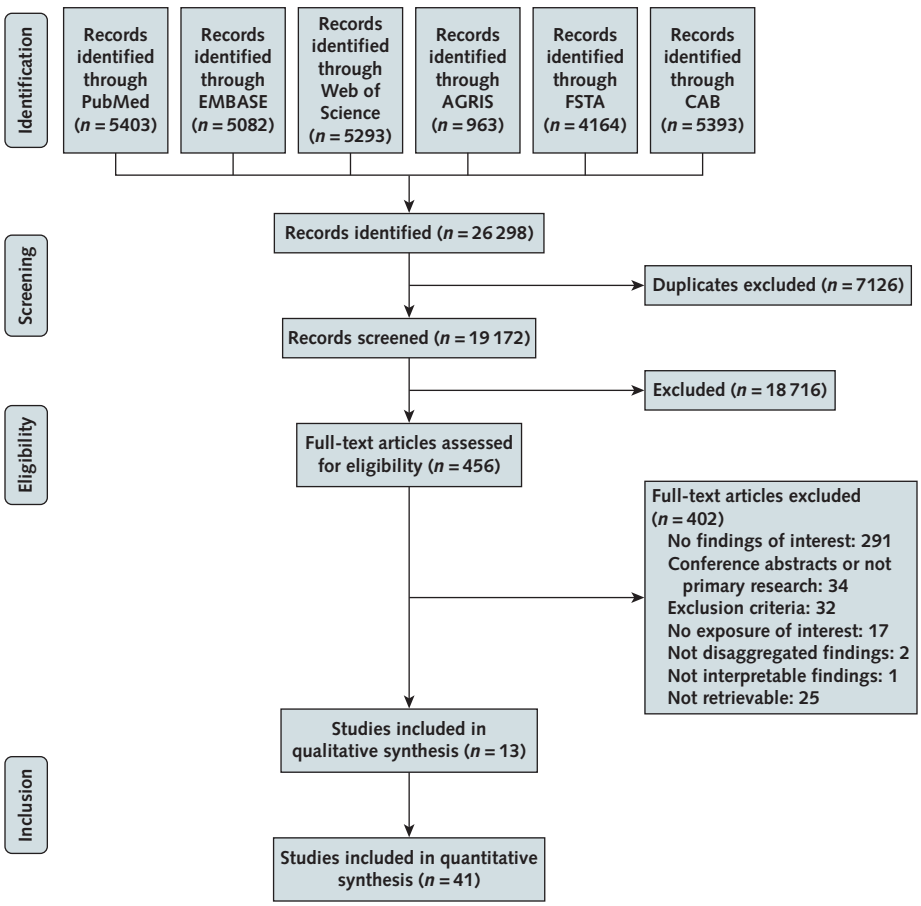
Data Synthesis and Analysis

We synthesized results from studies using a 4-step approach that involved simultaneous quantitative and qualitative data collection and analysis. First, we selected 2 to 3 eligible articles per study design, identified key themes, and coded them in categories. Second, we used these categories to design ad hoc data extraction forms. Third, using an iterative process, we compared the key themes of the categories identified across all studies and developed analytic themes. Fourth, we applied the critical meta-narrative synthesis to transform the quantitative data into qualitative data (28, 29). For the last step, we used 4 systematic profiles and several critical questions to extract the identified narratives and to guide our synthesis of data (**Supplement Table 4**, available at Annals.org).

We synthesized and narratively reported the findings according to participants' meat consumption. We defined those who consumed meat as omnivores and analyzed them separately from persons who typically avoided meat, whom we defined as vegetarians, including lacto-ovo vegetarians or low-meat consumers.

For quantitative studies, we assessed the certainty of evidence for each review finding according to GRADE domains (risk of bias, imprecision, inconsistency, indirectness, and publication bias) (30, 31). For qualitative studies, we assessed the certainty of evidence according to GRADE-CERQual (Confidence in the Evidence from Reviews of Qualitative Research) domains (methodological limitations, relevance, coherence, and adequacy) (32).

Figure. Evidence search and selection.



AGRIS = International System for Agricultural Science and Technology; CAB = Centre for Agriculture and Biosciences; FSTA = Food Science and Technology Abstracts.

Findings were initially considered as high certainty and were downgraded (from high to very low) by 1 or more levels if serious or several minor or moderate concerns were detected in 1 or more domains.

Role of the Funding Source

The study received no funding.

RESULTS

The search yielded 19 172 articles, of which 456 were deemed potentially eligible on the basis of title and abstract. We excluded 402 studies (**Supplement Table 5**, available at Annals.org). After full-text appraisal, we included 41 quantitative (33–73) and 13 qualitative studies (74–86). The **Figure** presents the flow diagram with the search results and selection of studies.

Study Characteristics

Table 1 presents the characteristics of the 54 included studies. Of the 41 quantitative studies, 21 were done in Europe, 11 in the United States, 7 in Australia, 1 in Canada, and 1 in New Zealand. Eighteen studies were done between 1988 and 2009, and 23 were done between 2011 and 2019. Of the 13 qualitative studies, 7 were done in Europe, 3 in the United States, and 3 in Australia. Six were done between 1991 and 2010, and 7 were done between 2011 and 2018. The number of participants ranged from 100 to 22 935 (aged 18 to >65 years) in the quantitative studies and from 19 to 460 (aged 16 to >75 years) in the qualitative studies. Among the included studies, 41 reported data on meat in general, 6 reported data on both meat in general and red meat, and 7 reported data on red meat only.

Findings

We identified 2 main themes: reasons for meat consumption (38 quantitative [62 963 participants] and 10 qualitative [419 participants]) and willingness to reduce meat consumption in the face of undesirable health effects (5 quantitative [8983 participants] and 4 qualitative [616 participants]). **Table 2** shows the main findings and their certainty (**Supplement Tables 6** and **7**, available at Annals.org). Of the quantitative studies, 23 of 38 (60.5%) reporting "reason for meat consumption" and 5 of 5 (100%) reporting "willingness to reduce meat consumption in the face of undesirable health effects" were assessed as having high risk of bias due to

Table 1. Characteristics of the Included Studies

Study, Year (Reference)	Primary Focus	Type of Study	Country	Data Collection Methods	Sampling	Participants, *n*	Female Sex, %	Type of Meat	Risk of Bias/ Methodological Limitations
Andrade et al, 2017 (53)	Self-perceived healthy eating attitudes after 10-y follow-up	Quantitative	Spain	FFQ and qualitative questions	NR	4572	56.6	Meat in general	High
The Realeat Survey Office, 1990 (34)	Survey on attitudes toward meat consumption	Quantitative	United Kingdom	Survey	NR	4162	NR	Meat in general	High
Beardsworth and Bryman, 1999 (35)	Changing patterns of meat consumption and meat avoidance	Quantitative	United Kingdom	Self-administered questionnaire	Convenience	350	80.3	Meat in general	High
Cordts et al, 2014 (36)	Effect of information on the negative attributes of meat consumption on demand for meat	Quantitative	Germany	Online survey	NR	590	48.1	Meat in general	High
Crnic, 2013 (37)	Prevalence of vegetarianism, learn about who and why persons become vegetarians	Quantitative	Slovenia	Survey	NR	800	NR	Meat in general	High
Decima Research, 2006 (44)	Survey to assess Canadians' level of awareness of the link between foods and disease	Quantitative	Canada	Computer-assisted telephone interview	NR	2029	52	Meat in general	High
Fessler et al, 2003 (43)	Meat consumption and reasons for meat avoidance	Quantitative	United States	Web-based survey	NR	945	65.5	Meat in general	High
Forestell et al, 2012 (39)	Dietary habits and lifestyle behaviors of vegetarians, pesco-vegetarians, semivegetarians, and flexitarians to omnivores	Quantitative	United States	NEO-FFI, FFQ, FN, VS, TFEQ/EI, EAT, FCQ, GEH questionnaires and follow-up online questionnaire	Convenience	240	100	Red meat	High
Gutkowska et al, 2018 (66)	Effect of consumer perception of beef values on consumer behavior toward this type of meat	Quantitative	Poland	Survey questionnaire	NR	1004	NR	Meat in general and beef	High
Haverstock and Forgays, 2012 (51)	Motivations for food choices	Quantitative	United States	Eating pattern questionnaire and FCQ	NR	247	85.4	Meat in general	High
Honkanen and Ottar Olsen, 2009 (58)	Russian food preferences: Fish lovers, fish haters, various food lovers, food indifferent, and red meat lovers	Quantitative	Russia	Face-to-face interview	Random	1081	50.2	Meat in general	Moderate
Izmirli and Phillips, 2011 (63)	Relationship between the consumption of animal products and attitudes toward animals	Quantitative	Australia	Online survey	Convenience	3433	NR	Meat in general	Moderate
Kayser et al, 2013 (54)	Attitudes toward meat; low-meat consumers differ from typical consumer behavior	Quantitative	Germany	Survey	Convenience	956	51.2	Meat in general	Low
Kovačić et al, 2016 (42)	Willingness to reduce meat consumption after the WHO report	Quantitative	Croatia	Survey	NR	169	60.4	Red meat	High
Latvala et al, 2012 (64)	Meat consumption patterns among Finnish consumers, considering both stated past changes and intended future changes	Quantitative	Finland	Online survey	NR	1623	50	Meat in general	High

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Table 1–Continued

Study, Year (Reference)	Primary Focus	Type of Study	Country	Data Collection Methods	Sampling	Participants, *n*	Female Sex, %	Type of Meat	Risk of Bias/ Methodological Limitations
Lea and Worsley, 2001 (65)	Meat consumption, beliefs about meat and nutrition, perceived difficulties with and benefits of vegetarian diets, personal values, number of vegetarian significant others, use in and trust of health/nutrition/food information sources, and demographic characteristics	Quantitative	Australia	Postal survey	Partly random and partly nonrandom	707	NR	Meat in general	Low
Lea and Worsley, 2002 (47)	Belief and demographic factors associated with the perception that meat is intrinsically unhealthy	Quantitative	Australia	Booklet with questionnaire	Partly random and partly nonrandom	698	56	Meat in general and red meat, specifically beef or lamb	Low
Lea and Worsley, 2003 (45)	Factors associated with the belief that vegetarian diets provide health benefits	Quantitative	Australia	Postal survey	Partly random and partly nonrandom	707	NR	Meat in general and red meat, specifically beef or lamb	Low
Lea and Worsley, 2003 (46)	Consumers' perceived benefits and barriers to consumption of a vegetarian diet	Quantitative	Australia	Postal survey	Random	601	56.8	Meat in general	Low
Lentz et al, 2018 (67)	To investigate New Zealand consumers' attitudes, motivations, and behaviors regarding meat consumption	Quantitative	New Zealand	Online survey	Random	841	50.4	Meat in general	Low
Love and Sulikowski, 2018 (68)	To measure implicit and explicit attitudes toward meat in men and women	Quantitative	Australia	Survey	NR	123	65	Meat in general	Low
McCarthy et al, 2003 (56)	Consumer perceptions toward beef and the influence of these perceptions on consumption	Quantitative	United Kingdom	Survey	Random	300	NR	Red meat (beef)	High
Mooney and Walbourn, 2001 (52)	Types of food college students actively avoid and some specific underlying sociocultural reasons for this rejection	Quantitative	United States	FAI, disgust and hedonic-restrained eating scales	Convenience	113	50.4	Meat in general	High
Mullee et al, 2017 (38)	Attitudes and beliefs about vegetarianism and meat consumption among the Belgian population	Quantitative	Belgium	Online questionnaire with multiple-choice questions	NR	2357	49.2	Meat in general	High
Neale et al, 1993 (62)	Study of the attitudes toward food, patterns of food consumption, and health of young vegetarian women	Quantitative	United Kingdom	Self-completed questionnaire with open and closed questions	Convenience	167	100	Meat in general	High
Neff et al, 2018 (69)	To learn about what is eaten in meatless meals, attitudes and perceptions toward meat reduction, and to build on and add depth to previous research on meat reduction behaviors in the United States and other high meat-consuming countries	Quantitative	United States	Web-based survey	Random	1112	51	Meat in general, red meat, and processed meat	High

Continued on following page

Table 1–Continued

Study, Year (Reference)	Primary Focus	Type of Study	Country	Data Collection Methods	Sampling	Participants, *n*	Female Sex, %	Type of Meat	Risk of Bias/ Methodological Limitations
Péneau et al, 2017 (70)	To investigate the existence of dilemmas between health and environmental motives when purchasing meat, fish, and dairy products; determining the sociodemographic profiles of persons reporting dilemmas; and comparing the dietary quality of these persons with those reporting no dilemma	Quantitative	France	Online survey	NR	22 935	75.2	Meat in general	Low
Phillips et al, 2010 (40)	Female and male students' attitudes toward use of animals	Quantitative	Australia	Online survey	Convenience	3444	55.4	Meat in general	Moderate
Piazza et al, 2015 (study 1a and 1b) (71)	To test whether the 4Ns would emerge as the lion's share of spontaneous justifications omnivores offer in defense of eating meat	Quantitative	United States	Survey	NR	295	55.2	Meat in general	Low
Pohjolainen et al, 2015 (59)	Barriers perceived by consumers to lowering their meat consumption levels and adopting a plant-based diet	Quantitative	Finland	Postal survey	Random	1890	56.3	Meat in general	Moderate
Richardson et al, 1993 (57)	Future events investigating meat eating and vegetarianism	Quantitative	United Kingdom	Postal survey	NR	1018	50	Meat in general	High
Ripoll and Panea, 2019 (72)	To identify the profiles of consumers of light lamb meat and the influence of involvement on consumers' attitudes, behaviors, beliefs, preferences, quality cues, and sensory perception regarding light lamb meat	Quantitative	Spain	Questionnaire	NR	100	54	Red meat (lamb)	Low
Rothgerber, 2014 (49)	Justifications that meat eaters use and how gender may be related to choice of meat-eating justification strategy and, secondarily, to diet	Quantitative	United States	MEJ and diet survey	NR	214	87	Meat in general	Moderate
Rothgerber, 2013 (48)	Reasons for the discrepancy and focuses on several dimensions that may demarcate semi- from strict vegetarians: belief in human–animal similarity and liking of and disgust toward meat	Quantitative	United States	Survey	NR	214	87	Meat in general	High
Rozin et al, 1997 (60)	Moralization and its consequences in the domain of vegetarianism	Quantitative	United States	Open-ended questionnaires/ratings of current attitudes/list of possible reasons to avoid meat	Convenience	104	66.3	Meat in general	High
Santos and Booth, 1996 (55)	The expectations that meat avoidance would follow a pattern of eliminating red meat, then white meat, and finally fish were tested	Quantitative	United Kingdom	Meat-avoidance questionnaire	NR	158	79.1	Meat in general	High

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Table 1–Continued

Study, Year (Reference)	Primary Focus	Type of Study	Country	Data Collection Methods	Sampling	Participants, *n*	Female Sex, %	Type of Meat	Risk of Bias/ Methodological Limitations
Spencer et al, 2007 (33)	Prevalence and correlates of U.S. medical students' self-identification as vegetarians	Quantitative	United States	Healthy Doc-Healthy Patient questionnaire and modified FFQ	NR	857	NR	Meat in general	High
Tobler et al, 2011 (41)	Consumers' beliefs about ecological food consumption and their willingness to adopt such behaviors and consumers' willingness to reduce meat consumption	Quantitative	Switzerland	Survey	Random	6189	52.4	Meat in general	High
Vainio, 2019 (73)	To explore why consumers of meat-based diets are not convinced by scientific evidence and to examine whether consumers of meat-based and plant-based diets attend to information in different ways	Quantitative	Finland	Online survey	NR	1279	55.7	Red meat	High
White et al, 1999 (61)	Prevalence and characteristics of vegetarians in the Women Physicians' Health Study and compared them with omnivores in the cohort	Quantitative	United States	Survey	Random	4362	NR	Meat in general	High
Woodward, 1988 (50)	Purchase of meat or meat products, in relation to other factors that may be gaining in influence	Quantitative	United Kingdom	Street intercept survey	Convenience	584	NR	Meat in general	High
Dowsett et al, 2018 (86)	To examine the meat–animal connection by presenting information about animals' intelligence and personality and details about the meat production process to induce cognitive dissonance and the negative affective state associated with it	Qualitative*	Australia	Open-ended responses	Convenience	460	59.6	Red meat (lamb)	No or very minor
Verbeke et al, 2010 (83)	European citizens' and consumers' attitudes and preferences regarding beef and pork	Qualitative*	Germany, Spain, France, and United Kingdom	Focus group discussion	Random	65	NR	Red meat (beef and pork)	Moderate
Beardsworth and Keil, 1991 (85)	Motivations, beliefs, and attitudes of practicing vegetarians and vegans	Qualitative	United Kingdom	Semistructured interview	Snowball sampling	76	NR	Meat in general	Moderate
Beardsworth and Keil, 1992 (81)	Cultural and sociological factors that influence patterns of food selection and food avoidance	Qualitative	United Kingdom	Interview	Snowball sampling	76	51	Meat in general	Moderate
Boyle, 2011 (82)	Eating patterns and vocabularies of motive for newly practicing, or developmental, vegetarians	Qualitative	United States	Semistructured interview	Snowball sampling	45	100	Meat in general and red meat	Serious

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Table 1–Continued

Study, Year (Reference)	Primary Focus	Type of Study	Country	Data Collection Methods	Sampling	Participants, *n*	Female Sex, %	Type of Meat	Risk of Bias/ Methodological Limitations
Brownie and Coutts, 2013 (76)	Perceptions and practices of older Australians in relation to a healthy diet	Qualitative	Australia	Focus group	Snowball sampling	29	79	Meat in general and red meat	No or very minor
Fox and Ward, 2008 (78)	Views of health in vegetarians	Qualitative	United Kingdom	Open-ended questions and follow-up interviews	Convenience	33	70	Meat in general	No or very minor
Graça et al, 2014 (79)	Change habits toward less harmful choices	Qualitative	Portugal	Semistructured focus groups	Convenience	40	62.5	Meat in general	No or very minor
Guerin, 2014 (74)	Interpersonal interactions and conflicts between vegans and omnivores as the stage for deciphering underlying beliefs; omnivores construct ideas about veganism	Qualitative	United States	Interview	Snowball sampling	19	53	Meat in general	No or very minor
Hoek et al, 2017 (77)	Consumer perceptions, experiences, and attitudes toward health and environmental aspects in relation to foods	Qualitative	Australia	Semistructured virtual face-to-face interview	Quota sampling	29	56	Meat in general	No or very minor
Jabs et al, 1998 (75)	Factors involved in making dietary change and to develop theoretical understanding of the process	Qualitative	United States	In-depth, open-ended, semistructured interview	Snowball sampling	19	68	Meat in general	No or very minor
Kouris et al, 1991 (84)	Reasons for observed food habits and consumption of various foodstuffs	Qualitative	Greece	Interview	From electoral rolls	104	50	Meat in general	Moderate
Macdiarmid et al, 2016 (80)	The public's awareness of the environmental effect of food and its willingness to reduce meat consumption	Qualitative	United Kingdom	Focus groups and face-to-face and telephone interviews	Purposive sampling	87	54	Meat in general	No or very minor

4Ns = natural, normal, necessary, and nice; EAT = Eating Attitudes Test; FAI = Food Avoidance Inventory; FCQ = Food Choice Questionnaire; FFQ = food frequency questionnaire; FN = food neophobia; GEH = general eating habits; MEJ = meat-eating justification; NEO-FFI = NEO Five-Factor Inventory; NR = not reported; TFEQ/EI = Three-Factor Eating Questionnaire/eating inventory; VS = variety seeking; WHO = World Health Organization.
* Mixed-method study design, but only qualitative data were included.

lack of validation of the measurement instruments (**Supplement Table 8**, available at Annals.org). Of the qualitative studies, 1 of 12 (8.3%) reporting "reason for meat consumption" had serious methodological limitations due to lack of reporting of the investigator and participants' relationship, lack of detail about the data analysis process, and unclear reporting of findings (**Supplement Table 9**, available at Annals.org).

Reasons for Meat Consumption

Quantitative Studies

Nineteen studies reported on reasons for omnivores' meat consumption (35, 38, 42, 45–47, 56–59, 65–73). Most consumed meat because they enjoyed it (38, 46, 56–59, 65, 66, 71), they perceived it as being part of a complete and healthy diet (38, 42, 47, 56–59, 65, 66, 68–73), and they considered it part of their culture (58, 71). In addition, lack of food alternatives and lack of cooking skills to prepare a tasty dish without meat were often reported as barriers to reducing meat consumption (38, 45, 59, 65, 69).

Ten studies reported that, overall, men had a more positive attitude toward meat consumption than women (34–36, 38, 51, 52, 65, 66, 68, 69) and that they considered meat as part of a healthy diet and their culture (36, 38, 48, 69). Women were substantially more concerned about health consequences (34, 36, 38, 51, 65, 66) and more frequently avoided eating meat because of health and ethical concerns (34, 40, 52). Three studies reported inconsistent results on how elderly persons value meat consumption (51, 65, 66). In 2 studies, these persons noted potential undesirable health consequences (51) and the presence of diet-related diseases (66) as important reasons to reduce meat consumption. Another study, however, reported that older people were no more concerned about health than younger people, with both groups believing that meat was necessary for maintaining health (65).

Seventeen studies reported on reasons for avoiding meat among vegetarians or low-meat consumers. All participants reported health (for example, risk for cancer, heart diseases) as 1 of the main reasons for avoiding meat (37–39, 41, 43, 45, 46, 49–51, 54, 55, 60–63, 67). Other reasons for avoiding meat included animal welfare or environmental concerns (37, 43, 46, 51, 54, 55, 60–63, 67, 69).

The overall certainty of the evidence was rated as low because 20 of 38 (53%) studies proved to be at high risk of bias due to lack of validation of the measurement instruments and likely selectivity of study populations.

Qualitative Studies

Three studies reported on the reasons omnivores consume meat (74, 77, 83): enjoyment (74, 77), the perception that meat was part of a healthy diet (74, 77, 83), and the belief that it was part of their culture (77). Lack of food alternatives and cooking skills to prepare a tasty dish without meat were often mentioned as barriers to reducing consumption (74, 77).

Two studies reported that older people believe that aging is associated with a decline in food intake and thus a reduction in meat consumption, with a particular focus on red meat (76, 84). Many elderly participants viewed fish as a healthier alternative to red meat and were aiming to regularly incorporate fish into their diet (76). Most older people believed that people ate too much meat and that it was the cause of the increase

Table 2. Review Finding Table and Certainty of Evidence

Review Finding	Type of Research Evidence (Reference)	Certainty of Evidence
Reasons for meat consumption		
Most omnivores were highly attached to meat	Quantitative (35, 38, 42, 45–47, 56–59, 65–73)	Low: Risk of bias and indirectness
	Qualitative (74, 77, 83)	Low: Minor methodological limitations, minor relevance and adequacy concerns and limited information on the data analysis process
Men had a more positive attitude toward meat consumption than women	Quantitative (34–36, 38, 51, 52, 65, 66, 68, 69)	Low: Risk of bias and indirectness
Elderly omnivores were generally concerned about health in respect to their food choices	Quantitative (34, 40, 52)	Low: Risk of bias and indirectness
Elderly omnivores believed that aging is associated with a decline in food intake	Qualitative (76, 84)	Low: Minor methodological limitations, minor relevance and adequacy concerns and limited information on the data analysis process
All vegetarians or low-meat consumers reported health as 1 of the main reasons for not eating meat	Quantitative (37–39, 41, 43, 45, 46, 49, 50, 51, 54, 55, 60–63, 67)	Low: Risk of bias and indirectness
For many vegetarians, health concern was the primary motivation to stop eating meat	Qualitative (73–75, 78, 81, 85)	Low: Minor methodological limitations, minor relevance and adequacy concerns and limited information on the data analysis process
Willingness to change meat consumption in the face of undesirable health effects		
Most omnivores reported low willingness to reduce meat consumption	Quantitative (36, 42, 44, 53, 64)	Low: Risk of bias and indirectness
	Qualitative (77, 79, 80, 86)	Low: Minor methodological limitations, moderate concerns about relevance, minor adequacy concerns and limited information on the data analysis process

in the frequency of cancer, high blood pressure, diabetes, and heart disease (84).

Six studies explored reasons for avoiding meat among vegetarians and low-meat consumers and suggested that motivations for vegetarianism and meat avoidance vary and change over time (81, 85). Persons might initially avoid meat because of 1 motivation or concern (for example, health) and later integrate other beliefs or reasons to support their behavior (for example, animal welfare and environmental concerns) (78, 82). For many vegetarians, concern about health (for example, to avoid genetic health problems, such as heart disease) was the primary motivation to stop eating meat, but ethical concerns (for example, animal welfare) were also often reported as a major reason (73–75, 78, 81, 85).

The overall certainty of the evidence was rated as low because of methodological limitations due to lack of reporting of the investigator and participants' relationship (8 of 10 [80%] studies), limited information on the data analysis process and the likely selectivity of study populations (3 of 10 [30%] studies), and adequacy concerns (small number of participants).

Willingness to Change Meat Consumption in the Face of Health Concerns

Quantitative Studies

Five studies evaluated willingness to change meat consumption when faced with health concerns (36, 42, 44, 53, 64). One study provided participants with a World Health Organization report on the risk for colorectal cancer associated with red meat consumption (42). Another study provided participants with a fictional newspaper article reporting potentially undesirable health effects of meat consumption, including risk for stroke, heart attack, diabetes, and cancer (36). In both studies, most participants reported that they would not reduce meat consumption in the future, partially because they mistrusted the information provided (36, 42). In 1 study, many of the participants believed additives used in the production process were the real health problem rather than the meat consumption itself (42). Men attached greater importance to possible barriers for reducing meat consumption, considering it as part of a healthy diet and their culture, whereas most women expressed environmental concerns and animal welfare as motivations for reducing meat consumption (36).

Two additional studies asked participants what changes they would make to improve or maintain their health, and meat reduction was not among the most frequently reported; other dietary or lifestyle changes, such as exercise or eating more fruits and vegetables, were, among 10 options, selected more often (44, 53). One study that asked what future changes participants would make specifically regarding meat consumption found that most, especially men, had no intention of changing meat consumption (64). Many participants already believed that they had reduced their meat consumption in the past and did not plan any further reductions (64).

The overall certainty of the evidence was rated as low because all studies proved to be at high risk of bias due to lack of validation of the measurement instruments, and for indirectness because 3 of 5 (60%) studies did not inform participants about the undesirable health effects of meat consumption and the likely selectivity of populations.

Qualitative Studies

Four studies evaluated willingness to change meat consumption in the face of health concerns (77, 79, 80, 86). Two studies asked participants how they perceived the possibility of changing meat consumption habits to minimize undesirable health effects. Most participants reported that they would not reduce consumption (79, 80). One study asked participants their opinion about consumption of fewer animal-derived products and consuming more plant-based foods. Participants were concerned about reducing meat consumption because they perceived meat as an important component of a healthy diet (77). Reasons participants reported not desiring to change consumption included belief that they already ate small quantities and did not need to reduce further (this reason was more frequently cited when discussing reduction of red meat than other types of meat) (80), that they had already reduced meat consumption in the past (80), that the consequences of meat consumption were trivial compared with other behaviors (for example, smoking tobacco) (79, 80), and that they did not trust the available scientific information (79). In another study, participants were presented with nutritional information about lamb meat and then asked about their future meat consumption intentions. Most participants believed they would continue with their current consumption, with the most common reasons being the belief that they needed protein and the enjoyment of eating meat (86).

The overall certainty of the evidence was rated as low because of methodological limitations due to lack of reporting of the investigator and participants' relationship (3 of 4 [75%] studies), because of concerns in relevance due to not informing participants about the undesirable health effects of meat consumption and the likely selectivity of populations (4 of 4 [100%] studies), and because of adequacy concerns (small number of participants).

DISCUSSION

Key findings from our systematic review include the reasons omnivores consume meat: They consider meat an essential component of a healthy diet, they enjoy eating meat, they feel that meat is a part of their traditions, and they believe they lack the knowledge and cooking skills to prepare an adequate meal without meat. Study participants' willingness to change meat consumption in response to health concerns is generally low. Our findings were consistent across the 2 bodies of evidence (quantitative and qualitative research). The overall certainty of evidence was low, predomi-

nantly because of risk of bias or methodological limitations, lack of validation of the questionnaires, issues of indirectness or relevance, and issues of adequacy.

Strengths of this review include explicit eligibility criteria, an extensive search, and duplicate assessment of eligibility and risk of bias or methodological limitations. The use of 2 complementary bodies of evidence (mixed-methods) and the use of the GRADE approach to assess the certainty of the evidence allowed greater confidence in the interpretation of results (87).

This study also has limitations. We included studies done only in Europe, Australia, Canada, the United States, and New Zealand, reflecting food values and preferences of populations living in high-income countries. Therefore, we cannot generalize these findings to other populations. In addition, the studies reporting willingness to reduce meat consumption in the face of health concerns did not provide participants with sufficient information about the certainty of the evidence, nor about the effect meat consumption has on health. Studies failed to consistently report participants' socioeconomic status, educational level, and religious beliefs, precluding exploration of the effect of these characteristics on dietary values and preferences. Another limitation is related to the applicability of our results to the NutriRECS red meat recommendation because most of the included studies do not focus on red or processed meat, but rather meat in general. Finally, our systematic review focuses only on the influence of health effects and does not address other reasons that influence meat consumption, such as animal welfare and environmental concerns.

We performed a search of MEDLINE through June 2019 to identify relevant previous reviews. More recent study results are consistent with those of earlier studies: During the past 2 decades, omnivores have remained highly attached to meat, and willingness to change consumption has remained generally low (88, 89). Regarding prior systematic reviews, 1 review evaluated omnivores' perceptions and behaviors regarding protein consumption in general and not red meat in particular (88). That systematic review concluded that omnivores' willingness to change consumption in terms of reducing or substituting meat (for example, by eating insects or meat substitutes) is low. One recent narrative review evaluated psychological aspects of meat consumption in general and concluded that eating meat is entrenched in Western culture (89), which is consistent with our findings. Other existing narrative reviews explored motivations for consuming or avoiding meat and suggested, in keeping with our results, that the reasons for consuming meat are complex and diverse and may vary according to age and sex (90, 91).

Our findings have direct implications for stakeholders making both public health and clinical nutritional recommendations. Our results highlight the inappropriateness of assuming that informed persons would choose to reduce meat consumption on the basis of small and distant health benefits, particularly if the benefits are uncertain (10, 92). The results suggest that it may be similarly inappropriate to assume that informed persons would choose to modify their preferred diet in other ways on the basis of small and uncertain health benefits. However, studies generally did not present the possible adverse health consequences of meat consumption in ways that captured the current evidence and its uncertainty. Optimal insight into people's values and preferences, and in particular into willingness to reduce meat consumption, requires such a presentation. Subsequent research should address this issue.

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Appendix: Members of the NutriRECS Working Group

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Correction: Nutritional Recommendations (NutriRECS) on Consumption of Red and Processed Meat

On the author disclosure forms accompanying recent related articles on red and processed meat consumption and health outcomes (1-6), Bradley Johnston did not indicate a grant from Texas A&M AgriLife Research to fund investigator-driven research related to saturated and polyunsaturated fats. This funding is for work in the field of nutrition and the start of funding period was within the 36-month reporting period required in Section 3 of the disclosure form of the International Committee of Medical Journal Editors (ICMJE). Dr. Johnston has updated his disclosure form to include this research funding and also to note funding received from the International Life Science Institute (North America) that ended before the 36-month ICMJE reporting period. The corrected disclosure forms now accompany the articles (1-6).

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4.2. Study 2: "Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study"

4.2.1. Summary of Study 2 results

4.2.1.1 Online Survey

4.2.1.1.1 Participants' Characteristics

Of the 304 individuals who participated in our study, typical respondents were women around 40 years old with a university degree (85%), employed (81%), and having at least one comorbidity (74%).

4.2.1.1.2 Participants' Meat Consumption Behaviour

Many participants reported consuming less than three servings of meat per week (76% of URM and 57% of PM), 24% of participants consumed three or more servings of URM and 43% of PM. The type of URM most frequently consumed was beef or veal (76.0%) and, for PM, Serrano ham or shoulder ham (71.4%). The three main reasons for meat consumption among the participants included flavour, cost and availability, and were similar for URM and PM (**Annex 4A** presents the reasons for meat consumption for unprocessed red meat and processed meat).

With regard to URM consumption, 27.3% had previously reduced consumption for health; for PM, the same was true of 38.2% of participants, whereas 38.5% reported to have reduced their intake of meat in general for other non-health-related reasons. Among the eight different non-health-related reasons participants could choose from, animal welfare and environmental concerns were the most frequently reported.

Unprocessed red meat was defined as mammalian meat (e.g., beef, pork, lamb), and processed meat was defined as white or red meat that was preserved by smoking, curing, salting, or by the addition of preservatives (e.g., hot dogs, charcuterie, sausage, ham, and cold cut deli meats). One serving corresponded to 120 g for unprocessed red meat and 50 g for processed meat.

4.2.1.1.3 Willingness to Change Meat Consumption (Questions 1, 2 and 3)

The majority of participants were unwilling to introduce any changes to their URM and PM consumption in the face of the associated reductions in overall cancer-incidence and cancer-mortality risks. Most respondents were unwilling to stop their intake (URM: 78.6%; PM: 77.9%); of those unwilling to stop, most were also unwilling to reduce (URM: 81.1%; PM: 91.5%) their intake when presented with the cancer-incidence scenario; likewise, most participants were unwilling to stop (URM: 75.4%; PM: 76.4%), and of those unwilling to stop, to reduce (URM: 85.7%; PM: 80%) when presented with the mortality scenario. Similarly, none of the participants were willing to increase their URM and/or PM intake.

4.2.1.1.4 Willingness to Change Meat Consumption with Higher Certainty (Questions a)

The availability of higher-certainty evidence affected the participants' willingness to change their consumption in a minority of respondents who were unwilling to stop or reduce in response to the initial evidence presentation: 26.6% participants were willing to stop and 6.7% were willing to reduce their URM intake when they were presented with the cancer-incidence scenario. Similarly, with the cancer-mortality scenario, 19.0% were willing to sop and 6.9% were willing to reduce their intake. For PM, 35.8% of participants were willing to stop and 10.3% to reduce their intake when presented with the cancer incidence scenario; similarly, for the cancer-mortality scenario, 29.2% were willing to stop and 13.6% to reduce.

4.2.1.1.5 Willingness to Change Meat Consumption with a Larger Risk Reduction (Questions b)

The availability of a hypothetically larger reduction in cancer risk affected the willingness to change the meat consumption of some participants who were unwilling to stop or reduce in response to higher-certainty evidence: 37.0% participants reported to be willing to stop and 56.0% to reduce their URM intake when presented with the cancer-incidence scenario. Similarly, with the cancer-mortality scenario, 42.0% participants reported to be willing to stop and 54.0% to reduce their URM intake. For PM, 38.0% of participants were willing to stop and 50.0% to reduce their PM intake when presented with the cancer incidence scenario, whereas in the cancer-mortality scenario, 55.0% of participants reported to be willing to stop and 53.0% to reduce their PM intake.

4.2.1.1.6 Predictors of Willingness to Change Meat Consumption

In the logistic regression analysis, gender appeared to be the only significant predictor of willingness to stop PM consumption in the cancer-incidence scenario (OR: 0.40; 95% CI: 0.15–0.93) and URM consumption in the cancer-mortality scenario (OR: 0.34; 95% CI: 0.11–0.88), with men being less willing to stop compared to women. Men also appeared to be less willing to stop eating PM (OR: 0.43; 95% CI: 0.18–0.96) and URM (OR: 0.27; 95% CI: 0.08–0.74) if the certainty was higher when presented with the cancer-incidence and cancer-mortality scenarios, respectively. Age, level of education, occupational status and religious belief did not appear to be significant predictors for any other dependent variables of willingness.

4.2.1.2 Semi-Structured Interviews

4.2.1.2.1 Participants' Characteristics

Of the 304 participants, seven agreed to participate in the semi-structured interviews; there were four men and three women, with a mean age of 38.6 years (SD = 5.0). All participants (100%) reported having a university degree, being employed, and six (86%) reported not having any comorbidity. **Annex 4B** presents the participants' sociodemographic and medical history.

4.2.1.2.2 Participants' Meat Consumption Behaviour

Participants' meat consumption varied. Three participants consumed between 3 and 4 servings of PM per week, one participant consumed between 11 and 12 servings per week and three participants declared

consuming less than one serving per week. Regarding URM, three participants declared to consume less than one serving per week, two declared consuming between 1 and 2 servings per week and two consumed between 3 and 4 servings per week. When asked if they had reduced their meat consumption in the past for health reasons and/or for other reasons, three participants declared having reduced both their URM and PM intake in the past due to health reasons, two participants reported having reduced their intake for animal welfare and environmental concerns and one participant reported cost as the main reason for having reduced his consumption. From the survey, none of the participants reported to be willing to stop or reduce their meat intake in the future.

4.2.1.2.3 Meat Consumption Preferences

We have identified three main themes reflecting the participants' preferences: 1) Social and/or family context of meat consumption, 2) Health- and non-health-related concerns about meat, and 3) Uncertainty of the evidence. Here we present some quotations from research participants.

Social and/or Family Context Meat Consumption

Two participants did not consider themselves regular meat eaters and reported eating meat mainly in social contexts, one participant reported consuming meat for its nutritional properties and mainly in social contexts and, another participant reported consuming meat mainly for the health and nutritional needs of her family.

Health- and Non-Health-Related Concerns about Meat

Two participants reported health as the main reason for having reduced their meat intake in the past, whereas other two participants highlighted other aspects that should be of concern when consuming meat. Animal welfare and/or environmental concerns were stated as important aspects to be considered when consuming meat.

Uncertainty of the Evidence

Three participants reported that the certainty of the evidence was not sufficiently convincing to cause changes in their meat consumption.

4.2.1.3 Integrated Data

The data from the quantitative (online survey) and qualitative (semi structured interviews) analyses are integrated and presented in a joint display (**Annex 4C**), which allows a deeper understanding of the participants' values and preferences around meat consumption. The quotes from the transcripts that most clearly represent the participants' views have been included in the right column.

4.2.1.4 Follow-Up Assessment at 3 Months

The same seven participants who participated in the semi-structured interviews completed the follow-up assessment, with the addition of one-woman participant; four men and four women with a mean age of 39.3 years (SD = 5.0) participated. Five participants (63%, three men and two women) reported not having made any changes in their URM and PM consumption, two participants (25%, one man and one woman) reported having increased their meat intake—one participant for URM and the other for PM—and finally, one woman participant (12%) reported having reduced the intake of PM.

4.2.2. Study 2 publication

Valli C, Santero M, Prokop-Dorner A, Howatt V, Johnston BC, Zajac J, Han M-A, Pereira A, Kenji Nampo F, Guyatt GH, Bala MM, Alonso-Coello P, Rabassa M. **Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study**. *International Journal of Environmental Research and Public Health*. 2021; 18(21):11585.

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Article

Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study

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Abstract: Background. In addition to social and environmental determinants, people's values and preferences determine daily food choices. This study evaluated adults' values and preferences regarding unprocessed red meat (URM) and processed meat (PM) and their willingness to change their consumption in the face of possible undesirable health consequences. Methods. A cross-sectional mixed-methods study including a quantitative assessment through an online survey, a qualitative inquiry through semi-structured interviews, and a follow-up assessment through a telephone survey. We performed descriptive statistics, logistic regressions, and thematic analysis. Results. Of 304 participants, over 75% were unwilling to stop their consumption of either URM or PM, and of those unwilling to stop, over 80% were also unwilling to reduce. Men were less likely to stop meat intake than women (odds ratios < 0.4). From the semi-structured interviews, we identified three main themes: the social and/or family context of meat consumption, health- and non-health-related concerns about meat, and uncertainty of the evidence. At three months, 63% of participants reported no changes in meat intake. Conclusions. When informed about the cancer incidence and mortality risks of meat consumption, most respondents would not reduce their intake. Public health and clinical nutrition guidelines should ensure that their recommendations are consistent with population values and preferences.

Keywords: health; values and preferences; red meat; processed meat; cross-sectional study; mixed methods; explanatory sequential; survey

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1. Introduction

Many believe that people's dietary choices have important consequences for their health. All individuals face the daily choice regarding what to eat, and in what quantity [1]. People's food choices, in addition to social and environmental determinants, may depend on their beliefs regarding health effects, their beliefs about the environmental effects of their diet, the pleasure they take in eating, their social and cultural milieu and the relative importance they place on these issues.

When developing guidance for public dietary behaviour, respect for individual autonomy requires understanding the health-outcome-related values and preferences that are linked to diet among members of the public. Most dietary guidelines have, however, not only failed to conduct systematic reviews (SRs) of people's values and preferences, but have also neglected this issue when making their recommendations [2,3].

With regard to meat, given the association between unprocessed red meat (URM) and processed meat (PM) consumption and adverse health outcomes (cancer and cardiovascular events) [4], dietary guidelines have generally recommended limiting meat intake [5–7]. In developing a guideline regarding meat consumption, our group undertook a SR that addressed relevant health-related values and preferences. We found that reasons for meat consumption varied and that people's willingness to change their meat consumption is generally low [8], but because researchers had never undertaken the most relevant studies to inform the question, the evidence was only low quality.

We therefore developed and conducted a cross-sectional explanatory sequential mixed-methods study in order to evaluate adults' values and preferences regarding URM and PM intake and their willingness to change their intake in the face of possible undesirable health consequences based on the dose–response meta-analysis SR of meat and cancer risk [9]. Unprocessed red meat was defined as mammalian meat (e.g., beef, pork, lamb), and processed meat was defined as white or red meat that was preserved by smoking, curing, salting, or by the addition of preservatives (e.g., hot dogs, charcuterie, sausage, ham, and cold cut deli meats). One serving corresponded to 120 g for unprocessed red meat, and 50 g for processed meat [10].

2. Methods

2.1. Study Design and Setting

This cross-sectional explanatory sequential mixed-methods study included a quantitative assessment through an online survey, a qualitative inquiry through semi-structured interviews, and a follow-up assessment through a telephone survey. Our team conducted the study in Spain between November 2020 and March 2021, based on a previously published study protocol where further details on the methods are provided [11]. The report follows STROBE guidelines [12].

This work constitutes one part of NutriRECS (Nutritional Recommendations; www.nutrirecs.com, accessed on 26 November 2020), an initiative that aims, by following a rigorous and transparent approach based on the methods promoted by the National Academy of Medicine, Guideline International Network and GRADE, and that includes the incorporation of values and preferences of the public [13], in order to develop trustworthy nutritional recommendations.

2.2. Study Population

People learned about this study thorough the Cochrane website and Twitter, where we published all of the information related to the study, eligibility criteria, contact information of the researcher carrying out the study, and the related link to access the online survey. People who were interested in participating completed the online consent form and accessed the survey. Respondents included adults between 18 and 80 years of age who currently consume URM and/or PM. We excluded adults who had active cancer and those who had suffered a major cardiovascular event such as: stroke, angina, myocardial infarction, heart

failure, symptomatic peripheral arterial disease, as well as pregnant women and those unwilling or unable to provide informed consent.

2.3. Questionnaire and Study Procedures

The questionnaire was first developed and reviewed by experts on the topic in order to ensure the validity of the included items in the questionnaire; secondly, we pilot-tested it in English in a convenience sample of participants [14]. On the basis of the pilot study, our team modified the questionnaire, performed a translation into Spanish—one researcher translated the survey that was reviewed and a second researcher confirmed it—and finally, we developed an online version that we tested on 34 Spanish participants to establish clarity and understanding. Based on the findings of the pre-testing, we refined the survey to improve face and content validity. See Supplementary Materials for the Spanish version of the online survey.

The questionnaire addressed the participants' demographic characteristics, their medical history and meat consumption beliefs and behaviours, and it also included a direct-choice exercise. This exercise presented scenarios that were tailored to each individual's weekly meat consumption and included, based on a prior SR and dose–response meta-analysis, the best estimates of the risk reduction of overall lifetime cancer incidences and cancer mortality that is associated with a decrease in URM and/or PM consumption [9]. In order to keep the presentation understandable and assimilable, we decided to focus only on cancer and thus, we omitted the possible cardiovascular effects. The scenarios also presented the corresponding certainty of the evidence for the potential risk reductions. The questionnaire was tailored to participants' individual meat consumption (i.e., after they had stated their mean consumption, subsequent questions referred to those prior responses) and participants' willingness to change their meat intake (those unwilling to change responded to additional questions regarding whether higher quality evidence or a larger effect would change their willingness).

Participants first considered the cancer-incidence scenario and expressed their willingness to "stop" their URM and PM intake using a 7-point Likert-scale with 1 (meaning definitely unwilling) and 7 (meaning definitely willing) (Question 1). If participants were unwilling to stop ($\leq$4 of the Likert-scale), they were asked, using a 7-point Likert-scale question (Question a), if they would stop their intake if the certainty of the evidence was higher. If they were still unwilling to stop ($\leq$4 of the Likert-scale), we asked them, using a multiple-choice question (Question b), if they were willing to stop if the evidence showed a larger risk reduction. If, after the above questions, participants were still unwilling to stop, we presented them with an additional 7-point Likert-scale question about their willingness to "reduce" their intake (Question 2). Similar to what was reported above, participants unwilling to reduce their intake ($\leq$4 of the Likert-scale), were presented with the questions about the certainty of the evidence (Question a) and, if still unwilling, the magnitude of the risk (Question b). If participants were also unwilling to reduce their intake ($\leq$4 of the Likert-scale), they were finally presented with a question about whether they were instead willing to increase their meat consumption using a 7-point Likert-scale question (Question 3). This logic of questions was applied for both types of meat and for both the cancer-incidence and cancer-mortality scenarios (Figure 1).

Two additional questions invited respondents to participate in a semi-structured interview and a follow-up assessment at 3 months. If the respondents had agreed to participate in the semi-structured interviews, then we arranged a meeting (through a secured Skype/Zoom call or by telephone) in which we reviewed and discussed their answers from the online survey and asked additional questions addressing their motives to change or continue with their current URM and/or PM consumption. At 3 months after the online survey, we conducted follow-up interviews via email and/or phone and asked the participants who had agreed to be contacted if they had made any changes in their meat consumption.

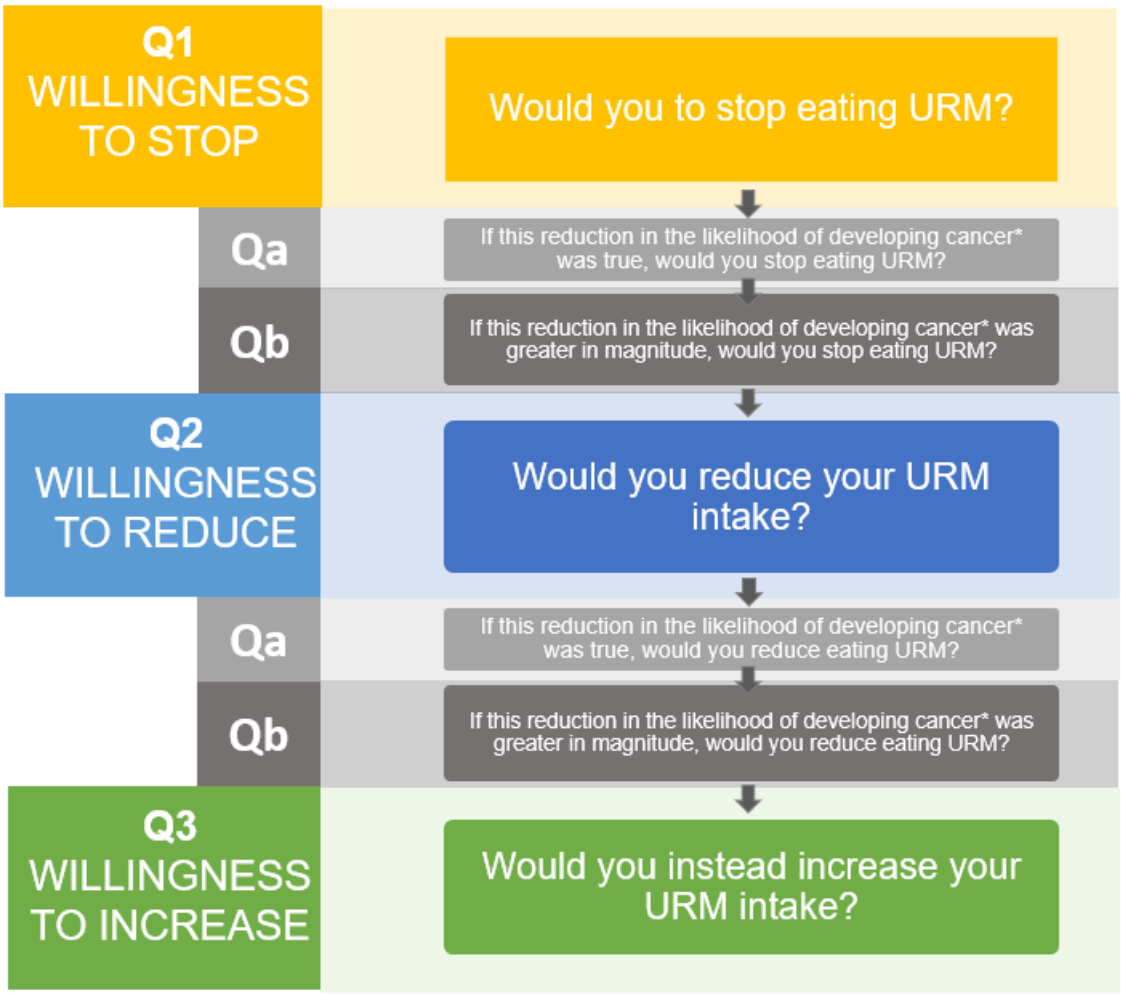

Figure 1. Questions framework for the direct-choice cancer-incidence exercise for unprocessed red meat. Abbreviations: URM ≡ unprocessed red meat; Q1 = Question 1; Q2 = question2; Q3 = Question3; Qa = Question a; Qb = Question b. Q1–Q2–Q3: Willingness to stop, reduce and increase meat intake was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes). Qa: Willingness to stop and reduce meat intake with higher certainty was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes). Qb: Willingness to stop and reduce processed meat consumption with a larger risk reduction was formulated as a multiple choice question. This logic of questions was applied for both types of meat and for both cancer-incidence and cancer-mortality scenarios. * For the mortality scenarios "developing cancer" was changed into "dying from cancer".

2.4. Data Synthesis and Analysis

2.4.1. Quantitative Analysis

All statistical analyses were performed using RStudio (version 1.2.5033) [15]. Data were checked for normal distribution using the Kolmogorov–Smirnov test. An independent samples t-test (normal distribution) or Mann–Whitney U test (non-normal distribution) was used to assess the differences between the two groups. For categorical variables, differences between groups were analyzed by the chi-square test. Missing values were excluded from the analysis.

We described the participants' demographic and medical history information as well as their meat consumption behaviours using mean ± standard deviation or as median and inter-quartile-range (IQR) and number (percentage). Because the data were not normally distributed, we presented the participants' willingness to stop, reduce and increase meat consumption in the face of undesirable cancer as medians and IQRs.

We performed a separate logistic regression analysis for each dependent variable in order to explore the determinants of the participants' willingness to change meat consumption in the direct-choice scenarios. The dependent variables were the choice (unwilling versus willing) to stop and reduce eating URM and/or PM in the face of cancer-incidence risks as well as cancer-mortality risks. The team identified the independent variables of sex, age, level of education, occupational status and religious belief a priori as known potential confounders and they were included in each statistical model. Linear regression was not performed as planned in the protocol because the assumption of linearity was violated.

We calculated the number and percentage of participants who had made any changes in their meat consumption at the follow-up after three months.

2.4.2. Qualitative Analysis

After collecting the data and transcribing the semi-structured interviews, we conducted an iterative, thematic analysis, using constant comparison within and across the transcripts of the study's participants by following a six-step approach (i.e., familiarisation with the data, generating initial codes, searching for themes, reviewing the themes, defining and naming the themes and producing the final report) [16].

2.4.3. Integrating Qualitative and Quantitative Analyses

We conducted a sequential analysis of the quantitative and qualitative components of the data. We analysed each dataset separately and then, at the end of the study, listed the findings from each component of our study and drew meta-inferences. Findings of interest from both data sets were compared and contrasted for convergence (whether findings from each data set agree), complementarity (whether findings offer complementary information on the same issue), dissonance (appear to contradict each other) and "silence" (a particular finding could only be explored in one data set) [17]. The integrated data were presented using a joint display [18], which presents each theme from the qualitative analyses according to the proportion that was obtained from the relevant online survey questions.

3. Results

3.1. Online Survey

3.1.1. Participants' Characteristics

Of the 304 individuals who participated in our study, typical respondents were women around 40 years old with a university degree (85%), employed (81%), and having at least one comorbidity (74%) (Table 1).

Table 1. Participants' sociodemographic and medical history.

	Overall (*n* = 304)
Sex, *n* (%)	
Women	189 (62.0)
Men	115 (38.0)
Age, years	
Mean (SD)	39.8 (10.7)
Median (Q1, Q3)	38.0 (32.0, 46.0)
Education level, *n* (%)	
Primary education	3 (1.0)
Secondary education	14 (4.6)
Professional education	24 (7.9)
University education	259 (85.2)
No studies	1 (0.3)
Employment status, *n* (%)	
Employed	247 (81.2)
Unemployed	34 (11.2)

Table 1. *Cont.*

	Overall (*n* = 304)
Student	20 (6.6)
Marital status, *n* (%)	
Married	94 (30.9)
Common-law couple	5 (1.6)
Living with my partner or family	87 (28.6)
Separated	2 (0.7)
Divorced	12 (3.9)
Widow/widower	1 (0.3)
Single	100 (32.9)
Children, *n* (%)	
One child	42 (13.8)
Two children	62 (20.4)
Three or more children	14 (4.6)
None	183 (60.2)
Religion, *n* (%)	
Catholicism	62 (20.4)
Other	9 (3.0)
None	230 (75.7)
Physical activity intensity ¥, *n* (%)	
Low	82 (27.0)
Moderate	139 (45.7)
High	80 (26.3)
Weight, kg	
Mean (SD)	69.9 (14.5)
Median(Q1, Q3)	68.0(59.8, 79.0)
Height, m	
Mean (SD)	1.70 (0.1)
Median (Q1, Q3)	1.70 (1.6, 1.8)
BMI	
Mean (SD)	24.3 (4.1)
Median (Q1, Q3)	23.6 (21.5, 26.2)
Comorbidities, *n* (%)	
Hormonal system disorders	14 (4.6)
Digestive diseases	12 (3.9)
Musculoskeletal disorders	8 (2.6)
Other	41 (13.5)
None	226 (74.3)
Family history of cancer, *n* (%)	
Yes	198 (65.1)
No	73 (24.0)
I don't know	30 (9.9)

Abbreviations: SD = standard deviation; Q1 = Quartile 1; Q3 = Quartile 3, kg = kilograms; m = meters; BMI = body mass index. ¥ Physical activity (PA) intensity was categorized as follows: participants who reported doing PA every day were categorized in the "high" category; who reported doing PA at least once a week was categorized in the "moderate" one and the rest of participants were categorized in the "low" category.

3.1.2. Participants' Meat Consumption Behaviour

Many participants reported consuming less than three servings of meat per week (76% of URM and 57% of PM), 24% of participants consumed three or more servings of URM and 43% of PM. Figure 2 presents the meat-consumption frequency behaviour. The type of URM most frequently consumed was beef or veal (76.0%) and, for PM, Serrano ham or shoulder ham (71.4%) (See Supplementary Materials: Figures S1 and S2). The three main reasons for meat consumption among the participants included flavour, cost and availability, and were similar for URM and PM (See Supplementary Materials: Table S1).

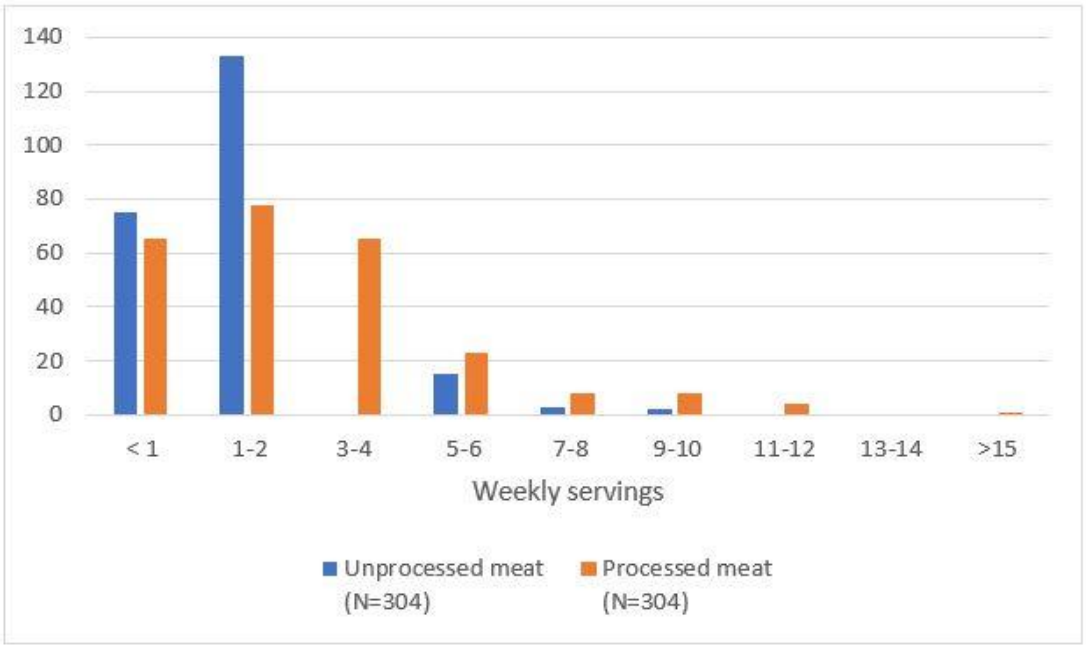

Figure 2. Meat consumption frequency behavior.

With regard to URM consumption, 27.3% had previously reduced consumption for health; for PM, the same was true of 38.2% of participants, whereas 38.5% reported to have reduced their intake of meat in general for other non-health-related reasons. Among the eight different non-health-related reasons participants could choose from, animal welfare and environmental concerns were the most frequently reported (Table 2).

Table 2. Participants' meat reduction in the past.

Past reduction due to health reasons	
Unprocessed red meat	
N	283
No, *n* (%)	200 (65.8)
Yes, *n* (%)	83 (27.3)
Processed meat	
N	283
No, *n* (%)	167 (54.9)
Yes, *n* (%)	116 (38.2)
Past reduction due to other reasons	
Meat in general	
N	282
No, *n* (%)	165 (54.3)
Yes, *n* (%)	117 (38.5)
Other reasons, *n* (%)	
Animal welfare	62 (20.4)
Environmental concerns	67 (22.0)
Family preferences	15 (4.9)
Social context	7 (2.3)
Availability/accessibility	5 (1.6)
Flavour	21 (6.9)
Cost	14 (4.6)
Other	31 (10.2)

Unprocessed red meat was defined as mammalian meat (e.g., beef, pork, lamb), and processed meat was defined as white or red meat that was preserved by smoking, curing, salting, or by the addition of preservatives (e.g., hot dogs, charcuterie, sausage, ham, and cold cut deli meats). One serving corresponded to 120 g for unprocessed red meat and 50 g for processed meat.

3.1.3. Willingness to Change Meat Consumption (Questions 1, 2 and 3)

The majority of participants were unwilling to introduce any changes to their URM and PM consumption in the face of the associated reductions in overall cancer-incidence and cancer-mortality risks. Most respondents were unwilling to stop their intake (URM: 78.6%; PM: 77.9%); of those unwilling to stop, most were also unwilling to reduce (URM: 81.1%; PM: 91.5%) their intake when presented with the cancer-incidence scenario; likewise, most participants were unwilling to stop (URM: 75.4%; PM: 76.4%), and of those unwilling to stop, to reduce (URM: 85.7%; PM: 80%) when presented with the mortality scenario. Similarly, none of the participants were willing to increase their URM and/or PM intake. Table 3 presents the participants' willingness to stop, and if unwilling to stop, to reduce, and if unwilling to reduce, to increase URM and PM consumption in the face of cancer-incidence and cancer-mortality risks.

Table 3. Willingness to change meat consumption in the face of cancer-incidence and cancer-mortality risks.

	URM	**PM**
Willingness to stop—Question 1		
Cancer Incidence		
N	126	163
Willing, *n* (%)	27 (21.4)	36 (22.1)
Unwilling, *n* (%)	99 (78.6)	127 (77.9)
Median	3.0	3.0
Q1, Q3	(1.0, 4.0)	(2.0, 4.0)
Cancer Mortality		
N	118	157
Willing, *n* (%)	29 (24.6)	37 (23.6)
Unwilling, *n* (%)	89 (75.4)	120 (76.4)
Median	3.0	3.0
Q1, Q3	(1.0, 4.0)	(2.0, 4.0)
Willingness to stop with higher certainty—Question a		
Cancer Incidence		
N	94	120
Willing, *n* (%)	25 (26.6)	43 (35.8)
Unwilling, *n* (%)	69 (73.4)	77 (64.2)
Median	3.0	3.0
Q1, Q3	(2.0, 5.0)	(2.0, 5.0)
Cancer Mortality		
N	84	106
Willing, *n* (%)	16 (19.0)	31 (29.2)
Unwilling, *n* (%)	68 (81.0)	75 (70.8)
Median	3.0	3.0
Q1, Q3	(1.0, 4.0)	(2.0, 5.0)

Table 3. *Cont.*

	URM	PM
Willingness to stop with a larger risk reduction—Question b		
Cancer Incidence		
N	68	50
Unwilling, *n* (%)	21 (31.0)	17 (34.0)
Willing, *n* (%)	25 (37.0)	19 (38.0)
Neither unwilling nor willing, *n* (%)	22 (32.0)	14 (28.0)
Cancer Mortality		
N	67	74
Unwilling, n (%)	21 (31.0)	17 (23.0)
Willing, n (%)	28 (42.0)	41 (55.0)
Neither unwilling nor willing, n (%)	18 (27.0)	16 (22.0)
Willingness to reduce—Question 2		
Cancer Incidence		
N	37	47
Willing, *n* (%)	7 (18.9)	4 (8.5)
Unwilling, *n* (%)	30 (81.1)	43 (91.5)
Median	3.0	2.0
Q1, Q3	(1.0, 4.0)	(1.0, 3.0)
Cancer Mortality		
N	35	30
Willing, *n* (%)	5 (14.3)	6 (20.0)
Unwilling, *n* (%)	30 (85.7)	24 (80.0)
Median	3.0	3.0
Q1, Q3	(1.0, 4.0)	(2.0,4.0)
Willingness to reduce with higher certainty—Question a		
Cancer Incidence		
N	30	39
Willing, *n* (%)	2 (6.7)	4 (10.3)
Unwilling, *n* (%)	28 (93.3)	35 (89.7)
Median	3.0	3.0
Q1, Q3	(1.0, 4.0)	(2.0, 4.0)
Cancer Mortality		
N	29	22
Willing, n (%)	2 (6.9)	3 (13.6)
Unwilling, n (%)	27 (93.1)	19 (86.4)
Median	2.0	3.0
Q1, Q3	(1.0, 4.0)	(1.3,4.0)
Willingness to reduce with a larger risk reduction—Question b		
Cancer Incidence		
N	27	20
Unwilling, *n* (%)	12 (44.0)	10 (50.0)
Willing, *n* (%)	15 (56.0)	10 (50.0)
Neither unwilling nor willing, *n* (%)	0 (0)	0 (0)
Cancer Mortality		
N	26	20
Unwilling, *n* (%)	12 (46.0)	10 (50.0)
Willing, *n* (%)	14 (54.0)	10 (50.0)
Neither unwilling nor willing, *n* (%)	0 (0)	0 (0)

Table 3. *Cont.*

	URM	PM
Willingness to increase—Question 3		
Cancer Incidence		
N	22	25
Willing, *n* (%)	0	0 (0.0)
Unwilling, *n* (%)	22 (100.0)	25 (100.0)
Median	1.0	1.0
Q1, Q3	(1.0, 2.0)	(1.0, 2.0)
Cancer Mortality		
N	13	13
Willing, *n* (%)	0 (0.0)	0 (0.0)
Unwilling, *n* (%)	13 (100.0)	13 (100.0)
Median	1.0	1.0
Q1, Q3	(1.0, 1.0)	(1.0, 4.0)

Abbreviations: URM = unprocessed red meat, PM = processed meat, Q1 = Quartile 1; Q3 = Quartile 3. Question 1,2,3: Willingness to stop and reduce meat intake was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes). Question a: Willingness to stop and reduce meat intake with higher certainty was based on a 7-point Likert-scale with 1 (meaning definitely not) and 7 (meaning definitely yes). Question b: Willingness to stop and reduce unprocessed red meat consumption with a larger risk reduction was formulated as a multiple-choice question. Unwilling =≤4 of the Likert-scale, Willing =≥ 5 of the Likert-scale. The sample size (N) varied across the Willingness and cancer scenarios and type of meat because the questionnaire was tailored according to the participants' responses.

3.1.4. Willingness to Change Meat Consumption with Higher Certainty (Questions a)

The availability of higher-certainty evidence affected the participants' willingness to change their consumption in a minority of respondents who were unwilling to stop or reduce in response to the initial evidence presentation: 26.6% participants were willing to stop and 6.7% were willing to reduce their URM intake when they were presented with the cancer-incidence scenario. Similarly, with the cancer-mortality scenario, 19.0% were willing to sop and 6.9% were willing to reduce their intake. For PM, 35.8% of participants were willing to stop and 10.3% to reduce their intake when presented with the cancer-incidence scenario; similarly, for the cancer-mortality scenario, 29.2% were willing to stop and 13.6% to reduce. Table 3 presents the participants' willingness to stop and reduce URM and PC consumption in the face of cancer-incidence and cancer-mortality risks with higher certainty.

3.1.5. Willingness to Change Meat Consumption with a Larger Risk Reduction (Questions b)

The availability of a hypothetically larger reduction in cancer risk affected the willingness to change the meat consumption of some participants who were unwilling to stop or reduce in response to higher-certainty evidence: 37.0% participants reported to be willing to stop and 56.0% to reduce their URM intake when presented with the cancer-incidence scenario. Similarly, with the cancer-mortality scenario, 42.0% participants reported to be willing to stop and 54.0% to reduce their URM intake. For PM, 38.0% of participants were willing to stop and 50.0% to reduce their PM intake when presented with the cancer-incidence scenario, whereas in the cancer-mortality scenario, 55.0% of participants reported to be willing to stop and 53.0% to reduce their PM intake. Table 3 presents the participants' willingness to stop and reduce URM and PC consumption in the face of cancer-incidence and cancer-mortality risks with a larger risk reduction.

3.1.6. Predictors of Willingness to Change Meat Consumption

In the logistic regression analysis, gender appeared to be the only significant predictor of willingness to stop PM consumption in the cancer-incidence scenario (OR: 0.40; 95% CI: 0.15–0.93) and URM consumption in the cancer-mortality scenario (OR: 0.34; 95% CI:

0.11–0.88), with men being less willing to stop compared to women. Men also appeared to be less willing to stop eating PM (OR: 0.43; 95% CI: 0.18–0.96) and URM (OR: 0.27; 95% CI: 0.08–0.74) if the certainty was higher when presented with the cancer-incidence and cancer-mortality scenarios, respectively. Age, level of education, occupational status and religious belief did not appear to be significant predictors for any other dependent variables of willingness.

3.2. Semi-Structured Interviews

3.2.1. Participants' Characteristics

Of the 304 participants, seven agreed to participate in the semi-structured interviews; there were four men and three women, with a mean age of 38.6 years (SD = 5.0). All participants (100%) reported having a university degree, being employed, and six (86%) reported not having any comorbidity. Table S2 (See Supplementary Materials) presents the participants' sociodemographic and medical history.

3.2.2. Participants' Meat Consumption Behaviour

Participants' meat consumption varied. Three participants consumed between 3 and 4 servings of PM per week, one participant consumed between 11 and 12 servings per week and three participants declared consuming less than one serving per week. Regarding URM, three participants declared to consume less than one serving per week, two declared consuming between 1 and 2 servings per week and two consumed between 3 and 4 servings per week (See Supplementary Materials: Figure S3).

When asked if they had reduced their meat consumption in the past for health reasons and/or for other reasons, three participants declared having reduced both their URM and PM intake in the past due to health reasons, two participants reported having reduced their intake for animal welfare and environmental concerns and one participant reported cost as the main reason for having reduced his consumption. From the survey, none of the participants reported to be willing to stop or reduce their meat intake in the future.

3.2.3. Meat Consumption Preferences

We have identified three main themes reflecting the participants' preferences: (1) Social and/or family context of meat consumption, (2) Health- and non-health-related concerns about meat, and (3) Uncertainty of the evidence. Here we present some quotations from research participants.

Social and/or Family Context Meat Consumption

Two participants did not consider themselves regular meat eaters and reported eating meat mainly in social contexts.

"I'm not vegetarian and not vegan either, but if it was for me, I wouldn't choose meat as part of my daily meals. But once in a while if I go out with friends, I do eat it. I haven't eaten meat on a regular basis for a year now" (Female participant, 33 years old)

"I have not eaten meat on a regular basis for many years now. I consume meat especially for social occasions" (Male participant, 41 years old)

One participant reported consuming meat for its nutritional properties and mainly in social contexts.

"I have not completely stopped eating meat, as I consider it necessary to have certain nutritional values such as iron or vitamin B12. In addition, due to my origin one of my favourite foods is Iberian ham. On the other hand, the meat that I usually consume is of high quality and does not usually come from large farms. Even, for tradition, I consume game meat when I return to the family home" (Male participant, 32 years old)

One participant reported consuming meat mainly for the health and nutritional needs of her family.

"If it was for me, I would follow a more vegetarian diet, but I have to adapt to the needs of my children and family" (Female participant, 39 years old)

Health- and Non-Health-Related Concerns about Meat

Two participants reported health as the main reason for having reduced their meat intake in the past.

"In 2015 when I became a mother, I started to look for information about nutrition and get more information about what was healthy to take care of me and my son, that is when I decided to reduce my meat consumption" (Female participant, 39 years old)

"I had this idea that meat was high in fat and more expensive. So, I started to reduce my meat consumption, especially red meat, and in the end, I was eating mostly chicken. Gradually, I started to remove all types of meat from my daily meals" (Female participant, 33 years old)

Two participants highlighted other aspects that should be of concern when consuming meat. Animal welfare and/or environmental concerns were stated as important aspects to be considered when consuming meat.

"In recent years, there has been a lot of investigative journalism about the situation of large-scale animal farms and the deplorable conditions in which they are raised. In addition, livestock farming is directly related to greenhouse gas emissions and the deforestation of huge regions to grow pasture and feed for livestock. Livestock farming is one of the human activities that generates the most CO_2 emissions" (Male participant, 32 years old)

"From what I have read, too much meat can lead to diseases but on the other hand I am concerned about the sustainability aspects related to its consumption. This doesn't mean I don't eat meat, but I don't buy processed meat. I do eat beef sometimes and when I buy it, I go to the butcher so that I can choose the type of meat, the cut, and make sure of the origin" (Male participant, 41 years old)

Uncertainty of the Evidence

Three participants reported that the certainty of the evidence was not sufficiently convincing to cause changes in their meat consumption.

"I have no proof, nor enough evidence to think that I should reduce my consumption. If the evidence said that there was a real and significant reduction, I would reduce my consumption." (Male participant, 39 years old).

"I like meat, and it is for sure a barrier to reduce or quit its consumption, especially when the evidence is unclear." (Male participant, 47 years old).

"As far as I can see, the evidence is not valid enough to completely stop eating meat." (Female participant, 39 years old).

3.3. Integrated Data

In Table 4, the data from the quantitative (online survey) and qualitative (semi-structured interviews) analyses are integrated and presented in a joint display, which allows a deeper understanding of the participants' values and preferences around meat consumption. The quotes from the transcripts that most clearly represent the participants' views have been included in the right column. Table 4 will be interpreted in the discussion.

3.4. Follow-Up Assessment at 3 Months

The same seven participants who participated in the semi-structured interviews completed the follow-up assessment, with the addition of one woman participant; four men and four women with a mean age of 39.3 years (SD = 5.0) participated. Five participants (63%, three men and two women) reported not having made any changes in their URM and PM consumption, two participants (25%, one man and one woman) reported having increased their meat intake—one participant for URM and the other for PM—and finally, one woman participant (12%) reported having reduced the intake of PM.

Table 4. Joint display of integrated data from qualitative and quantitative data sets.

Qualitative Data	Quantitative Data		Representative Quotes	Interpretation
Semi-Structured Interview Themes	**Online Survey Questions**	**Online Survey Results**		
Social and/or family context meat consumption	What are the most important factors that favour your consumption of red meat and processed meat? Select all that apply *	Social context was selected as a factor favouring unprocessed red meat and processed meat consumption by 52% and 40% of participants respectively.	*"I consume meat especially social occasions"*	Participants reported that social gatherings influenced their meat consumption.
		Family preference was selected as a factor favouring unprocessed red meat and processed meat consumption by 50% and 33% of participants respectively.	*"I have to adapt to the needs of my children and family"*	Participants reported that family preference influenced their meat consumption.
		Tradition was selected as a factor favouring unprocessed red meat and processed meat consumption by 57% and 33% of participants respectively.	*"Even, for tradition, I consume game meat when I return to the family home"*	Participants reported that tradition influenced their meat consumption
Health- and non-health-related concerns about meat	What are the most important factors that favour your consumption of unprocessed red meat? Select all that apply *	Health was selected by 41% of participants as a factor favouring unprocessed red meat consumption.	*"I consider red meat necessary to have certain nutritional values such as iron or vitamin B12"*	Participants highlighted the nutritional value of unprocessed red meat as a reason for consuming it.
	In the past, have you cut back on red and / or processed meat for non-health reasons?	Environmental concerns were selected by 22% of participants.The second highest selected reason as a non-health-related reason for having reduced meat consumption in the past.	*"Livestock farming is one of the human activities that generates the most CO_2 emissions"*	Non-health-related reasons such as environmental concerns play an important role in people's meat consumption habits.
Uncertainty of the evidence	What are the most important factors that favour your consumption of unprocessed red meat and processed meat? Select all that apply *	Taste was selected as a factor favouring unprocessed red meat and processed meat consumption by 79% and 49% of participants respectevely. The most selected factor.	*"I like meat, and it is for sure a barrier to reduce or quit its consumption, especially when the evidence is unclear"*	Taste was one of the most voted factors for consuming meat, and this could explain why in the face of uncertain evidence, participants were unwilling to stop and/or reduce their intake.

* 11 factors were provided to choose from, see Table S1 in the Supplementary Materials.

4. Discussion

4.1. Main Findings

In this cross-sectional explanatory sequential mixed-methods study that included more than 300 adults in Spain, we found that, in the face of the available evidence regarding cancer-incidence and cancer-mortality risk reductions they would achieve, most people were unwilling to reduce their meat intake. Men were appreciably less willing to reduce meat consumption than were women. In the semi-structured interviews, participants reported consuming meat in social contexts and/or in response to family preferences. Health proved to be one important factor in favour of consuming meat and other aspects such as environmental concerns emerged as important considerations. Three of seven participants reported that the evidence was too uncertain for them to make changes in their current consumption. Overall, quantitative and qualitative findings were in agreement.

The included participants can be considered as infrequent meat eaters since the majority consumed between 1 and 2 servings of meat per week versus the estimated average consumption of three servings of meat per week [19]. This could explain why people who already had a low meat consumption were not willing to further decrease their meat intake. In fact, during the semi-structured interviews, some participants did not consider themselves as regular meat eaters and reported consuming meat occasionally, mainly in social contexts or because of tradition and/or family preferences. The participants' unwillingness to reduce or increase consumption suggests that participants were satisfied with their meat consumption habits and did not feel the need to make any changes; as emerged during the interviews, people felt that they were already consuming a healthy amount of meat that did not need to be changed.

4.2. Our Results in the Context of Previous Research

Our results are similar to the findings from a previous mixed-methods systematic review that was conducted by our team [8]. In this review, we showed that most omnivores were unwilling to change their meat intake. More recent studies also show a low willingness to change meat consumption [14,20,21]. Both our review and further studies also showed that men were more attached to meat consumption, and less willing to change their intake. In addition, although our results showed that participants were unwilling to reduce their meat in the face of cancer risks, many had reduced their intake in the past for other aspects, such as environmental concerns and animal welfare reasons. These aspects, which emerged during the interviews, are similar to the conclusions of a recent systematic review that found that environmental motives were already appealing to significant proportions of Western meat-eaters, who were adopting certain meat-curtailment strategies such as meat-free days [22].

4.3. Strengths and Limitations

Our study has several strengths. It is the first study, to our knowledge, that has comprehensively and explicitly evaluated people's health-related values and preferences, and their willingness to change meat consumption when informed of the potential adverse cancer risk and the uncertainty around this evidence. The information that patients received was based on a recent rigorous dose–response meta-analysis [9]. We developed and published a protocol reporting this study's methodology [13]. We followed an explanatory mixed-methods approach to the collection of both quantitative and qualitative evidence that enhanced the interpretability of our results. We used health states to ensure a similar understanding among participants of the presented outcomes.

Our study also has some limitations. Most of the included participants had a university degree and consumed less than three servings per week, which was the average meat intake in Spain [19]; therefore, our results might not be representative for the rest of the Spanish population. Although we provided information about the associated reductions in cancer risk in different formats, we did not check for understanding. We also only presented data on cancer risk and did not present other health risks, such as cardiovascular

effects, in order not to overburden the participants. In addition, while the semi-structured interviews and follow-up assessment findings were collected from a small proportion and convenience sample of participants (only 7 and 8 participants agreed to participate, respectively); however, their sociodemographic characteristics and their meat consumption behaviours were very similar to the rest of study's participants. The response rate for the survey questions on willingness varied. The less willing they were to change meat consumption, the more questions a participant had to answer (see study procedures).

4.4. Implications for Practice and Research

This study will be informative in the development of both public health and clinical nutritional recommendations regarding meat consumption. For example, given that people are unlikely to modify their meat consumption on the basis of small and uncertain health benefits, panels would be more likely to make conditional rather than strong recommendations for the reduction of meat consumption for healthcare reasons. Our study provides guidance on the methods and procedures of how to conduct an exploratory sequential mixed-methods observational study that aims to identify people's health-related values and preferences. Future research is needed to replicate this study in other populations with higher meat intake and in other settings and cultures. The design we used could be applicable to other foods and/or nutrients, settings and/or nutritional contexts.

5. Conclusions

When informed about the cancer incidence and mortality risks of meat consumption, most respondents would not reduce their intake. Organizations developing public health and clinical nutrition guidelines should ensure their recommendations are consistent with population values and preferences.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijerph182111585/s1, Figure S1: Types of unprocessed read meat consumed (N = 304); Figure S2: Types of processed read meats consumed (N = 304); Figure S3: Meat consumptionfrequency behaviour in the semi-structured interviews; Table S1: Reasons for meat consumption for unprocessed red meat and processed meat; Table S2: Characteristics of semi-structured interview participants. Spanish version of the online survey available here (https://es.surveymonkey.com/r/CZF2DF9 accessed on 26 November 2020).

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: All data generated or analysed during this study are included in this published article and its Supplementary Materials.

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Abbreviations

IARC	International Agency for Research in Cancer
IQR	inter-quartile-range
SR	systematic review
URM	unprocessed red meat
PM	processed meat

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4.3. Study 3: "Peoples' values and preferences towards animals' welfare and environmental concerns of meat consumption: A mixed-methods systematic review"

4.3.1. Summary of Study 3 results

4.3.1.1 Study selection

We retrieved 23,531 articles. After title and abstract screening, 429 were potentially eligible. We excluded 359 studies. After full-text screening, we included 56 quantitative, 12 qualitative, and 2 mixed-methods studies.

4.3.1.2 Study characteristics

Of the 56 quantitative studies, 31 were conducted in Europe, 11 in the United States, 4 in the United Kingdom, 4 in multiple countries, 4 in Australia, 1 in New Zealand, and 1 study did not specify where it was conducted. Forty-five studies were conducted between 2010 and 2020, and fifteen were conducted between 2000 and 2010. The number of participants ranged between 82 and 24,340. Of the 12 qualitative studies, 4 were conducted in Europe, 3 in the United States, 2 in Australia, 2 were conducted in multiple countries, and 1 in the United Kingdom. Ten studies were conducted between 2011 and 2019, whereas two studies were conducted before 2010 (one in 2005 and the other in 2008). The number of participants ranged between 19 and 270. The two mixed-methods studies were conducted in Europe in 2018 and 2019 and included between 42 and 1532 participants.

4.3.1.3 Findings

We identified four main themes: 1) reasons for eating meat (8 quantitative studies (28,923 participants), 1 qualitative study (30 participants)); 2) reasons for avoiding meat (29 quantitative studies (64,651 participants), 7 qualitative studies (457 participants), and 1 mixed-methods study contributing quantitative evidence (1,532)); 3) willingness to change meat consumption (27 quantitative studies (54,326 participants), 7 qualitative studies (527 participants), and 2 mixed-methods studies contributing qualitative evidence (66 participants)); and 4) willingness to pay more for environmentally friendly meat (2 quantitative studies (2,702 participants)).

4.3.1.3.1 Reasons for eating and/or buying meat

4.3.1.3.1.1 Quantitative data set

Eight studies reported on reasons for eating and/or buying meat. Among these studies, three (37%) provided participants with data on the environmental impact of meat, while five (63%) did not present participants with any information.

4.3.1.3.1.2 Qualitative data set

One study reported on reasons for eating and/or buying meat and did not provide any information about the environmental impact of meat to participants.

4.3.1.3.1.3 Integrated evidence and related confidence

Findings from the quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of moderate concerns of methodological limitations/risk of bias and serious concerns of relevance. **Annex 5A** presents the integrated evidence and related confidence (Evidence profile table).

- Consumers chose meat with a lower footprint, when provided with carbon footprint information of meat production. However, other characteristics such as type of meat, fat content and price were considered more important.
- The environment (for example, carbon footprint information on the label) was not considered a significant aspect when buying/consuming meat; other aspects such as: nutritional values, freshness of the meat, food safety, eating enjoyment/taste, and animal welfare were considered more important.
- Consumers bought meat products based on tangible aspects such as colours and appearance rather than intangible characteristics such as environmental aspects of production; only some participants bought environmentally friendly meat products, the main barriers were the higher price of these products and the unwillingness to change their diet.

4.3.1.3.2 Reasons for avoiding meat

4.3.1.3.2.1 Quantitative data set

Thirty studies reported on reasons for avoiding meat. None of the studies provided participants with data on the environmental impact of meat.

4.3.1.3.2.2 Qualitative data set

Seven studies reported on reasons for avoiding meat consumption. One study (14%) provided participants with information on the environmental impact of meat production, and six studies (86%) did not.

4.3.1.3.2.2 Integrated evidence and related confidence

Findings from quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of minor concerns of methodological limitations/risk of bias, minor concerns of coherence, and serious concerns of relevance. **Annex 5B** presents the integrated evidence and related confidence (Evidence profile table).

- For vegetarians and low meat consumers/meat reducers, the reasons for adopting a vegetarian diet or limiting their meat intake varied. For many people, environmental concerns were among the most

important reasons for avoiding meat consumption, whereas for others, environmental concerns were not considered one of the main reasons for avoiding meat.

- Environmental concerns were considered a contributory factor rather than the primary driver for avoiding meat. However, environmental impact of meat production was mentioned as one reason for avoiding meat intake by some participants, along with other reasons, for example perceived health. Other reasons such as: animal welfare; health concerns; self-fulfilment and taste or aesthetics were considered among the main reasons for avoiding meat.
- Women were more likely to avoid meat or eating smaller portions of meat for environmental reasons, except for one study where men were more likely to report environmental concerns as a reason for avoiding meat.
- The younger population was more likely to agree that a vegetarian diet leads to environmental benefits.
- People's meat consumption behaviour influenced their motivations for avoiding meat intake. The stricter the diet in terms of avoiding meat consumption and animal products, the more important environmental concerns were reasons for avoiding meat. Similarly, one study reported that all vegans found the environment an important issue for meat consumption, while only a minority of omnivores mentioned it.

4.3.1.3.3 Willingness to change meat consumption

4.3.1.3.3.1 Quantitative data set

Twenty-seven studies evaluated people's willingness to change meat consumption. Three studies (12%) provided participants with data on the environmental impact of meat consumption, whereas twenty-four studies (88%) did not present participants with any information.

4.3.1.3.3.2 Qualitative data set

Eight studies evaluated people's willingness to change meat consumption when faced with environmental concerns of meat consumption. One study (12%) provided participants with data on the environmental impact of meat, and seven studies (88%) did not provide any information.

4.3.1.3.3.3 Integrated evidence and related confidence

Findings from quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of moderate concerns of methodological limitations/risk of bias and serious concerns of relevance. **Annex 5C** presents the integrated evidence and related confidence (Evidence profile table).

- Most of the omnivores were reluctant to reduce meat consumption in the future, even when informed on the environmental impact of meat consumption.

- Similarly, when provided with an information sheet about the impact of food production on climate change, most of the participants showed low awareness of the association between climate change and meat consumption, and some participants reported considering reducing their meat consumption or had already reduce their intake in the past. However, environmental concerns tended to be a contributory factor rather than the primary driver; other aspects were considered more important for the environment rather than reducing meat consumption.
- Most of omnivores were willing to adopt other strategies to reduce the climate impact rather than reducing meat intake: eating more organic food, driving less, eating local foods; using alternate transportation, recycling, using eco-friendly products, reporting the ecological impact on the food's labels. On the contrary, three studies reported that most of the participants, when presented with different sustainable food behaviours they could choose from, they were willing to reduce their meat intake in terms of quantity rather than eating plant-based meat substitutes and proteins from insects or buying specific meat such as organic meat or replace most of the meat by vegetables. Omnivores considered meat consumption to have a trivial effect on the environment and believed that other behaviours were more effective. Food packaging, food waste, transportation of food, and production and processing of food in relation to the environmental impact of food were considered more important.
- Women perceived higher environmental benefit of eating less meat than men and were more willing to reduce meat intake. Young women were most incline to change their meat consumption.
- Frequent meat consumers were less positive towards a reduction of meat, whereas those with higher concerns for environmental problems were much more likely to intend to stop eating meat. On the contrary, one study found that gender, as well as age, meat consumption behaviour (high vs. low intake) and socio-economic status had no impact on peoples' belief that eating less meat would help reducing climate change.

4.3.1.3.4 Willingness to pay more for environmentally friendly meat

4.3.1.3.4.1 Quantitative data set

Two studies evaluated people's willingness to pay more for environmentally friendly meat and meat products. None of the studies provided participants with data on the environmental impact of meat consumption.

Both studies reported that consumers were willing to pay more for meat produced with a significantly lower environmental impact. Labels indicating that the beef mince had a low or moderate fat content, was organic meat produced locally, and met animal welfare standards were also significant for consumers. Women and older people showed higher willingness to pay more for meat with minimal environmental impact. Findings were only reported from quantitative data sets and the overall confidence in the evidence was rated as

moderate because of no or minor concerns of methodological limitations (serious risk of bias), serious concerns of relevance, and minor concerns of adequacy. **Annex 5D** presents the evidence and related confidence (Evidence profile table).

4.3.2. Study 3 publication

Valli C, Maraj M, Prokop-Dorner A, Kaloteraki C, Steiner C, Rabassa M, Solà I, Zajac J, Johnston BC, Guyatt GH, Bala MM, Alonso-Coello P. **People's Values and Preferences about Meat Consumption in View of the Potential Environmental Impacts of Meat: A Mixed-Methods Systematic Review**. *International Journal of Environmental Research and Public Health*. 2023; 20(1):286.

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Review

People's Values and Preferences about Meat Consumption in View of the Potential Environmental Impacts of Meat: A Mixed-methods Systematic Review

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Abstract: Background: Health is not the only aspect people consider when choosing to consume meat; environmental concerns about the impact of meat (production and distribution) can influence people's meat choices. Methods: We conducted a mixed-methods systematic review, searched six databases from inception to June 2020, and synthesised our findings into narrative forms. We integrated the evidence from quantitative and qualitative data sets into joint displays and assessed the confidence in the evidence for each review finding following the GRADE-CERQual approach. Results: Of the 23,531 initial records, we included 70 studies: 56 quantitative, 12 qualitative, and 2 mixed-methods studies. We identified four main themes: (1) reasons for eating meat; (2) reasons for avoiding meat; (3) willingness to change meat consumption; and (4) willingness to pay more for environmentally friendly meat. The overall confidence was low for the reasons for eating and/or buying meat, for avoiding meat, and for willingness to change meat consumption, and was moderate for willingness to pay more for environmentally friendly meat. Conclusions: Regardless of people's general beliefs about meat and its impact on the environment, most people may be unwilling to change their meat consumption. Future research should address the current limitations of the research evidence to assess whether people are willing to make a change when properly informed.

Keywords: food preferences; consumer behaviour; meat consumption; environmental concerns; values and preferences; mixed methods; systematic review

1. Introduction

Besides the availability of and access to food, individuals' food choices are influenced by a wide range of factors [1], including biological, psychological, social, cultural, and historical influences [2]. These factors can be unconscious while others are more rational [2]. For example, many people consider meat a healthy food and an important source of nutrients that must be part of their diet, whereas other people avoid or limit their meat

intake because they believe that meat is harmful given its alleged association with chronic diseases such as cancer [3]. Health, however, is not the only aspect people consider when choosing to consume meat; other factors such as concern for animal welfare and the environmental impact of meat (production and distribution) can influence people's meat choices and thus its consumption [4].

If one believes that guidelines should reflect people's values and preferences (rather than prescribing what a panel thinks people should do according to the panel's values and preferences), understanding people's overall meat values and preferences becomes crucial for producing trustworthy nutritional recommendations [5,6]. However, many dietary guidelines, including meat recommendations, do not explicitly address their target population's values and preferences on meat intake [5,7,8].

Previously, as part of the NutriRECS initiative (www.nutrirecs.com (accessed on 17 March 2020)), we published a systematic review specifically addressing the health-related values and preferences regarding meat consumption [3]. The evidence informed the recommendations for unprocessed red meat and processed meat intake [9]. Cognizant of the increasing evidence suggesting that large-scale meat production facilities, by depleting the availability of fresh water and as a major source of anthropogenic greenhouse gas emissions, are a substantive driver for global warming and environmental degradation, some people have limited their meat consumption as a result of these environmental concerns [10–12]. We have therefore conducted a systematic review to evaluate how environmental concerns may influence meat consumption behaviours.

2. Methods

We conducted a systematic review according to a protocol registered in PROSPERO (CRD42018088854) [13] and adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) reporting statement [14].

2.1. Data Sources and Searches

We designed and conducted an exhaustive search in MEDLINE (via PubMed), EMBASE (via Ovid), Web of Science (Institute for Scientific Information), CAB abstracts (via CABI; Centre for Agriculture and Bioscience), AGRIS (International System for Agricultural Science and Technology), and FSTA (Food Science and Technology Abstracts) from inception to June 2020. We defined search terms related to meat consumption; consumer behaviour; and values, preferences, and attitudes and combined them with relevant terms from the controlled vocabulary from each database. We did not restrict our search by publication status or date of publication (Table S1). We also reviewed reference lists of the included articles and relevant systematic reviews.

2.2. Study Selection

We included studies exploring how environmental values and preferences can influence meat consumption in adults ($\geq$80% of the sample were 18 years or older). If studies did not report the participants' age, we assumed that >80% of the participants were $\geq$18 years old. We included studies that obtained data by qualitative (e.g., interviews, focus groups), quantitative (e.g., cross-sectional survey), or mixed methods (e.g., both interviews or focus groups and a cross-sectional survey). We included only studies published from 2000 onwards conducted in Europe, Australia, Canada, and the United States (USA) because we considered them a homogeneous set of countries reflecting similar socio-economic characteristics and values. If a study was conducted in multiple countries, including countries that did not fulfil the eligibility criteria, it was included. We excluded experimental/intervention studies and studies focusing on: meat alternatives (e.g., cultured meat, in vitro meat, functional meat products, or genetically modified meat); meat quality (meat composition, sensory quality, and/or palatability factors or origin of meat); meat safety (e.g., food handling, chemical hazards/meat contamination, or storing/preservation of meat); meat industry (e.g., market research to inform or meet consumers' demands); meat

consumption trends; and studies focusing on specific populations (e.g., cancer survivors or pregnant women).

Following a calibration exercise, teams of two reviewers independently screened the titles and abstracts of all retrieved references from the search. Subsequently, teams of two reviewers independently reviewed the full text of articles deemed potentially eligible in the title and abstract screening. In case of disagreement, reviewers reached consensus with the help of a third reviewer.

2.3. Data Extraction

We used two ad hoc data extraction forms for quantitative and qualitative studies (Tables S2 and S3). For mixed-methods studies, the quantitative and qualitative evidence was extracted separately in the corresponding extraction form. After calibration, two reviewers independently abstracted information from each study including: (1) study identification; (2) objectives or research questions; (3) participant characteristics; (4) general design and methods; (5) risk of bias/methodological limitations; and (6) findings. In case of disagreement, reviewers reached consensus with assistance from a third reviewer.

2.4. Risk-of-Bias/Methodological Limitations Assessment

For quantitative studies, we used an adapted version of available GRADE guidance to assess the risk of bias (RoB) of studies on the importance of outcomes on values and preferences [15]. We considered five items grouped in three domains: (1) selection of participants; (2) missing outcome data; and (3) the measurement instruments' validity. We rated studies as high risk of bias if the measurement instrument did not have evidence of validity, or it was unclear, and as moderate risk if it was validated but two or more items proved at high risk of bias.

For qualitative studies, we used the Critical Appraisal Skills Programme (CASP) qualitative research checklist to assess the methodological limitations (ML) of the studies, consisting of the appropriateness of the following items: (1) aim of the research; (2) qualitative methodology; (3) research design; (4) recruitment strategy; (5) data collection; (6) researcher and participants relationship; (7) ethical issues; (8) data analysis; (9) summary of findings; and (10) value of the research [16]. We rated studies as "serious methodological limitations" if three or more items had serious concerns, as "Moderate methodological limitations" if they had two items with serious concerns, "minor methodological limitations" if one item had serious concerns, and "No or minor concerns" if no items had serious concerns. A pair of reviewers independently assessed RoB/methodological limitations; in case of disagreement, they reached consensus with the help of a third senior methodologist.

For mixed-methods studies, we used the mixed methods appraisal tool (MMTA) consisting of the appropriateness of the five following items: (1) use of mixed-methods design, (2) integration of different components of the study, (3) interpretation of qualitative and quantitative components, (4) reporting of inconsistencies between quantitative and qualitative results, and (5) quality criteria of quantitative and qualitative evidence [17].

2.5. Data Synthesis and Analysis

We synthesised our findings into narrative forms following an iterative four-step approach that involved simultaneous quantitative and qualitative data collection and analysis.

First, we selected two to three eligible articles per study design, identified key themes, and coded them in different categories. Second, we used these categories to design ad hoc data extraction forms. Third, through an iterative process, we compared the key themes of the different categories identified across all studies, categorised them into different groups depending on the type of population (e.g., women, vegetarians, elderly) and developed analytic themes. Finally, we applied a critical meta-narrative synthesis to transform the quantitative data into qualitative data [18–20]. For the latter, we used four systematic profiles and several critical questions (e.g., "Modal profile" refers to the most occurring different attributes, and therefore if most study participants reported to consume meat,

they were described as omnivores) to extract the identified narratives and to guide our synthesis of data (Table S4) [18]. We synthesised and narratively reported the findings according to the identified themes. Within each identified theme, we divided the findings into different subsections (if applicable) according to the following criteria:

1. Type of data: whether the findings were from quantitative (e.g., questionnaire) or qualitative (e.g., interview) data sets.
2. Previous knowledge/information on the environmental impact of meat: whether the participants had been informed about the environmental impact of meat before being asked about their beliefs, preferences, and/or behaviours.

2.6. Integrating Qualitative and Quantitative Analyses

We compared the narratively reported findings from the quantitative and qualitative data sets, searching for similarities and differences [21]. We integrated them into joint displays, which present findings from both quantitative and qualitative data sets per theme [21–23], and assessed whether findings from each data set agreed, offered complementary information, or contradicted each other [22].

2.7. Confidence in the Evidence

We assessed the confidence in the integrated evidence using the GRADE-CERQual approach [24]. This is the most appropriate approach for assessing the extent to which a review finding is a reasonable representation of the phenomenon of interest—in our case the phenomenon of interest was people's values and preferences regarding meat consumption related to environmental impact. Therefore, we assessed the confidence in the evidence considering the following GRADE-CERQual domains: methodological limitations, relevance, coherence, and adequacy, with the exception that we used different appraisal tools for the risk of bias or methodological limitations depending on whether the evidence was quantitative or qualitative as explained above.

To increase consistency and transparency in the overall assessment, we assigned a number value to each of the GRADE-CERQual levels of the concerns as follows: no or very minor concerns were valued as 0; minor concerns as 1; moderate concerns as 2 and; serious concerns as 3. Based on the sum of values per domain and per theme, we judged the overall confidence for all the identified themes as: high confidence (values between 0 and 1); moderate confidence (values between 2 and 4); low confidence (values between 5 and 8); and very low confidence (values between 9 and 12).

3. Results

3.1. Study Selection

We retrieved 23,531 articles. After title and abstract screening, 429 were potentially eligible. We excluded 359 studies (Table S5). After full-text screening, we included 56 quantitative [25–78], 12 qualitative [79–90], and 2 mixed-methods studies [91,92]. Figure 1 presents the flow diagram with the search results and the selection of studies.

3.2. Study Characteristics

Of the 56 quantitative studies, 31were conducted in Europe, 11 in the United States, 4 in the United Kingdom, 4 in multiple countries, 4 in Australia, 1 in New Zealand, and 1 study did not specify where it was conducted. Forty-five studies were conducted between 2010 and 2020, and fifteen were conducted between 2000 and 2010. The number of participants ranged between 82 and 24,340. Of the 12 qualitative studies, 4 were conducted in Europe, 3 in the United States, 2 in Australia, 2 were conducted in multiple countries, and 1 in the United Kingdom. Ten studies were conducted between 2011 and 2019, whereas two studies were conducted before 2010 (one in 2005 and the other in 2008). The number of participants ranged between 19 and 270. The two mixed-methods studies were conducted in Europe in 2018 and 2019 and included between 42 and 1532 participants. Table 1 presents the

characteristics of the 73 included studies. The risk-of-bias and methodological limitation assessment of the included studies is reported in Table S6–S8.

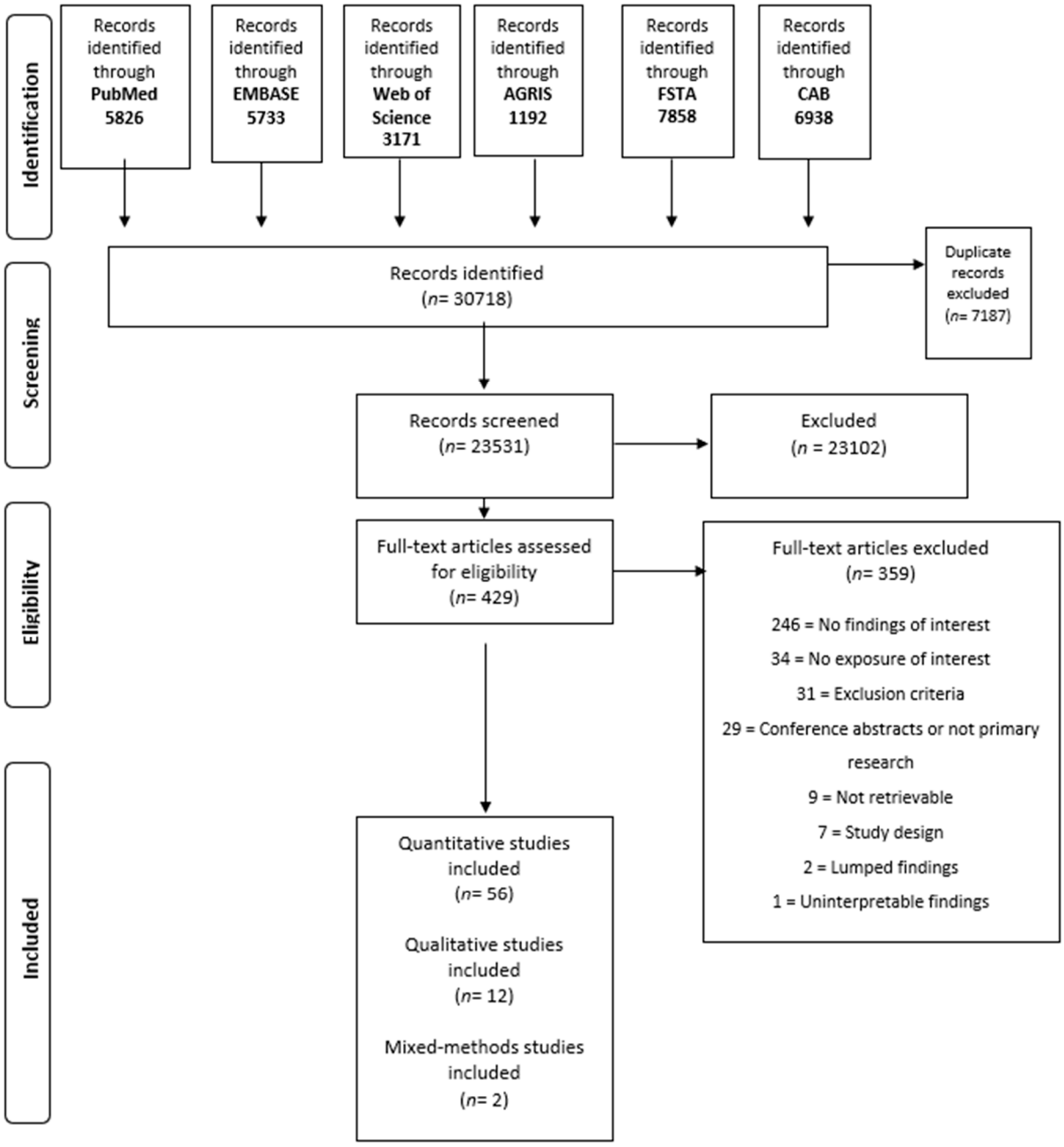

Figure 1. Flow diagram with the search results and selection of studies.

Table 1. Study characteristics.

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Akaichi 2020 [74]	To investigate substitution and complementary effects of beef mince attributes (with a focus on labels of Low, Moderate, High Fat, Local, National, Imported, Organic, Low, Moderate, and High Greenhouse Gas Emissions) on consumers' preferences and willingness to pay for the product, drawing on data from large choice experiments conducted in the UK and Spain.	UK and Spain	QUANT	Questionnaire	Quota	2417	60
Apostolidis 2019 [25]	To compare and contrast the importance of the seven sustainability-related labels for three consumer groups (meat eaters, meat reducers, and vegetarians).	UK	QUANT	Questionnaire administered face to face	Convenience	600	65
Asvatourian 2018 [60]	To identify dietary patterns and their associated GHG emissions, then to explore their relationship, as domain-specific behavioural patterns, with measures of environmental attitudes and behaviours.	South West Scotland	QUANT	Postal survey questionnaire	Random	422	32
Bryant 2019 [61]	To investigate UK meat-eaters' views of various aspects of vegetarianism and veganism.	United Kingdom	QUANT	Questionnaire	Convenience	1000	50
Clonan 2015 [62]	To investigate consumers' self-reported red and processed meat consumption (from intake and purchasing data) against/towards animal welfare, human health, and environmental sustainability.	UK	QUANT	Postal survey questionnaire	Random	842	60
Cordts 2014 [33]	To determine the effect of information regarding the negative attributes of meat consumption on demand for meat in Germany, with the focus on four particular attributes: animal welfare, human health, personal image, and climate change.	Germany	QUANT	Online survey questionnaire	Quota	590	48
Crnic 2013 [34]	To investigate the fundamental characteristics of vegetarianism.	Slovenia	QUANT	Questionnaire	Random	NR	NR
de Boer 2013 [63]	To investigate consumers' behaviours towards meat consumption and climate change.	Netherlands	QUANT	Online survey questionnaire	Stratified	1083	50
de Boer 2016 [64]	To assess how consumers evaluate the mitigation effectiveness of the food-related and the energy-related options, particularly whether they recognise the crucial differences between the less meat option, the local food option, and the organic food option.	Netherlands	QUANT	Online survey questionnaire	Quota	527	50
de Boer 2018 [65]	To assess how responses to the options for pro-environmental protein consumption (plant based or animal based) might be shaped by cultural, culinary, and economic spatial gradients (including GDP per capita) at the regional level and differences in environmentally friendly behaviour and gender at the individual level.	EU countries (Portugal; Spain; Malta; Slovenia; Greece; Cyprus; Hungary; Bulgaria; Romania; Latvia; Lithuania; Estonia; Poland; Slovakia; Czech Republic; Italy; France; Ireland; United Kingdom; Netherlands; Belgium; Luxembourg; Germany; Austria; Finland; Sweden; Denmark)	QUANT	Telephone survey	Random	24340	NR

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
de Gavelle 2019 [36]	To identify different dietary types which might constitute degrees of transition to low-meat diets (omnivores, pro-flexitarians, flexitarians, vegetarians), to characterise how these diets differ in terms of protein source intake, and to determine whether attitudes and beliefs might explain these dietary types.	France	QUANT	Online survey questionnaire	Quota	2055	52
De Groeve 2017 [66]	To examine associations between the support and variables related to meat curtailment and to examine the effect of providing information about the climate impact of meat on the support for the less meat initiatives (LMIs).	Belgium	QUANT	Online survey questionnaire	Convenience	429	54
DeBacker 2014 [35]	To investigate the motives underlying the different forms of vegetarianism and semi-vegetarianism in a culture where meat continues to play a crucial role in people's diets.	Flanders, Belgium	QUANT	Online survey questionnaire	Convenience	1556	NR
Dyett 2013 [37]	To explore the main reasons for adopting and maintaining a vegan lifestyle among a heterogenous group of vegans from different U.S. states; and to determine whether participants' diet and lifestyle choices coincided with positive health indices and selected outcome assessment.	USA	QUANT	Postal survey questionnaire	Convenience	100	76
Eldesouky 2020 [26]	To obtain information on the consumer decision-making process for beef, in order to determine the relative importance of sustainability claims and traditional attributes, and to identify consumer profiles with similar perceptions and intentions.	Spain	QUANT	Online survey questionnaire	Random stratified	285	51
Frewer 2005 [27]	To investigate consumers' perceptions and attitudes towards animal welfare issues related to animal husbandry and environmental impact.	Netherlands	QUANT	Online survey questionnaire	Convenience	1000	NR
Ginn 2019 (Study 1) [67]	To examine perceived effectiveness of meat reduction as a climate change mitigation strategy.	United States	QUANT	Questionnaire	Convenience	527	60
Ginn 2019 (Study 2) [67]	To examine whether people responded differently to brief messages about meat's impact than to messages about more traditionally accepted strategies for mitigating climate change (e.g., driving less).	United States	QUANT	Questionnaire	Convenience	275	52
Grunert 2018 [28]	First, to analyse which production attributes related to environment, health, and animal welfare are ranked highest by consumers when making choices about purchases of pork in Germany and Poland. Second, to investigate how those production attributes that are regarded as important by consumers are traded off against conventional product attributes (fat content, colour, origin) and price in a choice experiment.	Germany; Poland	QUANT	Online survey questionnaire	Convenience	2005	48

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Hagmann 2019 [38]	To compare consumer groups with different self-declared diet styles regarding meat (vegetarians/vegans, pescatarians, low- and regular meat consumers) in terms of their motives, protein consumption, diet quality, and weight status.	Switzerland	QUANT	Paper-based questionnaire	Random	4213	47
Haverstock 2012 [39]	To examine participants' reasons for limiting animal products as well as factors related to stability or disruption of participant animal product limitation. To focus on differences and similarities between current and former animal product limiters (pescatarians, vegetarians, vegans).	USA	QUANT	Online survey questionnaire	Snowball and convenience	247	85
Herzog 2009 [40]	To examine the relationships between a moral emotion (i.e., sensitivity to visceral disgust) and animal activism, attitudes toward animal welfare, and consumption of meat.	USA	QUANT	Online survey questionnaire	Convenience	424	67
Hoffman 2013 [41]	To examine the differences between health-oriented and ethical-oriented vegetarians by comparing conviction, nutrition knowledge, dietary restriction, and years as vegetarian between the two groups.	USA	QUANT	Online survey questionnaire	Convenience	312	85
Hopwood 2020 [42]	To evaluate the structure of common motives for a vegetarian diet, to use that measure to develop behavioural and psychological profiles of people who would be most likely to adopt a plant-based diet for different reasons, and to examine whether this profile predicts responses to advocacy materials.	United States	QUANT	Questionnaire	Convenience	7488	57
Hunter 2016 [68]	To explore fear using protection motivation theory to measure how individuals appraise and cope with the threat of climate change consequences in the food mitigation context in order to understand factors which motivate consumers to reduce or alter their meat consumption.	Sweden	QUANT	Postal survey questionnaire	Random	219	45
Izmirli 2011 [43]	To determine the relationship between the consumption of animal products and attitudes towards animals among university students in Eurasia.	11 Eurasian countries: China, Czech Republic, Great Britain, Iran, Ireland, South Korea, Macedonia, Norway, Serbia, Spain, and Sweden	QUANT	Online survey questionnaire	Convenience	3.433	NR
Kayser 2013 [44]	To analyse the determinants that play a role in the differences in meat consumption patterns in Germany.	Germany	QUANT	Online survey questionnaire	Quota	956	51
Koistinen 2013 [29]	To provide information on the relative preferences of consumers for minced meat attributes and examine whether meat type, method of production, fat content, price, and presence of carbon footprint information have impact on consumer choice.	Finland	QUANT	Online survey questionnaire	Purposive	1.623	50

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Latvala 2012 [69]	To examine changes in meat consumption among Finnish consumers, taking into account both stated past changes and intended future changes. Reasons for change were also identified.	Finland	QUANT	Online survey questionnaire	Purposive	1623	50
Lea 2003 [45]	The aim of this study was to examine consumers' perceived benefits and barriers to the consumption of a vegetarian diet.	South Australia	QUANT	Questionnaire	Random	601	57
Lea 2004 [46]	To determine the proportion of non-vegetarians with similar beliefs as vegetarians and to examine their personal characteristics.	Australia	QUANT	Postal survey questionnaire	Partly random and partly nonran-dom	707	56
Lea 2008 [70]	To examine Australians' food-related environmental beliefs and behaviours.	Australia	QUANT	Postal survey questionnaire	Random	223	52
Lentz 2018 [47]	To explore the understanding of meat consumption and potential drivers for its reduction in New Zealand. The study investigated consumers' attitudes, motivations, and behaviours in regard to meat consumption.	New Zealand	QUANT	Online survey questionnaire	Random	841	50
Lindeman 2001 (Study 1) [48]	To examine whether abstract values are related to concrete Food Choice Motives (FCMs), whether these Food Choice Ideologies (FCIs) are related to a humanist or a normative view of the world, and whether various dietary groups (e.g., vegetarians and omnivores) endorse these FCIs in different ways.	Finland	QUANT	Paper-based questionnaire	Convenience	82	100
Lindeman 2001 (Study 2) [48]	To examine whether abstract values are related to concrete Food Choice Motives (FCMs), whether these Food Choice Ideologies (FCIs) are related to a humanist or a normative view of the world, and whether various dietary groups (e.g., vegetarians and omnivores) endorse these FCIs in different ways.	Finland	QUANT	Paper-based questionnaire	Convenience	149	100
Mäkiniemi 2014 [71]	To examine how young adults in Finland perceive barriers to climate-friendly food choices and how these barriers are associated with their choices.	Finland	QUANT	Paper-based questionnaire	Convenience	350	80
Malek 2019 [72]	To identify consumer segments with varying levels of willingness to make the following changes to their protein consumption: reduce meat consumption, follow a meat-free diet most of the time, avoid meat consumption altogether, and follow a strict plant-based diet (i.e., stop eating all animal products).	Australia	QUANT	Online survey questionnaire	Panel provider/quota sam-pling?	287	53
McCarthy 2003 [30]	To examine consumer perceptions towards beef and the influence of these perceptions on consumption.	Ireland	QUANT	Questionnaire	Random	218	NR
McCarthy 2004 [31]	To investigate Irish consumers' beliefs about pork and poultry consumption.	Ireland	QUANT	Questionnaire on a 'door to door' basis	Random	257	87

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Mullee 2017 [49]	To investigate the attitudes and beliefs about vegetarianism and meat consumption among the Belgian population to better understand motivations underlying these behaviours.	Belgium	QUANT	Online survey questionnaire	Random	2.436	49
Neff 2017 [50]	To learn about what is eaten in meatless meals and attitudes and perceptions towards meat reduction, and to build upon and add depth to previous research on meat-reduction behaviours in the USA and other high-meat-consuming countries.	USA	QUANT	Online survey questionnaire	Convenience	1112	51
Peneau 2017 [32]	To investigate the sociodemographic profiles of individuals reporting health and environmental dilemmas when purchasing meat, fish, and dairy products, and to compare diet quality of individuals with and without dilemmas.	France	QUANT	Online survey questionnaire	Convenience	22,935	75
Philips 2011 [51]	To examine whether social dominance differences between countries influence attitudes towards the use of animals, by surveying the student population in a range of Eurasian countries.	11 Eurasian countries: China, Czech Republic, Great Britain, Iran, Ireland, South Korea, Macedonia, Norway, Serbia, Spain, and Sweden	QUANT	Online survey questionnaire	Convenience and random	3432	55
Ploll 2019 [52]	To provide insights into the relationship between motives and the expression of behavioural patterns of vegetarians and vegans in comparison to the average omnivore.	Austria	QUANT	Online survey questionnaire and hard copy in person	Convenience	556	80
Pohjolainen 2016 [73]	To analyse consumer environmental consciousness, including problem awareness and support to action dimensions, the latter including perceived self-efficacy as well as solutions to problems.	Finland	QUANT	Questionnaire	Random	1890	56
Povey 2001 [53]	To examine differences between the attitudes and beliefs of four dietary groups (meat eaters, meat avoiders, vegetarians, and vegans) and the extent to which attitudes influence intentions to follow each diet. Additionally, the role of ambivalence was examined.	United Kingdom	QUANT	Questionnaire	Convenience	111	40
Pribis 2010 [54]	To examine whether reasons to adopt vegetarian lifestyle differ significantly among generations.	USA	QUANT	Questionnaire	Convenience	609	65
Ruby 2013 (Study 1) [55]	To explore vegetarians concerns about the impact of their daily food choices on the environment and on animal suffering.	NR	QUANT	Questionnaire	Convenience	272	65
Schösler 2015 [56]	To investigate whether the alleged link between meat consumption and particular framings of masculinity, which emphasise that 'real men' eat meat, may stand in the way of achieving objectives. To analyse whether meat-related gender differences vary across ethnic groups (Turkish, Chinese, and Native Dutch).	Netherlands	QUANT	Questionnaire administered face to face	Quota and snowball	1057	52

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Siegrist 2015 [57]	To examine whether the perceptions of various environment-related food consumption patterns changed between 2010 and 2014 and what factors influenced such changes.	Switzerland	QUANT	Postal survey questionnaire	Random	2781	54
Siegrist 2019 [78]	To examine how consumers evaluated the environmental impact of various foods, and to investigate whether the perceived environmental effect of foods, health consciousness, and food disgust sensitivity is related to the consumption of meat substitutes and organic meat.	Switzerland	QUANT	Postal survey questionnaire	Random	5586	52
Spencer 2007 [58]	To examine dietary and other personal health characteristics, as well as mentoring and clinical characteristics, for association with US medical students' vegetarianism.	USA	QUANT	Paper-based questionnaire	Convenience	1849	NR
Tobler 2011 [75]	To examine consumers' beliefs about ecological food consumption and their willingness to adopt such behaviours.	Switzerland	QUANT	Postal survey questionnaire	Random	6189	52
Truelove 2012 [76]	To explore people's perceptions and attitudes of behaviour that cause and mitigate global warming.	USA	QUANT	Online survey questionnaire	Convenience	112	61
Vanhonacker 2013 [77]	To explore consumer attitudes towards a series of food choices with a lower ecological impact.	Belgium	QUANT	Online survey questionnaire	Convenience	221	64
Verain 2015 [59]	To explore different types of sustainable food behaviours. A distinction between sustainable product choices and curtailment behaviour is empirically investigated and predictors of the two types of behaviours are identified.	Netherlands	QUANT	Online survey questionnaire	Quota	942	50
Boyle 2011 [79]	To investigate the eating patterns and vocabularies of motives for newly practicing, or developmental, vegetarians.	US	QUAL	Semi-structured interviews	Snowball	45	100
Fox 2008 [80]	To examine, by means of online ethnographic methods, vegetarians' own perspectives on how health, ethical, and environmental beliefs motivate their food choices; to investigate the interactions between beliefs on health, animal cruelty, and the environment, and how these may contribute to food choice trajectory.	US, UK, Canada	QUAL	Interviews	Convenience	33	70
Graça 2014 [81]	To contribute to a further understanding of the psychological factors that may hinder or promote a personal disposition to change food habits to benefit each of these domains, and to explore people's opinions about how different lifestyles and behaviours affect the environment, public health, and animals.	Portugal	QUAL	Semi-structured focus groups	Convenience	40	63

Table 1. *Cont.*

Study Id *	Primary Focus	Country	Type of Study	Data Collection Methods	Sampling	Included Participants	Gender (% Female)
Guerin 2014 [82]	To investigate interpersonal interactions and conflicts between vegans and omnivores.	US	QUAL	Interviews	Snowball	19	53
Happer 2019 [83]	To uncover the way in which attitudes and behavioural commitments might be negotiated in response to new information and through interaction with others.	China, Brazil, UK, US	QUAL	Focus groups	Quota	270	NR
Hoek 2016 [84]	To investigate consumers' perceptions, experiences, and attitudes toward health and environmental aspects in relation to foods.	Australia	QUAL	Semi-structured, virtual, face-to-face interviews	Quota	29	56
Lea 2005 [85]	To investigate consumers' perceived barriers and benefits of plant food consumption and views on the promotion of these foods.	Australia	QUAL	Focus groups	Convenience	50	72
Macdiarmid 2016 [86]	To explore in depth the public's view and perception of the environmental impact of food and awareness of the link between climate change and meat, and to gauge the public's opinion about their willingness to eat less meat as part of a more sustainable diet.	Scotland	QUAL	Focus groups	Purposive	87	54
Mceachern 2002 [87]	To investigate consumer value residing in meat consumption, with special emphasis on factors relating to organic production values.	Scotland	QUAL	Semi-structured, in-depth interviews	Quota sampling and snow-balling	30	100
Myceck 2018 [88]	To understand how vegans and vegetarians conceptualise and explain their food consumption identities in relation to their broader identity practices.	US	QUAL	In-depth, face-to-face interviews	Purposive and snow-balling	20	0
Mylan 2018 [89]	To understand how meat consumers enact 'meat reduction' in the context of their everyday lives, exploring the motivations, strategies, and experiences of eating less meat.	UK	QUAL	Semi-structured interviews	Convenience	20	NR
Spendrup 2017 [90]	To gain an understanding of consumers' arguments in making a conscious consumer choice of protein and the strategies used for reaching such a purchase decision.	Sweden	QUAL	Focus groups	Purposive	21	NR
Austgulen 2018 [91]	To investigate whether Norwegian consumers are ready to make food choices based on what is environmentally sustainable.	Norway	MM	Online questionnaire and focus groups	Quota	1532	50
Scott 2019 [92]	To investigate how people reason and explain their apparently unsustainable actions given their environmental beliefs and how people that one would think were more prone to being vegetarian justify their choice to eat meat.	Spain	MM	Face-to-face survey questionnaire	Convenience	42	43

Abbreviations: MM = mixed methods, NR = not reported, QUAL = qualitative, QUANT = quantitative, UK = United Kingdom, US = United States. * Studies are organised by type of study (quantitative, qualitative, and mixed methods) and are in alphabetical order.

4. Findings

We identified four main themes: (1) reasons for eating meat (8 quantitative studies (28,923 participants), 1 qualitative study (30 participants)); (2) reasons for avoiding meat (29 quantitative studies (64,651 participants), 7 qualitative studies (457 participants),

and 1 mixed-methods study contributing quantitative evidence (1532)); (3) willingness to change meat consumption (27 quantitative studies (54,326 participants), 7 qualitative studies (527 participants), and 2 mixed-methods studies contributing qualitative evidence (66 participants)); and (4) willingness to pay more for environmentally friendly meat (2 quantitative studies (2702 participants)). Table S6–Table S9 present the integrated findings and the confidence in the evidence.

4.1. Reasons for Eating and/or Buying Meat

4.1.1. Quantitative Data Set

Eight studies reported on reasons for eating and/or buying meat [25–32]. Among these studies, three (37%) provided participants with data on the environmental impact of meat [25,26,29] while five (63%) did not present participants with any information [27,28,30–32].

Informing about the Environmental Impact

When provided with carbon footprint information on meat production, consumers chose products with a lower footprint [25,26,29]. One study found that information on the impact of the carbon footprint provided was meat-type-specific: when participants were given information on the carbon footprint impact of beef products, they were more likely to choose products with a lower footprint. However, in the case of pork meat, the impact was the opposite with participants choosing products with a higher footprint [29]. Moreover, when participants were asked what product features of minced meat had a significant impact on their diet choices, the method of production (conventional, health and safety-oriented, animal-welfare-oriented, and organic production) was important to the minority, while low fat content and price were the most important attributes [29]. In another study, although consumers opted for products with lower carbon footprint labels, other aspects were considered more important, such as the type of meat (e.g., beef vs. turkey) and fat content [25]. Authors also reported that women with a higher income were more concerned with their meat choices based on both their health and environmental impact [25].

Not Informing about the Environmental Impact

When participants were asked to report which meat attribute was important when buying/consuming meat, the environment (for example, carbon footprint information on the label) was not considered the most important characteristic [27,28,30–32], while other aspects such as: nutritional values [28,32], freshness of the meat [27], food safety [27,28,30,31], eating enjoyment/taste [27,30,31], and animal welfare [28,31] were considered more important.

4.1.2. Qualitative Data Set

One study reported on reasons for eating and/or buying meat and did not provide any information about the environmental impact of meat to participants [87].

People bought meat products based on tangible aspects such as colour and appearance rather than more intangible characteristics including environmental aspects of production [87]. Only some participants bought environmentally friendly meat products; the main barriers mentioned were the higher price of these products and their general unwillingness to change their diet [87].

4.1.3. Integrated Evidence and Related Confidence

Findings from the quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of moderate concerns of methodological limitations/risk of bias and serious concerns of relevance. The integrated evidence and related confidence are presented in Table S9.

4.2. Reasons for Avoiding Meat

4.2.1. Quantitative Data Set

Thirty studies reported on reasons for avoiding meat [32–59,91]. None of the studies provided participants with data on the environmental impact of meat.

Eleven studies reported that environmental concerns were among the most important reasons for avoiding meat consumption among vegetarians and low-meat consumers/meat reducers [35,43,44,46,48,49,52,54,55]. One study found that environmental concerns were among the most important reasons for being vegetarian together with health [54]. One study reported environmental concerns together with animal welfare as the main reasons to avoid or limit meat intake [44], and similarly, two studies reported that vegetarians agreed more on the benefits for the environment and animal welfare, or meat reduction, compared with the potential benefits of preventing diseases (e.g., heart disease and cancer) [35,46,49].

On the other hand, 12 studies reported that environmental concerns were not among the main reasons for avoiding meat [35,37,39–42,45,47,53,56,58,91]. Health benefits and the high costs of meat [47], animal welfare together with health [37,39,45,53,58], taste/dislike of meat [35,56] together with animal welfare [35] or health reasons [56], and animal welfare alone [40,41] were the more prominent reasons for avoiding meat in these studies. One study reported that health, the environment, and animal rights were all considered to be generally compelling reasons to adopt a plant-based diet but with health motives being the most common reason [42]. Another study reported that although participants believed that a reduction in meat intake had benefits to the environment, most of the participants who reported having reduced their intake in the past did not do it for environmental reasons [91].

Four studies reported that, overall, women, compared with men, were more likely to avoid meat or eat smaller portions of meat for environmental reasons [33,39,49,59]. On the other hand, in one study men were more likely to report environmental concerns as a reason for avoiding meat compared with women who reported health as the main reason for avoiding meat intake, particularly red meat—beef, lamb and to some extent pork [51].

Two studies reported that younger populations were more likely to agree that there are environmental benefits associated with the consumption of a vegetarian diet [45,54], while those middle-aged appeared to be motivated by health reasons [54]. In one study, individuals with higher education and living alone were more likely to report a dilemma between buying meat for health reasons and not buying it for environmental reasons [32]. In addition, people with higher levels of awareness of the potential environmental impact of meat consumption were more likely to eat less meat and eat more meat substitutes [57].

Finally, three studies reported that people's motivations for avoiding meat intake were influenced by their dietary behaviour; the stricter the diet in terms of avoiding meat consumption and animal products people followed, the more important environmental concerns were as reasons to avoid meat [34,38,47].

4.2.2. Qualitative Data Set

Seven studies reported on reasons for avoiding meat consumption [79,80,82,83,85,88,89]. One study (14%) provided participants with information on the environmental impact of meat production [83], and six studies (86%) did not [79,80,82,85,88,89].

Five studies reported that environmental concerns were not among the main reasons for having reduced meat intake [79,80,83,88,89]; other reasons such as animal welfare [80,89]; health concerns [80,89]; self-fulfilment; and taste or aesthetics (such as colour and appearance) [79] were considered among the main reasons for avoiding meat. However, for some participants, the environmental impact of meat production was mentioned as one important reason for avoiding meat intake [79]. Similarly, another study reported that environmental benefits were considered important reasons for following a more plant-based diet along with the perceived health benefits of plant foods and their taste, variety, and versatility [85]. Environmental concerns tended to be a contributory factor rather than the primary driver for avoiding meat [83]; people might have started avoiding meat for a

specific reason such as the decision to protect animals, but later other reasons such as health concerns or environmental protection reinforced and supported the choice of avoiding meat [82].

Environmental concerns about meat consumption were considered important depending on participants' dietary behaviour; one study reported that all vegans found the environment an important issue for meat consumption, while only a minority of omnivores mentioned it [82].

4.2.3. Integrated Evidence and Related Confidence

Findings from quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of minor concerns of methodological limitations/risk of bias, minor concerns of coherence, and serious concerns of relevance. The integrated evidence and related confidence are presented in Table S10.

4.3. Willingness to Change Meat Consumption

4.3.1. Quantitative Data Set

Twenty-seven studies evaluated people's willingness to change meat consumption [31,33,45,47,50,56,57,59–73,75,77,78]. Three studies (12%) provided participants with data on the environmental impact of meat consumption [33,66,68], whereas twenty-four studies (88%) did not present participants with any information [31,45,47,50,56,57,59–65,67,69–73,75,77,78].

Informing about the Environmental Impact

When informed about the environmental impact of meat, most participants reported low willingness to reduce their meat intake [33,66,68], partially because they mistrusted the information provided [33] and because other strategies such as replacing beef, for example, with chicken every other meal [68] or reporting the ecological impact on the food's labels [66] were believed to be more favourable for the environment. Moreover, they believed that by stopping meat consumption completely, their actions would have no effect on mitigating climate change. One study provided participants with a fictional newspaper article describing the potential environmental damage of meat production (e.g., greenhouse gas emissions) [33]; in a second study participants were given a fact sheet on the impact of meat on the climate and presented with information indicating that a reduction in meat intake would reduce greenhouses gas emissions and that beef and mutton have significantly higher emission costs than other meats [66]. A third study presented participants with a one-page cover story reporting the causes and consequences of and mitigating actions for climate change in relation to meat consumption [68].

Not Informing about the Environmental Impact

When people were asked if they would be willing to reduce their meat intake in the future, most of them reported that they would not reduce their consumption [56,60,63,64,69,70,73,75–78]. Several reasons and/or barriers were reported for not wanting to reduce meat intake [45,48,50,61,71,92]. See Figure 2.

Two studies found that the perception of barriers was gender-specific: women considered high prices and poor supply to be more important barriers for reducing meat, whereas men considered disbelief, strangeness, eating habits [71], and the enjoyment of eating meat more important [31].

In addition, seven studies identified the behaviours participants believed to favour the environment [47,60,64,70,78,80]. Buying local and seasonal food [47,61,65,67,68,72,77], (Study 1 in [67]), decreased use of packaging [47,60,70,75], reducing food waste [61,79], driving less [68,82], and using less energy at home [67,77] (Study 1 in [67]) were behaviours believed to be more efficient in mitigating climate change.

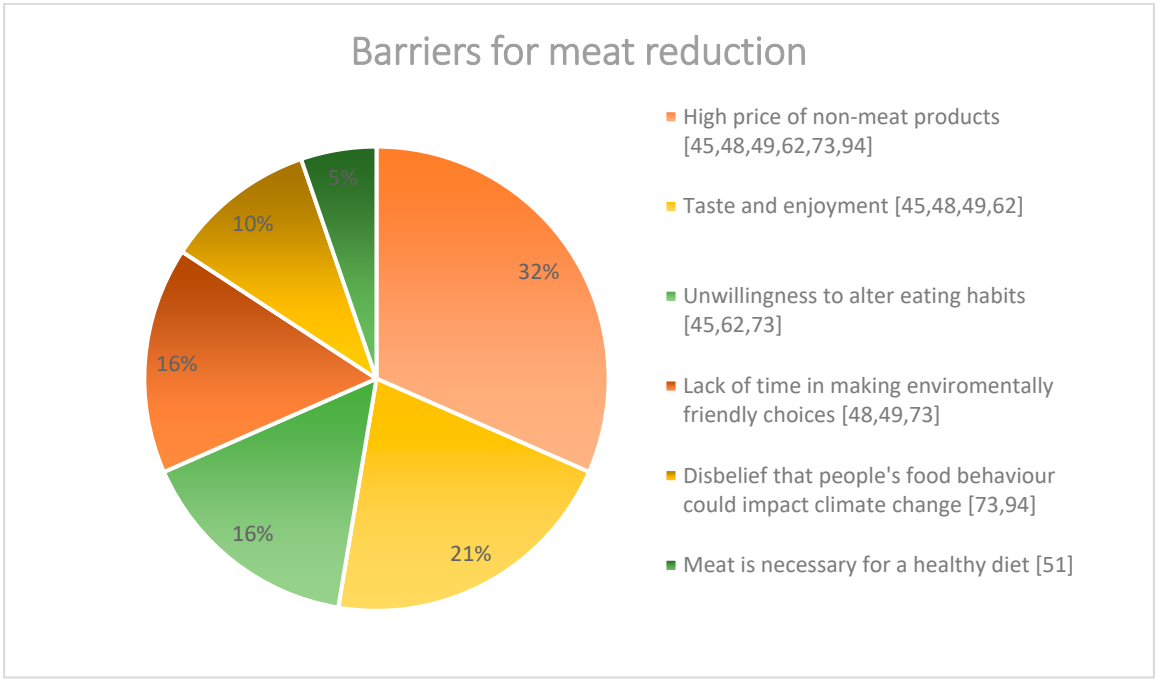

Figure 2. Barriers for meat reduction—quantitative data set. * Study 1 and Study 2.

Similarly, most omnivores reported to be willing to adopt or accept other strategies to reduce the climate impact rather than reducing meat [67,73,76,78] (Study 2 in [67]). See Figure 3.

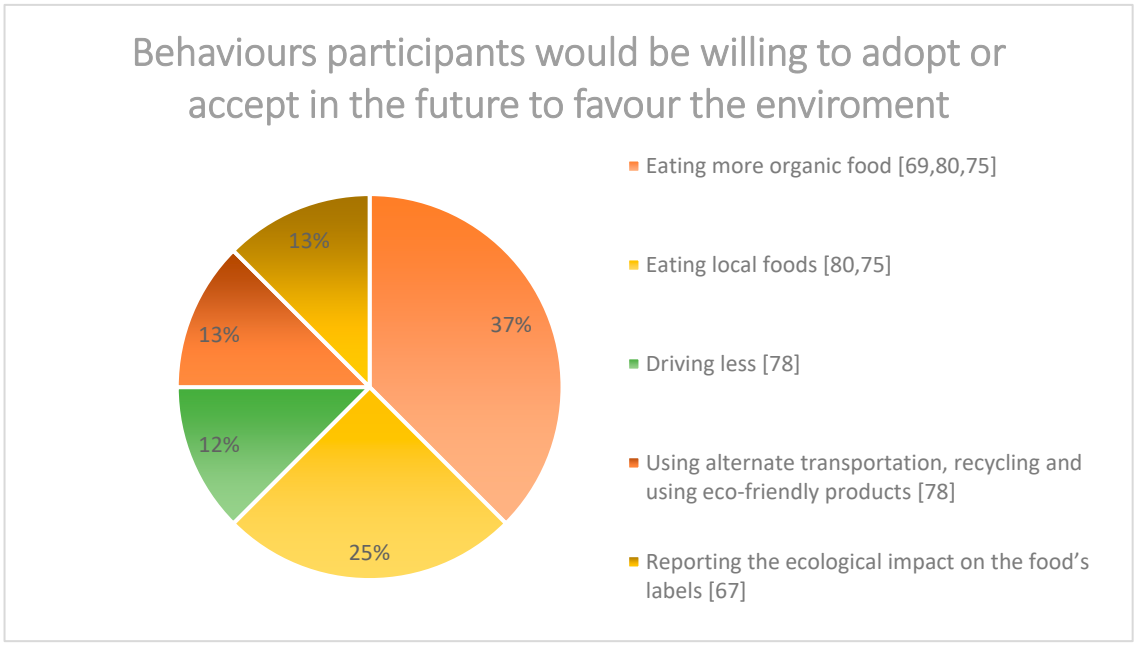

Figure 3. Behaviours participants would be willing to adopt or accept in the future to favour the environment. * Study 2.

Nevertheless, three studies reported that most of the participants, when presented with different sustainable food behaviours they could choose from, were willing to reduce their meat intake [59,65,80]. One study reported that participants were more willing to reduce the meat quantity in their traditional meal rather than eating plant-based meat substitutes and proteins from insects [80]. In another study, most participants were willing

to eat less meat but of better quality (certified origin) instead of replacing most of the meat with vegetables [65], and in a third study, participants were more willing to reduce meat intake (eat smaller portions, take a meat-free day per week) than buy organic meat, buy free range meat, or eat less dairy [59].

Thirteen studies reported that, overall, women perceived higher environmental benefits of eating less meat than men and were more willing to reduce meat intake [31,56,59,61–65,69,70,75,76,78], and women were more likely to have already reduced their meat consumption in the past [75]. Similarly, two studies reported that women had more positive views of vegetarianism and veganism compared with men [61,71]. Generally, male respondents and with higher incomes [71] were less willing to reduce their meat intake. Moreover, participants with higher education and socio-economic status were more willing to reduce their overall meat intake in the future [56,57,59,69]. In addition, smaller household sizes and higher age levels appear related to a higher level of meat curtailment [59].

Finally, participants who consumed meat in larger quantities and more frequently were less positive towards a reduction in meat intake [63–65,67,72,75], whereas those with higher concerns for environmental problems were much more likely to intend to stop eating meat [63,67,75,76]; also, an increased scepticism toward climate change was associated with a decrease in people's willingness to change their meat consumption [63].

Contrary to the above, one study found that gender, as well as age, meat consumption behaviour (high vs. low intake), and socio-economic status differences, had no impact on people's belief that eating less meat would help reduce climate change [62].

4.3.2. Qualitative Data Set

Eight studies evaluated people's willingness to change meat consumption when faced with environmental concerns of meat consumption [81,83–87,90,91]. One study (12%) provided participants with data on the environmental impact of meat [83], and seven studies (88%) did not provide any information [81,84–87,90,91].

Informing about the Environmental Impact

When provided with an information sheet about the impact of food production on climate change, most of the participants showed a low level of awareness of the association between climate change and meat consumption, and some participants reported considering reducing their meat consumption or had already reduced their intake in the past. However, environmental concerns tended to be a contributory factor rather than the primary driver; other aspects were reported to be more important for the environment and were country/culturally specific; for example, deforestation in Brazil was considered more important and harmful for the environment compared with meat consumption. Moreover, participants were sceptical of the credibility of sources and arguments reported by the media about the impact of meat consumption [83].

Not Informing about the Environmental Impact

Most of the participants were reluctant to reduce their meat intake for a more environmentally friendly diet [81,84,86,91], and overall, there was a lack of awareness of the climate impact of meat production [84,86,87,91]. On the other hand, although some participants recognised the importance of reducing meat consumption, they expressed difficulties in being a sustainable consumer daily [90]. Several reasons and/or barriers were reported for not wanting to reduce meat intake. Figure 4 shows people's barriers to reducing meat consumption [81,84–86,90,92].

In relation to people's scepticism about the serious impact that meat consumption has on the environment [91] and the disbelief that consumers could solve such a major issue [81,86,91,92], among the minority who said that they would consider eating less meat were those more inclined to do this for health benefits rather than environmental gains or only willing if there was evidence to support that it was indeed beneficial [86].

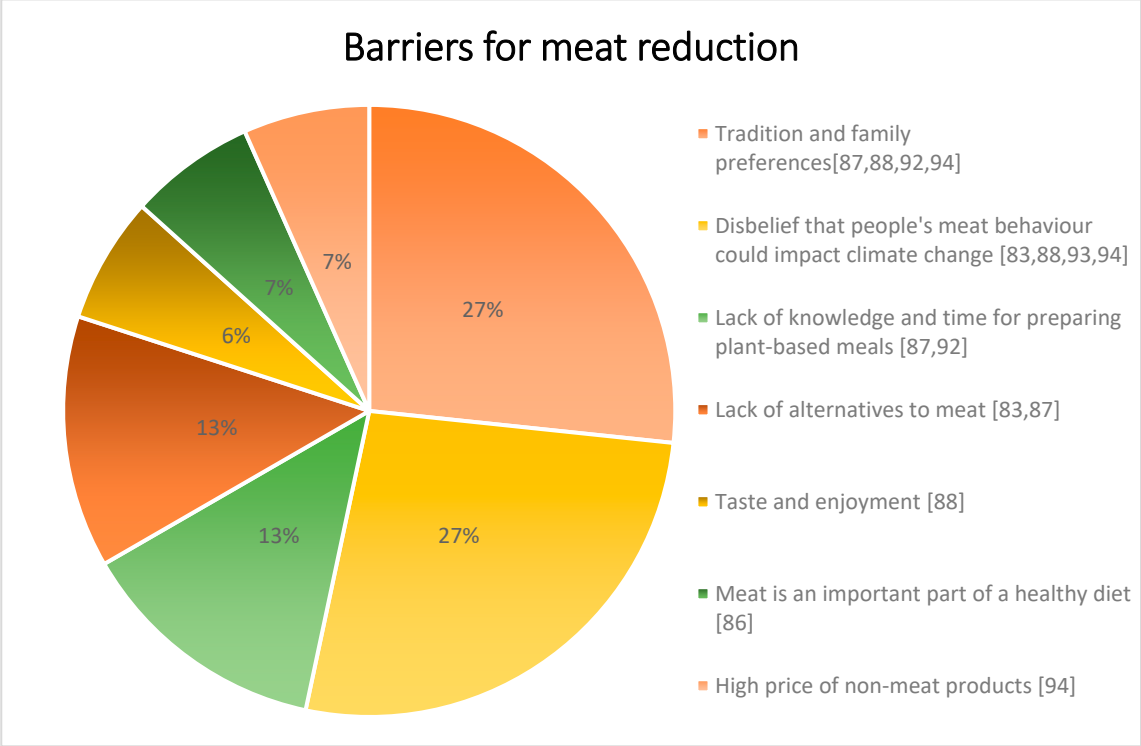

Figure 4. Barriers to meat reduction—qualitative data set.

Others believed that compared with other behaviours meat consumption was trivial and other behaviours would be more favourable for the environment than reducing meat consumption, food packaging (e.g., plastics, recycling), food waste (e.g., sell-by dates, promotions, household waste), the transportation of food (e.g., food miles, imported food, local food, seasonality), and the production and processing of food (e.g., agricultural and retail practices, factory pollution) [86].

Young women were most inclined to change their meat consumption compared with men [91].

4.3.3. Integrated Evidence and Related Confidence

Findings from quantitative and qualitative data sets were deemed complementary and the overall confidence in the evidence was rated as low because of moderate concerns of methodological limitations/risk of bias and serious concerns of relevance. The integrated evidence and related confidence are presented in Table S11.

4.4. Willingness to Pay More for Environmentally Friendly Meat

Quantitative Data Set

Two studies evaluated people's willingness to pay more for environmentally friendly meat and meat products [26,74]. None of the studies provided participants with data on the environmental impact of meat consumption.

Both studies reported that consumers were willing to pay more for meat produced with a significantly lower environmental impact [26,74]. Labels indicating that the beef mince had a low or moderate fat content [74], was organic meat produced locally, and met animal welfare standards were also significant for consumers [26]. Women and older people showed higher willingness to pay more for meat with minimal environmental impact [26,74]. Findings were only reported from quantitative data sets and the overall confidence in the evidence was rated as moderate because of no or minor concerns of methodological limitations (serious risk of bias), serious concerns of relevance, and minor concerns of adequacy. The evidence and related confidence are presented in Table S12.

5. Discussion

5.1. Main Findings

Our findings show that overall people are highly attached to meat. People are divided between those who believe that meat consumption has a harmful impact on the environment and those who believe that other factors, for example, food waste and food packaging, are more harmful to the environment compared with meat. Regardless of people's general beliefs about meat and its impact on the environment, most people in our included studies were unwilling to change their meat consumption, and, among those who did already reduce their meat intake in the past, environmental concerns were not always the main reasons but often a contributory factor among others.

People reported several barriers to reducing their meat intake: the high price of non-meat products, its taste, unwillingness to alter their eating habits, the lack of time to make climate-friendly choices, and disbelief that meat has an impact on climate change. Even in the few studies in which participants were presented with scientific evidence linking meat consumption and climate change, consumers did not consider the environment an important aspect when buying/eating meat, nor were they willing to reduce their meat intake.

Our findings are consistent across quantitative and qualitative evidence and across countries and publication years; the overall confidence was low for the themes *reasons for eating and/or buying meat*, *reasons for avoiding meat*, and *willingness to change meat consumption*, and moderate for the *willingness to pay more for environmentally friendly meat* theme.

5.2. Strengths and Limitations

Our study has several strengths. We performed a mixed-methods systematic review, including both quantitative and qualitative evidence, allowing us to have greater confidence in the interpretation of our findings. We explicitly reported inclusion and exclusion criteria, conducted an extensive search, and performed a duplicate assessment of eligibility and RoB or ML based on a publicly available protocol [13]. We applied the GRADE-CERQual approach to assess the overall certainty of our findings in consultation with GRADE and mixed-methods research experts.

Our study also has some limitations. First, we only included studies conducted in Europe, Australia, Canada, the United States, and New Zealand, and therefore our results reflect those of populations living in high-income countries. While limited data were available, we did not explore whether values and preferences differed in lower versus higher income participants in our eligible studies. Second, most of the included studies did not inform participants about the environmental impact of meat, and therefore their values and preferences were based solely on their personal knowledge or belief. Third, given that some of the authors have recently published a weak dietary recommendation that people continue their meat consumption [9], it is possible that our interpretation of results is biased. To help mitigate this possibility, in addition to duplicate independent data screening and abstraction and a risk-of-bias assessment, we included data abstractors and assessors who were not part of our recommendations. Finally, among the eight studies that did present participants with information on the environmental impact, we did not assess the credibility of this information, nor did we assess if participants were presented with the relative impacts of various behavioural changes that can impact global warming. Moreover, we were not able to investigate in depth if the results were dependent on the age of participants because the age of participants was not consistently reported across studies.

5.3. Our Results in the Context of Previous Research

Our findings are aligned with results from a previous synthesis [93,94]. One systematic review including only quantitative studies reported that only a small minority of included participants were willing to reduce their meat consumption for environmental reasons [93]. The same authors conducted a qualitative synthesis, reporting that the main barriers to meat reduction were the taste of meat, the belief that meat is healthy, and that it is a part

of a nutritious diet [94]. In addition, people who had already reduced or eliminated meat from their diet (vegetarians and vegans) did not do so solely for environmental reasons.

5.4. Implications for Research and Practice

Our results have direct implications for several stakeholders such as guideline developers, researchers, and policymakers. Our findings suggest that people are unwilling to change their eating habits and prefer to continue doing what they know and are familiar with, regardless of the alleged impact their behaviour might have on the environment. Based on our findings, it is likely that people will be reluctant to follow plant-based food recommendations contrary to their individual values and preferences. However, people in most of the included studies were not properly informed about the evidence, particularly the best available evidence or the relative impact of changing meat consumption versus various other behavioural changes on the environment. Future research should address these limitations and assess whether people are willing to make a change when properly informed.

Regarding our methods, this systematic review follows and reports step by step an innovative methodological approach to synthesise and assess the confidence of mixed-methods evidence by following solely the GRADE-CERQual approach. This approach could be adopted for future mixed-methods systematic review syntheses for different research areas.

6. Conclusions

Regardless of people's general beliefs about meat and its impact on the environment, most people may be unwilling to change their meat consumption; however, they have reported to be willing to adopt other, non-food-related strategies (for example, driving less) to mitigate climate change. Most of the participants were not informed about the consequences and impact on climate change, and therefore we cannot confidently conclude that people when properly informed would still be reluctant to change. Future research should address the current limitations of the research evidence (e.g., rather than perceived impact; robust, systematic evidence of the relative environmental impact of locally sourced vs factory farmed meats) to assess whether people are willing to change their meat consumption when properly informed.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijerph20010286/s1, Figure S1: Search Strategies; Table S2: Quantitative Data Extraction Form; Table S3: Qualitative Data Extraction Form; Table S4: Critical Metanarrative Synthesis: From Quantitative Data to Narratives; Table S5: Excluded Studies and Reasons for Exclusion (N = 357); Table S6: Risk-of-Bias Assessments for Quantitative Studies; Table S7: Methodological Limitations Assessments for Qualitative Studies; Table S8: Critical appraisal of Mixed-Methods studies; Table S9: Evidence Profile for "Reasons for eating and/or buying meat"; Table S10: Evidence Profile for "Reasons for avoiding meat"; Table S11: Evidence Profile for "Willingness to Change Meat Consumption"; Table S12: Evidence Profile for "Willingness to pay more for environmentally friendly meat".

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Abbreviations

AGRIS	International System for Agricultural Science and Technology
CAB abstracts	Centre for Agriculture and Bioscience
CERQual	Confidence in the Evidence from Reviews of Qualitative Research
CASP	Critical Appraisal Skills Programme
CMNS	critical meta-narrative synthesis
FSTA	Food Science and Technology Abstracts
ML	methodological limitations
NutriRECS	Nutritional Recommendations and accessible Evidence summaries Composed of Systematic reviews
PROSPERO	International Prospective Register of Systematic Reviews
RoB	risk of bias

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5. DISCUSSION

5.DISCUSSION

5.1 Main results

This thesis provides new knowledge on the identification, synthesis and evaluation of people's values and preferences in the development of dietary guidelines, specifically about red and processed meat recommendations. We started off by conducting a systematic review exploring peoples' health-related values and preferences about meat consumption to inform the NutriRECS panel formulating meat recommendations, followed by a cross-sectional study investigating people's values and preferences about meat consumption when presented with the associated health-related risks, and, finally, a systematic review exploring environmental concerns in relation to meat consumption.

Our mixed-methods systematic review (Study 1) showed that people are attached to meat and are generally unwilling to change their behaviour. Participants' willingness to change meat consumption was generally low, across the quantitative and qualitative research available evidence. In general, people considered meat an essential component of a healthy diet, enjoyed eating meat, felt that meat was a part of their traditions, and believed they lacked the knowledge and cooking skills to prepare an adequate meal without meat. However, the available studies reporting willingness to reduce meat consumption in the face of health concerns did not provide participants with sufficient information about the certainty of the evidence, nor about the effect of meat consumption has on health. Thus, we could not infer with confidence that properly informed people would be unwilling to make any changes. In addition, most of the included studies presented different limitations in terms of lack of validation of the questionnaires, issues of indirectness, and adequacy (small number of participants) (96).

In our cross-sectional explanatory sequential mixed-methods study (Study 2), we observed that, when informed about cancer incidence and mortality risks of meat consumption, most respondents were not willing to reduce their intake, and men were less willing to reduce meat consumption than were women. Overall, participants felt that they were consuming a healthy amount of meat, that did not need to be changed. The semi-structured interviews indicated that participants consumed meat, most commonly in social contexts and/or in response to family preferences. In addition, health proved to be, in fact, an important factor in favour of consuming meat, whereas other aspects, such as environmental concerns emerged as reasons for having reduced meat consumption in the past (102).

Our second mixed-methods systematic review (Study 3), showed that there are people who believe that meat consumption has a harmful impact on the environment, and others who believe that other factors, for example, food waste and food packaging, are more harmful to the environment. Overall, most people are unwilling to change their meat consumption because of the high price of non-meat products, its taste, strong attachment to their eating habits, the lack of time to make climate-friendly choices, and disbelief that meat

has an impact on climate change. Even in the few studies in which participants were presented with scientific evidence, linking meat consumption and climate change, consumers did not consider the environment an important aspect when buying/eating meat, nor were they willing to reduce their meat intake (100).

5.2. Our Results in the Context of Previous Research

The identification and incorporation of people's values and preferences about meat in the development of meat recommendations

The incorporation of people's values and preferences in dietary guideline development process helps recommendations to be more easily accepted, implemented, and adhered to by those intended to benefit from the guidelines (56). According to guidelines development groups, including the Institute of Medicine (60), the AGREE guidelines (104), and the Guidelines International Network (GIN) (48), the perspectives or values and preferences of patients or the public is among the factors to be considered when formulating recommendations and determining their strength and direction (105,180). The incorporation of the public perspective is especially relevant in situations where the net balance between the benefits and risks of a recommendation is small and/or uncertain. Under these circumstances, the decision depends more on the context of the individuals receiving the recommendation and their perspective. Therefore, considering the increased debate around the allegedly harmful health impacts of meat intake, peoples' values and preferences should be considered in the development of such recommendations.

Currently, it is unknown whether other FBDGs on meat intake incorporate the public perspective in their development or in the content of their recommendations. However, a recent systematic review assessing the methodological quality of Spanish dietary guidelines (published between 2007 and 2019), found that one of the main limitations across FBDGs was that they did not report how they sought the values and preferences of their target population and, for the minority of FBDGs informed by systematic reviews did not obtain value and preference data to inform recommendations (148). Therefore, it is likely than meat guidelines do not consider people's values and preferences regarding meat consumption.

According to the review conducted by Bechtold et al. 2018 on FBDGs, 34 identified published European FBDGs reported data on the dietary habits and sociocultural preferences; however, Bechtold et al. referred mainly to food consumption data and budget pattern (retrieved through national food consumption and household budget surveys) in terms of foods consumption frequency and patterns within a specific population, rather than the preferences in terms of determinants and willingness to follow specific dietary behaviours (30).

On the other hand, Bechtold et al. 2018 review highlights the concept of individualizations, as an important aspect to consider in the development of dietary guidelines, as it takes into account individuals' status and preferences such as, for example, the desired of following entirely a plant-based diet. This approach is shifting

away from the traditional approach of formulation population-based recommendations, based exclusively of the general population data. If dietary guidelines would accommodate individual requirements, the likelihood of acceptability and adherence would probably be higher. In this regard, only this guideline from The Netherlands reported considering an individualized approach in their overall development process (30).

The results of our mixed-methods systematic review (Study 1) informed the NutriRECS panel for the development of meat consumption recommendations. The NutriRECS meat panel consisting of 14 members from seven countries voted on the final recommendations (56). This panel chose to exclusively focus on health outcomes, and exclude from the decision-making process other potential concerns, such as environmental and animal welfare concerns, because they considered them very different issues, difficult to be properly assessed and that would require specific expertise in the field for the development of rigours ad-hoc systematic reviews. In addition to conducting a systematic review on people's values and preferences, three public participants without health science backgrounds were included as part of the NutriRECS panel, to ensure a proper representation of the population perspective. Values and preferences systematic review findings, as well as dose-response metanalysis results, were presented to the guideline panel, along with the related certainty of the evidence. Previously, the public panel member attended a separate meeting in which the overall methodological approach was explained (56).

As suggested by different guidelines development groups, both the development of systematic reviews and the inclusion of public representatives as part of the panel, are considered optimal methodological approaches, to ensure the appropriate consideration of the public perspective during the formulation of recommendations (36,105,181). Additionally, it is recommended that for those organizations with sufficient resources, the retrieved evidence is presented or consulted with individual patients or groups of patients for gathering relevant information on patients' views. On the other hand, for groups with fewer resources, non-systematic reviews of the literature and the use of the experience of panel members, based on their interactions with patients or the public should be considered (105,146,182).

In addition, in the recommendations developed by NutriRECS, in order to ensure that all panellists' voices were heard and that a structured and transparent approach to develop the final recommendations was followed, each panellist completed the GRADE evidence to decision framework individually, prior to the final guideline panel meeting (108,109). This framework facilitates panels making judgments in a structured and transparent way, about the different factors that can determine the direction and strength of the recommendations: quality of the evidence, balance between benefits and risks, variability or uncertainty about the values and preferences of patients, and costs (108,109). During the final meeting, the panellists reviewed the judgments made, agreed on final judgments, and considered the implications of those judgments for their recommendations (56).

The NutriRECS panel suggested "*For adults 18 years of age or older, to continue their current unprocessed red and processed meat consumption (weak recommendation, low-certainty evidence)*". The rationale for the recommendations to continue, rather than reduce the consumption of unprocessed red meat or processed meat - considering solely the health outcomes associated with meat intake- was based on the following aspects: a) the low to very low certainty of evidence for the potential adverse health outcomes associated with meat consumption, b) a very small and often trivial absolute risk reduction based on a realistic decrease of 3 servings of red or processed meat per week, and finally, c) the associated and uncertain risk reduction with a reduction of meat intake might not be enough for people wanting to reduce their intake, given their attachment to meat and finally, d) the large variability in peoples' values and preferences related to meat (162) (**Annex 2B**).

Health and non-health related values and preferences about meat

Our mixed-methods systematic review (Study 1) focusing on health-related values and preferences showed that most people are attached to meat and are not willing to reduce their intake. Contrary to how - in the last two decades - dietary guidelines and health institutions have depicted red and processed meat as unhealthy, many people believe that meat is an important component of a healthy diet (84-86).

Reasons for meat consumption identified in our mixed methods systematic review (Study 1) were similar and consistent with the reasons identified in the survey of Study 2. Enjoyment and flavour of meat were the most commonly reported reasons for eating meat (Study 1 and Study 2), and health reasons were consistently reported in the included studies of our review (Study 1) but were not the most frequently reported reason in our survey (Study 2). Our Study 1 found that meat was generally perceived as being part of a complete and healthy diet, whereas in Study 2, other reasons such as cost, availability of meat, tradition, and family preferences, resulted to be more important.

In line with our Study 2 results, Prokop-Dorner et al cross-sectional study (97), conducted in Poland, showed that taste was the predominant reason for eating meat, followed by family preferences, price and availability; health was the fifth most frequently reported reason, with only 23,2 % and 13,3 % of participants valuing the health aspect as important, for red meat and processed meat respectively. Similar results were also reported in the pilot study conducted in Canada (98): taste and cost were the most common factors for eating red and processed meat, followed by family preferences in the case of red meat, and cooking time for processed meat intake. With respect to cost, it was considered a facilitator for consumption in the case of processed meat, and a deterrent in the case of red meat, because of the difference in expense. Likewise, health was seen as a positive factor for consuming red meat for the nutritive content, whereas, for processed meat, it was seen as a negative factor, due to the addition of preservatives. Similar results were reported in our Study 2, with health being valued positively for red meat consumption and negatively for processed meat.

Along this line, among consumers that had eliminated meat from their diet (e.g., vegetarians), or simply reduced their intake (meat reducers), health was considered an important reason for having reduced meat consumption, as reported in our Study 1; however, health was not always the main reason but rather a contributor factor, among others. Similarly, in the survey conducted in Study 2, among those participants who reported having reduced their intake in the past, many declared having reduced it due to health reasons, although, other non-health related reasons were more frequently reported.

According to a recent evidence map review aiming to capture the motives for following a plant-based diet, the most frequent reasons for avoiding meat can be grouped into three broad categories: ethical (e.g., environmental concerns, animal welfare), health (to improve some health aspects or reduce the risk of health harms), and other (mostly related to sensory factors, political, finances, and tradition). This review showed that there are multiple motivations from these categories for wanting to adopt a plant-based diet, and that often these motivations are dynamic, and change over time (183). As reported in Study 1, people might start excluding meat because of health concerns - for example, to reduce the risk of heart disease - and later, other beliefs or reasons might start becoming as important as health, and are embedded into the reasoning process, to support their behaviour. Making a clear-cut distinction between what are main drivers and determinants for people's dietary behaviour, it is very difficult.

In the same line, other existing narrative reviews explored reasons for consuming or avoiding meat, and they suggested that the motivations for meat consumption are complex and diverse and may vary according to age and sex (184,185). In fact, as reported in our Study 1, men were more attached to their meat consumption and the older population were more concerned about health in respect to their food choices compared to the younger ones. On the other hand, according to Miki 2020 evidence map review, the available evidence has important limitations, mainly due to the sample size and number of studies, to draw clear conclusions on the association between age groups and motivations (183).

According to previous reviews, and consistent with our findings from Study 1, omnivores willingness to change consumption is generally low (186,187); eating meat is such an important component of the Western culture that cannot be easily modified, and people are so attached to their habits that are not willing to reduce their meat intake (187), nor willing to substitute their meat with other healthier options (for example, by eating insects or meat substitutes) (186).

As described above, non-health related values and preferences have resulted to be important aspects, and often more important, compared to health, that are considered when consuming meat. However, the importance placed on the non-health related aspects, such as environmental concerns of meat consumption and production, might not be sufficient for people to change their dietary behaviours as showed in our Study 3. In our second mixed-methods systematic review (Study 3) - investigating people's meat values and

preferences in the face of environmental concerns – we found that people were generally unwilling to make any changes regarding their meat consumption, regardless of their beliefs about meat and its impact on the environment. People were divided between those who believed that meat consumption was harmful for the environment and those who believed that other aspects; for example, food waste and food packaging, were more harmful compared with meat. These considerations are in line with the conclusions of a recent systematic review, that found that environmental motives were appealing to significant proportions of Western meat-eaters, who were adopting certain meat-curtailment strategies, such as meat-free days, but only were sufficiently important for reducing meat for a small minority (188).

The barriers for not willing to reduce meat intake – identified in our Study 3- were similar to the reasons for meat consumption, identified in our Study 2 and two other cross-sectional studies (97,98) from our research group: cost of non-meat products, taste, unwillingness to alter their eating habits, cooking time and skills, and disbelief that meat has an impact on climate change. Similar barriers were reported in Sanchez-Sabate et al. qualitative synthesis, aiming at investigating peoples' attitudes towards meat reduction (189).

Overall, health and non-health related factors cannot be considered independent and unique contributors to peoples' dietary choices but rather, coexisting factors that are so highly interconnected, that, ultimately, shape peoples' dietary behaviours.

Mixed-methods systematic reviews

Mixed-methods systematic reviews (MMSRs) have become an important and common approach in health research as they provide a complete overview of findings (both quantitative, qualitative, and mixed) and ultimately facilitate the decision-making process (151). Generally, MMSRs bring together quantitative and qualitative findings to better understand if an intervention works (quantitative evidence), and how and under which circumstances (qualitative evidence) (151). However, they are also becoming useful for providing a more comprehensive view on a specific phenomenon of interest.

The methods for conducting MMSRs is a field under development and yet, no comprehensive and final guidance exist. However, in 2014, the JBI Mixed Methods Review Methodology Group developed and proposed a first guidance, based on previous approaches (e.g., study of Sandelowski et al.), to assist researchers in the conduction of MMSRs, rather than reporting the results (151). However, such guidance was developed with the idea of providing a base that needed to be further developed (151).

In both of our MMRSs (Study 1 and Study 3), we followed the convergent integrated approach involving data transformation, to combine quantitative and qualitative data. Overall, two main types of synthesis designs exist: convergent and sequential synthesis designs (151,176). The convergent design can be either "integrated" (involving data transformation and allowing the combination of quantitative and qualitative data) or "segregated" (quantitative and qualitative data synthesis is conducted independently and the

generated quantitative and qualitative evidence will be later integrated together). The sequential design instead consists of a two-phase approach in which the data collection and analysis of one type of evidence is conducted after the collection and analysis of the other type (151,176). The convergent integrated approach is recommended when the research question can be answered by both quantitative and qualitative research designs (151). Such approach consists in: a) the extraction of data from quantitative studies (including data from the quantitative component of mixed methods studies) and qualitative studies (including data from the qualitative component of mixed methods studies), and b) data transformation. The latter can be either the transformation of quantitative data into qualitative (qualitizing) or vice versa (quantitating).

For both our MMSRs (Study 1 and Study 2), due to the nature of the research question and the types of data reported in the included studies, we adopted the transformation of quantitative into qualitative as also suggested by the JBI guidance as, quantifying data (by attributing numerical values to qualitative data) is more prone to error (151).

In addition, to better guide the qualitizing transformation process in a more standardized approach, we applied the critical meta-narrative synthesis, through systematic profiles, and critical questions that were asked to further extract narratives from the data; such approach was adapted based on the methodology reported in a previous mixed- methods systematic review (165). Although such approach is still not widely used, it provides clear and structured guidance on how to generate narratives from quantitative data.

Finally, after the quantitative and qualitative data extraction, synthesis and transformation is conducted, the evidence from both synthesis needs to be integrated. The integration step involves comparing the quantitative results and qualitative findings and organizing them to produce an overall conclusion: whether there is consistency, and/or findings are complementary, and/or contradict each other.

No clear guidance is provided on whether and how this integration should take place. However, according to a review of systematic reviews combining qualitative and quantitative evidence (176), within the convergent synthesis design, depending on when quantitative and qualitative data are integrated, we could distinguish three subtypes: data-based, results-based, and parallel-results convergent synthesis designs.

For our first mixed methods systematic review (Study 1), we adopted the parallel-results convergent synthesis designs, as the integration and interpretation of both data sets was conducted in the overall discussion. Instead, for our second mixed-methods systematic review (Study 3), we adopted the parallel-results convergent synthesis design, by integrating both data sets into joint displays and assessing whether findings from each data set agreed, offered complementary information, or contradicted each other.

One of the challenges in MMSRs is often the lack of clarity on the integration process of qualitative and quantitative data. One way to overcome such challenge is by providing an integrated synthesis in a

standardized format, separately from the overall conclusions. This can be achieved with the use of joint displays (190). Joint displays are frameworks facilitating the representation of findings from both quantitative and qualitative data sets per theme and allow researchers to withdrawn overall conclusions based on the level of agreement, and/or disagreement across findings (190). To overcome this challenge, for our second MMSR (Study 3) we integrated all data in joint displays, searching for similarities and differences across findings.

An additional challenge in MMSRs is the lack of guidance on which approach should be used to determine the overall certainty of the evidence. In our first MMSR (Study 1), as we synthesized quantitative and qualitative separately and integrated them only into the discussion section, we assessed the certainty of the quantitative and qualitative evidence with GRADE and GRADE CERQual approach, separately. Although the GRADE and GRADE-CERQual approaches are recommended by systematic reviews and guideline working groups, no clear recommendations have been made towards the use of both approaches within MMSRs, nor towards the appropriate approach for assessing quantitative evidence that has been transformed into qualitative data (narratives). In addition, no clear guidance is provided on how to assess the certainty of integrated evidence. Thus, for our second MMSR (Study 3), as we integrated quantitative and qualitative, we investigated - in consultation with experts in the field - which approach was best to use, and it was decided to use GRADE-CERQual. Given that GRADE-CERQual is considered the most appropriate approach for assessing the extent to which a review finding is a reasonable representation of the phenomenon of interest, and in our case the phenomenon of interest was people's values and preferences regarding meat consumption related to environmental impact, it was concluded to adopt the GRADE-CERQual approach for assessing the certainty of the integrated evidence.

Health related values and preferences about meat when informed about health risks

The results of our cross-sectional study (Study 2), were similar to the findings from our mixed-methods systematic review (Study 1), showing that most people were unwilling to change their meat intake, even when informed about the potential cancer risks.

Following and adapting the methodological approach reported in our published protocol (**Annex 2C**) as well as in our Study 2, two studies – the pilot study conducted in Canada (98) and the Prokop-Dorner study in Poland (97) - presented to participants evidence about the health risks related to meat consumption, specifically the probability of cancers risk reduction by reducing meat intake, in order to assess their predisposition of changing their consumption (97,98). In all studies, after being informed, participants reported a low willingness to change meat consumption (97,98,102).

One of the reasons for not wanting to reduce meat intake that emerged in the semi-structured interviews (Study 2) was that they believed they were already consuming a healthy amount of meat and did not need

to further reduce it. Similar results were found in Study 1, with many participants believing that they had already reduced their meat consumption in the past and did not plan any further reductions.

Other reported reasons for not wanting to reduce their intake were related to the traditional aspect of meat being part of their diet, and the family preferences for eating meat. Most of the reasons were similar across studies. In addition, participants highlighted the importance of sustainability as a concern that consumers should take into consideration and, they reported a general disbelief of the evidence presented. Participants reported that the uncertainty of the evidence was not convincing enough for making dietary change.

Similarly, the few studies included in our first MMSR (Study 1) informing participants on the health risks of eating meat – although the information provided was not consistent with what we presented (Study 2)- reported low willingness to change, partially because they mistrusted the information provided, and because many of the participants believed other aspects -for example, the additives used in the production process- to be the real health problem rather than the meat consumption itself.

Although, most of the participants reported low willingness to reduce their intake in face of the cancer risks presented in the survey, in the follow-up assessment conducted both in Study 2 and Prokop-Dorner study, some participants reported to have changed their eating habits since the survey. In Study 2, 25% of participants reported having increased their meat intake and 12% reported having reduced the intake of processed meat. In the Prokop-Dorner study, 42% of the participants from the Poland study reported having changed their meat intake with, 22% of participants possibly motivated by the information provided. The majority reported having decreased their intake, whereas the rest reported an increased in their consumption. One of the most reported reasons for having decided to change their meat consumption was related to health, followed by environmental concerns, animal welfare, preparation time, and availability.

Finally, as shown in our cross-sectional study (Study 2), gender seemed to be a predictor of willingness, with men being appreciably less willing to reduce their intake than women. Similar findings were also reported in our first mixed-methods systematic review (Study 1), as well as in the study conducted in Poland (97), with men being highly attached to meat and considering as part of a healthy diet and their culture, whereas in the pilot study conducted in Canada no differences were detected across age, sex, and employment status (98).

These results suggests that people are attached to their red and processed meat consumptions for many reasons and that, when confronted with very small and uncertain benefits of reducing meat consumption, most individuals, considering only health effects, choose to continue their current meat consumption.

Cross-sectional studies

As shown in both of our systematic reviews (Study 1 and Study 3), there is a large number of primary studies evaluating peoples' values and preferences about meat consumption. However, most of these studies

present several limitations. In the case of quantitative studies, a major limitation was the lack of piloting and validation of the measurement instruments (questionnaires) to capture peoples' values and preferences and, for qualitative studies, the lack of detail about the data analysis process and unclear reporting of findings, and lack of description of the relationship between the investigator and participants were the main limitations. In addition, most of the studies did not inform participants about the potential health impact of meat consumption, before assessing their values and preferences and willingness to make any dietary changes. Therefore, we conducted a de-novo mixed-methods cross sectional study (Study 2) aiming to overcome these limitations, and appropriately capture people's current health-related values and preferences of meat consumption.

As suggested by guideline working groups, another approach to obtain people's preferences – besides conducting systematic review- is by conducting de novo research, that can be either qualitative (e.g., interviews), quantitative (e.g., surveys), or mixed (both qualitative and quantitative research methods). The use of this strategy is recommended as a complementary source to obtain the public perspectives, although it is not consistently adopted by guideline development groups (147). In the survey conducted by the Blackwood et al. (2020) to identify the methods used by CPGs groups, it was showed that 58% (30/52) of the organizations that reincorporate the perspective of patients, they report conducting qualitative research (interviews and focus groups), and 54% (28/52) quantitative research (surveys) (147).

Differently from many published primary studies on peoples' preferences about meat, in NutriRECS, we developed a specific protocol, reporting all the methods and procedures to be followed and then conducted a pilot study (98). Furthermore, we pilot-tested the online survey in a purposive sample of participants. Among the many included studies in both of our systematic reviews (Study 1 and Study 3), only a minority of studies validated the questionnaires used: 37% (15/41 studies) in Study 1 and 26% (26/56 studies) in Study 3 (96,100).

In addition, before assessing people's willingness to change, we informed participants about the health impact of meat consumption and the related certainty, to assist them in making an informed decision. Among the included studies in our systematic review on peoples' health-related values and preferences (Study 1), only two primary studies (22%) provided participants with information about the undesirable health effects of meat consumption. The lack of information provided to surveyed participants highlights the inappropriateness of assuming that informed persons would choose to reduce meat consumption on the basis of small health benefits, especially if the benefits are uncertain (62, 191).

We followed a standardized approach through a direct-choice exercise methodology, for presenting the evidence and related certainty for both cancer incidence and cancer mortality risks, and for red and processed meat separately. The direct-choice exercises were conducted using MagicApp software

(http://magicproject.org/research-projects/share-it/). MAGIC (Making GRADE the Irresistible Choice) is a well-recognized initiative in the clinical setting, aiming to support clinicians and patients in the decision-making process by providing figurative and easy to understand scenarios.

To our knowledge, within the nutrition field, the pilot study on meat conducted in Canada (98) was the first study using the MAGIC decision aids scenarios. Outside the nutrition field, however, the MAGIC decision aids have been tested in the clinical setting and have demonstrated being useful tools that can assist clinicians and patients (192).

In addition, being our Study 2 a mixed-methods cross sectional study, in order to provide better clarity on the integration process of quantitative and qualitative data, we integrated the quantitative data retrieved from the survey and the qualitative data from the semi-structured interviews into joint displays of integrated mixed-methods data collection, similarly to what's reported in a recent analysis and comparisons of different joint displays used in mixed-methods research (190). Overall, according to Fatters et al., there are three types of joint displays: 1) joint displays of mixed-methods findings, 2) joint display analysis and, 3) joint displays of integrated data collections. The joint display of findings is used to deliver and represent the integrated findings, the joint display analysis is used by researchers to analyse the collected mixed data and creates interactions of qualitative and quantitative evidence, and finally, the joint display of integrated evidence is used by researchers to plan the data collection and to represent and explain how data were integrated by linking quantitative and qualitative evidence (190). While the first two types of joint displays are more commonly used, the joint displays of integrated data collection- although recognised as a useful tool to represent the integration of mixed-method evidence by the scientific community – is still limited in the available literature (190).

Finally, for our Study 2, we applied an explanatory sequential mixed methods design. According to Fetters et al., we can distinguish three main mixed-methods designs: 1) a convergent design with quantitative and qualitative data collection being conducted approximately at the same time, 2) an explanatory sequential mixed-methods design with quantitative data collection taking place first and informing subsequent qualitative data collection and finally, 3) an exploratory sequential mixed-methods research design with quantitative data collection coming first and informing the qualitative data collection. Depending on the aim, the timing, the process, and function either one of these designs can be sued. For the purpose of our Study 2, the explanatory sequential design was considered the more useful strategy for two main reasons: on one hand the findings from the survey aimed to influence the sampling strategy for the semi-structured interviews by including for example an equal number of participants that reported to be willing and unwilling to change their meat consumption behaviours to further investigate both reasoning and, on the other hand,

findings from the survey were considered fundamental to define the semi-structured interviews questions (qualitative data) from which further findings and construct could be extracted.

5.3. Strengths and limitations

This thesis consists of three studies that pursue a common objective: to generate new knowledge about the identification, synthesis, evaluation and incorporation of people's values and preferences in the development of FBDGs, specifically red and processed meat recommendations. The main strength of the thesis work is that the research process has been developed explicitly and systematically, with the preparation and the publication, of the corresponding research protocols (163, 169).

All the studies presented in this thesis are the result of the collaboration of a multidisciplinary group of national and international researchers in the area of guidelines development and have gone through a peer review process by the biomedical journals (all quartile 1) in which they have been published.

The main strengths of each of the studies are summarized in Table 2.

Table 2. Strengths of the studies

Study	**Strengths**
Study 1: "Health-related values and preferences regarding meat consumption: a mixed-methods systematic review" **Study 3**: "Peoples' values and preferences towards animals' welfare and environmental concerns of meat consumption: A mixed-methods systematic review	• We registered the protocol with PROSPERO (CRD42018088854) (163). • We adhered to the PRISMA statement (49). • We applied explicit eligibility criteria, used an extensive search, and performed duplicate assessment of eligibility and risk of bias or methodological limitations. • We used 2 complementary bodies of evidence (mixed methods). • We followed the GRADE and GRADE-CERQual approaches to assess the certainty of the evidence (50, 168). • We integrated quantitative and qualitative evidence and applied the GRADE-CERQual approach to assess the overall certainty in consultation with GRADE and mixed-methods research experts (**Study 3**).
Study 2: "Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study"	• We developed and published a protocol reporting the study's methodology (169). • We followed an explanatory mixed-methods approach to the collection of both quantitative and qualitative evidence. • It is the first study, to our knowledge, that has comprehensively and explicitly evaluated people's health-related values and preferences, and their willingness to change meat consumption when informed of the

	potential adverse cancer risk and the uncertainty around this evidence. • The information that patients received was based on a recent rigorous dose–response meta-analysis (82). • We used health states to ensure a similar understanding among participants of the presented outcomes.

The main limitation of the thesis work is that the identified values and preferences of meat consumption reflect food values and preferences of populations living in high-income countries, and therefore, cannot be generalized to other populations. In addition, the methodological approach that we followed has been applied so far, solely for the development of meat recommendations. The main limitations of the three studies and the strategies we adopted to reduce their potential impact on the results, are reported in **Table 3**.

Table 3. Limitations of the studies

Study	**Limitations**	**Potential impact on the results**	**Strategies to reduce their impact**
Study 1: "Health-related values and preferences regarding meat consumption: a mixed-methods systematic review"	Included studies conducted only in Europe, Australia, Canada, the United States, and New Zealand, reflecting food values and preferences of populations living in high-income countries.	We cannot generalize these findings to other populations.	In the development of NutriRECS meat recommendations, we highlighted that the values and preferences considered could not be generalized to all populations.
	The studies reporting willingness to reduce meat consumption in the face of health concerns did not provide participants with sufficient information about the certainty of the evidence, nor about the effect meat consumption has on health.	We could not assume that when informed about the effect of meat consumption has on health and the related certainty, participants would still be unwilling to change.	We conducted a cross-sectional study (**Study 2**) in which included participants were asked about their preferences of red and process meat.
	Studies failed to consistently report participants' socioeconomic status, educational level, and religious beliefs, precluding exploration of the effect of these	We could not explore the effect of these characteristics on dietary values and preferences.	In the development of NutriRECS meat recommendations, we highlighted that the values and preferences considered could not be

	characteristics on dietary values and preferences		generalized to all populations.
	Most of the included studies do not focus on red or processed meat, but rather meat in general.	Peoples' values and preferences might differ depending on the type of meat (red and processed) and thus, influencing differently the development of the NutriRECS red and processed meat recommendation .	We conducted a cross-sectional study (**Study 2**) in which included participants were asked about their preferences of red and process meat separately.
	Our systematic review focuses only on the influence of health effects and does not address other reasons that influence meat consumption, such as animal welfare and environmental concerns.	People's meat consumption values and preferences might be influenced by other aspects, rather than health alone that were not investigated.	We conducted a second systematic review (**Study 3**) investigating to what extent other aspect such as environmental concerns might impact peoples' values and preferences about meat consumption.
Study 2: "Health Related Values and Preferences Regarding Meat Intake: A Cross-Sectional Mixed-Methods Study"	Most of the included participants had a university degree and consumed less than three servings per week, which was the average meat intake in Spain.	Our results might not be representative for the rest of the Spanish population.	Two additional studies following similar methods were conducted in other countries (Canada and Poland); however, the majority of included participants had a higher education.
	Although we provided information about the associated reductions in cancer risk in different formats, we did not check for understanding.	We could not assume people understood uniformly the data presented.	We used health states to ensure a similar understanding among participants.
	We only presented data on cancer risk and did not present other health risks, such as cardiovascular effects, in order not to overburden the participants.	We did not know if people's values and preferences would change based on the health outcome presented.	None.
	The semi-structured interviews and follow-up assessment	We cannot assume the	We attempted to include participants

	findings were collected from a small proportion, and convenience sample of participants.	findings were representative of the entire sample of included participants.	with sociodemographic characteristics and meat consumption behaviours similar to the surveyed participants.
	The response rate for the survey questions on willingness varied. The less willing they were to change meat consumption, the more questions a participant answered.	The length of the survey might have impacted the response rate and participants responses.	We attempted to mitigate this challenge by piloting the survey and testing it in a sample of 34 participants.
Study 3: "Peoples' values and preferences towards animals' welfare and environmental concerns of meat consumption: A mixed-methods systematic review	We only included studies conducted in Europe, Australia, Canada, the United States, and New Zealand, and therefore our results reflect those of populations living in high-income countries.	We cannot generalize these findings to other populations.	In the development of NutriRECS meat recommendations we highlighted that the values and preferences considered could not be generalized to all populations.
	While limited data were available, we did not explore whether values and preferences differed in lower versus higher income participants in our eligible studies.	We could not explore the effect on dietary values and preferences.	None.
	Most of the included studies did not inform participants about the environmental impact of meat.	People's values and preferences were based solely on their personal knowledge or belief; we could not assume that when informed about the environmental impact of meat, participants would still be unwilling to change.	None.
	Some of the authors of this study have recently published a weak dietary recommendation that people continue their meat consumption.	It is possible that our interpretation of results is biased.	To help mitigate this possibility, in addition to duplicate independent data screening and abstraction and a risk-of-bias assessment, we included data

			abstractors and assessors who were not authors of previous recommendations.
	Among the studies that did present participants with information on the environmental impact, we did not assess the credibility of this information, nor did we assess if participants were presented with the relative impacts of various behavioural changes that can impact global warming.	We cannot exclude that participants responses might have changed depending on the type of information that was presented to them.	None.
	We were not able to investigate in depth if the results were dependent on the age of participants because the age of participants was not consistently reported across studies.	We cannot exclude that participants responses might have changed depending on their age.	None.

5.4. Implications for Practice and Research

5.4.1 Implications for Practice

- Organizations and working groups developing FBDGs should provide clarity in the terminology used to refer to the concept "people's values and preferences". It is necessary to clearly define which are the aspects that are measured and how it is done.

- Organizations and working groups developing FBDGs should apply a standardized approach on how to integrate people's values and preferences in the formulation of dietary recommendations .and provide explicit and structured methodological guidance.

- Organizations and working groups developing FBDGs should ensure that their recommendations consider the population's values and preferences.

- Organizations and working groups developing FBDGs should outline specific strategies on how to identify people's values and preferences in the development of dietary guidelines, to ensure that their perspective is considered in the guideline development process.

- Our findings suggest that people are unwilling to change their meat consumption and prefer continuing with their eating habits regardless of the potential health risks and the impact their behaviour might be on the environment; for this reason, it would be inadequate to assume that informed people would comply with meat reduction recommendations.

- In face of the people's low willingness to modify their meat consumption, panels are more likely to make conditional rather than strong recommendations, for the reduction of meat consumption for healthcare reasons.

5.4.2. Implications for research

- It is necessary to continue investigating methodological research approaches on how to optimize and standardize mixed-methods systematic reviews.

- We followed an innovative methodological approach to synthesise and assess the confidence of mixed methods evidence, by following solely the GRADE-CERQual approach. This approach could be adopted for future mixed-methods systematic review syntheses for different research areas.

- In the context of cross-sectional studies, future research should further investigate decision aids tools, and on the best approaches to properly inform participants about the relative health impact associated with their food consumption.

- People's meat consumption determinants and willingness to change their diet should be better explored and investigated in larger and more heterogenous populations including different sociodemographic and education levels and of different age groups.

- Future research should investigate how to improve the formulation of dietary recommendations in ways that can be easy that can be easily understood, implemented, and adhered by the target population. Dietary recommendations should provide individuals with the appropriate guidance for improving diet quality for better health.

- In the context of FBDGs, more research to generate guidance on methods for involving the public, identifying people's preferences as well as approaches for formulating recommendations that reflect those preferences should be conducted.

6.CONCLUSIONS

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- Health can be seen as a facilitator or a deterrent for meat intake, depending on the meat consumption behaviour of the target audience (whether people are meat consumers of meat reducers).

- Health and non-health related factors cannot be considered independent and unique contributors to peoples' dietary choices but rather, coexisting factors that are highly interconnected and that ultimately shape peoples' dietary behaviours.

- Overall, people are highly attached to meat consumption and wish to maintain their dietary habits, regardless of the potential harmful impact that meat might have on their health and/or the environment.

- Regardless of people's general beliefs about meat and its impact on the environment, most people are unwilling to change their meat consumption. Many people believe that other factors, for example, food waste and food packaging, are more harmful to the environment than meat.

- This thesis provides a methodological basis - that needs further development - for obtaining peoples' food values and preferences through mixed-methods cross-sectional studies and systematic reviews and integrate these values in the formulation of FBDGs recommendations.

7.BIBLIOGRAPHY

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8. ANNEXES

ANNEX 1. Abbreviations

- AGREE: Appraisal of Guidelines for Research and Evaluation
- CASP: Critical Appraisal Skills Pro-gramme
- CPGs: clinical practice guidelines
- EBM: evidence-based medicine
- EFSA: European Food Safety Authority
- EtD frameworks: Evidence to Decision frameworks
- FAO: Food and Agriculture Organization of the United Nations
- FBDGs: Food-based dietary guidelines
- GIN: Guidelines International Network
- GRADE: Grading of Recommendations Assessment, Development and Evaluation
- GRADE-CERQual: EvaluationConfidence in the Evidence from Reviews of Qualitative Research
- HEI: Healthy Eating Index
- HHS: Health and Human Services
- JBI: Joanna Briggs Institute
- MAGIC: Making GRADE the Irresistible Choice
- ML: methodological limitations
- MMSRs: Mixed-methods systematic reviews
- MMTA: mixed methods appraisal tool
- NutriRECS: Nutritional Recommendations working group
- PM: processed meat
- PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses
- RoB: Risk of Bias
- ROBINS-I: risk of bias (RoB) in the results of nonrandomized studies of interventions (NRSI)
- STROBE: Strengthening Reporting of Observational Studies in Epidemiology
- STROBE-nut: Strengthening Reporting of Observational Studies for Nutritional epidemiology
- U.S.: United States of America
- URM: unprocessed red meat
- USDA: U.S. Department of Agriculture
- WHO: World Health Organization

ANNEX 2. Additional publications

Johnston BC, Alonso-Coello P, Bala MM, Zeraatkar D, Rabassa M, **Valli C**, Marshall C, El Dib R, Vernooij RWM, Vandvik PO, Guyatt GH. Methods for trustworthy nutritional recommendations NutriRECS (Nutritional Recommendations and accessible Evidence summaries Composed of Systematic reviews): a protocol. BMC Med Res Methodol. 2018 Dec 5;18(1):162.

BMC Medical Research Methodology (2018): impact factor: 8.285, first quartile Q1 (Epidemiology; Health Informatics).

BMC Medical Research Methodology

STUDY PROTOCOL Open Access

Methods for trustworthy nutritional recommendations NutriRECS (Nutritional Recommendations and accessible Evidence summaries Composed of Systematic reviews): a protocol

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Abstract

Background: Recent systematic reviews and editorials suggest that many organizations that produce nutritional guideline recommendations do not adhere to internationally recognized standards set forth by the Institute of Medicine (IoM), Guidelines International Network (GIN), Appraisal of Guidelines Research and Evaluation (AGREE), and Grading Recommendations, Assessment, Development and Evaluation (GRADE).

Methods: The potential solution is an independent group with content expertise and skilled in the methodology of systematic reviews and practice guidelines to produce trustworthy guideline recommendations, recommendations that are supported by publication in a top tier journal. The *BMJ* Rapid Recommendations project has recently demonstrated the feasibility and utility of this approach. Here, we are proposing trustworthy nutritional guideline recommendations based on internationally accepted guideline development standards, recommendations that will be informed by rigorous and novel systematic reviews of the benefits and harms associated with nutritional exposures, as well as studies on the values and preferences related to dietary behaviors among members of the international community.

Discussion: Adhering to international guideline standards, conducting high quality systematic reviews, and actively assessing the values and preferences of key stakeholders is expected to improve the quality of nutritional guidelines and their relevance to end-users, particularly patients and community members. We will send our work for peer review, and if found acceptable, we will publish our nutritional recommendations in top-tier general medicine journals.

Keywords: Nutrition, Guidelines, Recommendations, Evidence-based, Patient engagement

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Background

Burden of disease and evidence-based care

Globally, chronic non-communicable illnesses represent the largest burden of disease, and healthy eating habits may be a cornerstone to the prevention and management of chronic disease [1, 2]. Evidence suggests that risk factors related to nutrition have a major impact on disability adjusted life years (DALYs) and death. In the US, estimates suggest that 14% of DALYs and 26% of deaths are attributable to dietary risk factors [3]. Of the 20 leading risk factors for disability in 2010, 13 were directly or indirectly related to diet, including high blood pressure, body-mass index, fasting glucose, and low consumption of fruits and vegetables [4]. The greatest relative burden from chronic diseases such as diabetes, heart disease and cancer may result from or may be exacerbated by poor nutrition [5].

Despite the evidence that nutrition may play a major role in curbing the burden of chronic disease, clinicians typically do not emphasize nutrition in their interactions with patients [6]. The knowledge and time required to apply nutritional counseling in clinical practice comes with a unique set of challenges, including a lack of sufficient nutrition training in medical school and residency programs, and a dearth of both time and financial compensation for offering counseling [7]. Intense media coverage on what is often times low quality, non-systematic collection of evidence (e.g. ecological observations, small clinical studies based on biomarkers) in the field of nutrition serves to compound the problem with a constant source of conflicting messages [8].

Clinicians, including registered dietitians, require primary research and systematic evidence synthesis, including meta-analyses, to understand the available evidence; nutrition practice guidelines to provide appropriate interpretation of evidence and direction in its application; and user-friendly presentations and access to facilitate efficient uptake. Systematic syntheses of evidence are often, however, not available, or the syntheses that do exist are of limited rigor. For example, in systematic reviews and nutrition practice guidelines, important health outcomes (i.e. end points most important to patients and community members, such as mortality, quality of life or dietary satisfaction) are often not optimally identified and synthesized, thus limiting our understanding of the impact of interventions on patient and community members' lives [9].

Evidence-based nutrition involves the integration of the best available evidence summaries, clinical and public health practice experience, and patient and community values and preferences [10, 11] (Johnston BC et al. The Philosophy of Evidence-Based Principles and Practice in Nutrition. Mayo Clinic Proceedings (submitted August 2018). Within this framework, clinicians can provide optimal care and, when appropriate and possible, engage in shared decision-making with patients, families and members of the community to help them prevent, resolve or cope with their physical, mental, and social health problems.

Table 1 Institute of Medicine standards for trustworthy guidelines (2011)

Transparency: details on guideline development and funding are explicit and publicly accessible
Management of conflicts of interest: prior to finalizing guideline, panelists being considered for membership should declare all interests and activities potentially resulting in conflicts, and all conflicts should be minimized
Guideline group composition is multidisciplinary with methodological expertise and including patient and community involvement
Use of systematic reviews for guideline questions
Establishing evidence foundations for and rating strength of recommendations
Clear articulation of recommendations
External review by a full spectrum of stakeholders (e.g. scientific and clinical experts, patients and community representatives)

The need for trustworthy nutrition guidelines

International groups, including the Institute of Medicine (IoM), Appraisal of Guidelines Research and Evaluation (AGREE), the Grading Recommendations, Assessment, Development and Evaluation (GRADE) working group [12–16], and the Guidelines International Network (GIN) have, using consensus methods, developed recognized and accepted guideline standards. All these standards promote establishing evidence foundations based on systematic reviews and subsequently using these systematic reviews to contribute to ratings of the strength of recommendations [12, 15]. Systematic reviews can offer high or low quality evidence and in either case guideline recommendations can be weak or strong. Table 1 summarizes the IoM standards for trustworthy guidelines.

Despite these widely accepted standards for trustworthy guidelines and vastly improved methods and processes for their production, systematic surveys of over 1100 practice guidelines across a wide range of health topics indicate that guidelines continue to suffer from important limitations [17–19]. An evaluation of 626 guidelines with the AGREE instrument has demonstrated that despite some increase in quality of guidelines over time, quality scores have, over the last two decades, remained moderate to low [19]. Similarly, an evaluation using IoM standards demonstrated continued poor adherence over the last two decades, with major deficiencies particularly in the management of conflicts of interest [18].

In the field of nutrition, previous systematic evaluations show similar methodological limitations [9, 20–22].

Guidelines issued by several organizations, including authoritative governing bodies, suffer from major limitations in their trustworthiness, relevance and usefulness for practice [9, 23]. For example, using the AGREE instrument, the overall quality of guidelines on nutrition in critically ill adults is suboptimal, with only four of nine guidelines being recommended for clinical use [22]. Using AGREE to assess guideline development across 9 guidelines on daily caloric intake from sugar, although each guideline suggested a decrease in the consumption of foods and beverages containing sugars, the guidelines scored poorly on the AGREE criteria, specifically in rigor of development, applicability, and editorial independence including conflicts of interest [9].

Not only are conflicts of interest an issue in nutritional guideline recommendations, but also in systematic reviews and primary studies [24, 25]. Although underpowered, the results of systematic reviews on the association between sugar-sweetened beverages (SSB) and weight gain or obesity appear to be influenced by industry funding. Among 17 identified systematic reviews, for those reviews without any reported financial conflict of interest, 83.3% (10/12) of conclusions were that SSB consumption could be a potential risk factor for weight gain. In contrast, the same percentage of conclusions, 83.3% (5/6) of those reviews disclosing some financial conflicts with the food and beverage industry indicated that the scientific evidence was insufficient to support a positive association between SSB consumption and weight gain [25]. Further, unique to the field of nutrition, conflicts related to committed dietary behaviours due to personal, family, religious, social, or cultural beliefs can impact the interpretation of results [26]. To optimize the trustworthiness of primary studies, systematic reviews and guideline recommendations in the field of nutrition, the importance of efficiently handling financial, intellectual and other conflicts of interest is paramount, more so because the nutrition field is highly polarized, with strong adherents to ideological stances and evidence of the relationship between financial conflict of interest and authors' conclusions [26–28].

Another problem is that nutrition guidelines often place excessive trust in the results of observational studies, despite their potentially higher risk of bias [29]. For instance, consider the evidence from a systematic review and meta-analysis of cohort studies versus the only RCT of vitamin C, a micronutrient, for preventing cardiovascular disease. The meta-analysis of nine cohort studies including over 290,000 patients reported a 25% (95% CI 7 to 40%) relative risk reduction in coronary heart disease among men consuming supplemental vitamin C [30]. The Physicians' Health Study II, a large stand alone RCT of 14,641 participants, found no reduced risk [31]. In considering a systematic review and meta-analyses of cohort studies versus RCTs of antioxidants (i.e. beta-carotene, vitamin A, vitamin C, vitamin E, selenium), results of early cohorts studies among people who consumed a diet rich in these micronutrients demonstrated a lower risk for developing cardiovascular disease and cancer [32], whereas a Cochrane systematic review and meta-analysis of 78 RCTs ($n = 296{,}707$) revealed no evidence to support antioxidant supplements for primary or secondary prevention of diseases [33]. Over 30 examples of inconsistent results between cohort studies and RCTs exist [34, 35] demonstrating that, although observational studies have important roles in identifying issues for subsequent study and providing guidance prior to the conduct of definitive investigation, the sole reliance on observational studies may result in misleading inferences and recommendations. Systematic reviews of the nutritional literature should consider observational studies separately from randomized trials, with the pooled estimates from the meta-analyses independently assessed for certainty (quality) of evidence.

The GRADE working group has produced standards for the evaluation of the certainty of evidence and for moving from evidence to recommendations that are far more detailed, explicit, transparent and carefully developed than prior systems, and are now in use by more than 100 organizations worldwide [16]. There is evidence that guideline panels making nutritional recommendations are often limited in their experience and ability to use GRADE methods [9, 36]. For instance, despite the fact that WHO made strong recommendations to limit the intake of sugar to below 10% of total daily energy intake, the overall quality of evidence to support recommendations was low to very low [9]. Similar findings have been observed in a review of guideline recommendations across a variety of health care disciplines [37]. With exceptions such as acute life-threatening clinical scenarios (e.g. vitamin K for a patient receiving warfarin with an intracranial bleed and an elevated INR), strong recommendations should not be based on low quality of evidence [15].

Another relevant limitation of many nutrition guidelines involves patient or community participation in the development of recommendations, particularly on the selection of outcomes deemed important to these participants. We systematically identified examples of limited quality guidelines in nine public health guidelines related to sugar consumption. As reflected in the domain stakeholder involvement on the AGREE instrument, many guidelines did not describe how they sought the views and preferences of their target population (patients or the general community), and those that did were vague about the process [9]. Further, guideline panels omitted including members of the general community on the panel, an important component of public health recommendations given the recognition of the importance of

patient and community oriented research. For instance, the rationale for the varied sugar intake recommendations gave undue weight to intermediate outcomes including nutrient displacement, and weight gain of the order of 1 kg [9], outcomes not likely of substantial importance to most patients and community members.

Overcoming the limitations of current nutritional recommendations

Typically, the many organizations that produce guidelines are encumbered by institutional constraints and conflicts of interest, resulting in a profusion of outdated guidelines that do not adhere to recognized standards [12, 13, 16]. A potential solution for the limitations of nutrition guidelines outlined above is for an independent group with clinical and nutritional content expertise and skilled in the methodology of systematic reviews and practice guidelines, but unencumbered by institutional constraints and conflicts of interest, to produce trustworthy recommendations. The *BMJ* Rapid Recommendations project, an initiative of MAGIC (Making GRADE the Irresistible Choice), has recently demonstrated the feasibility and utility of this approach and provided us with the inspiration for NutriRECS (Nutritional Recommendations and accessible Evidence summaries Composed of Systematic reviews) [37]. The NutriRECS working group aims to develop trustworthy nutritional recommendations based on internationally accepted methodological standards [12, 13, 16].

Objectives

NutriRECS will develop trustworthy guideline recommendations in nutrition. To do so we will include the application of novel and rigorous systematic review and guideline methods using the GRADE approach to investigate the relationship between diets, foods, nutrients and health outcomes; integrate patient and community values and preferences to inform guideline recommendations; apply strict safeguards against conflicts of interest; and use Evidence to Decision (EtD) frameworks to help people use the evidence in a structured and transparent way.

Given the extensive number of research questions and interventions in the broad field of nutrition, NutriRECS will only have the capacity to focus on a small number of guideline projects. Selected projects will be of broad interest to the general public and previous guideline recommendations produced by multiple authoritative organizations will have evidence of extensive methodological limitations (e.g. red and processed meat).

Methods

GRADE approach

The GRADE (Grading Recommendations, Assessment, Development and Evaluation) approach is a system for rating the quality of a body of evidence in systematic reviews and grading practice guideline recommendations in health care. GRADE offers a transparent and structured process for developing and presenting systematic reviews, and for carrying out the steps involved in developing recommendations (strong or weak) based on these evidence reviews [16]. Although the certainty of evidence represents a continuum, the GRADE approach results in an assessment of the certainty of a body of evidence into one of four categories (Table 2).

Table 2 Certainty of evidence

GRADE	*Definition*
High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very Low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Although certainty of evidence is a continuum; GRADE's discrete categorisation involves some degree of arbitrariness. Nevertheless, advantages of simplicity, transparency, and vividness outweigh these limitations

The strength of a recommendation (strong versus weak) reflects the extent to which a guideline panel is confident that adhering to a recommendation will have more desirable than undesirable consequences, or vice versa, across the range of patients, or members of the public, for whom the recommendation is intended (Table 3). The resulting recommendations would for instance either recommend in favor, or against, people reducing their intake of a particular food or dietary pattern, or, in choosing their diets, not base their choice of foods on these considerations. If appropriate, guideline panels may formulate recommendations on specific subgroups of interest (e.g. those with and without risk factors).

Panel composition and conflict of interest

For each NutriRECS project, panel members will be diverse (i.e. patients and community members, nutritional epidemiologists, research methodologists, primary care physicians, registered dietitians). As the emphasis of NutriRECS will be on producing unbiased recommendations, it will be important to limit conflicts of interest given that conflicts may be associated with conclusions in systematic reviews of nutrition [25, 26], and with nutritional recommendations [9, 21].

Neither the chair nor the methods editor for each NutriRECS guideline project will have any financial conflicts of interest. A financial conflict of interest

Table 3 Implications of strong and weak recommendations for different end-users

Implications	*Strong Recommendation*	*Weak Recommendation*
For patients	Most individuals in this situation would want the recommended course of action and only a small proportion would not.	The majority of individuals in this situation would want the suggested course of action, but many would not.
For clinicians	Most individuals should receive the recommended course of action. Adherence to this recommendation according to the guideline could be used as a quality criterion or performance indicator. Formal decision aids are not likely to be needed to help individuals make decisions consistent with their values and preferences.	Recognize that different choices will be appropriate for different patients, and that you must help each patient arrive at a management decision consistent with her or his values and preferences. Decision aids may well be useful helping individuals making decisions consistent with their values and preferences. Clinicians should expect to spend more time with patients when working towards a decision.
For policy-makers	The recommendation can be used to develop policy (e.g. tax on products high in sugar or salt)	Policy-making will require substantial debates and involvement of many stakeholders. Policies are also more likely to vary between regions. Performance indicators would have to focus on the fact that adequate deliberation about the management options has taken place.

would include the panel member or a family member of the panel member having received funds directly from a company that produces or promotes a particular dietary pattern, food, or nutrient. NutriRECS members will also be screened for intellectual conflicts that include having authored, co-authored, or held grant funding related to the topic of the guidelines, or have previously expressed strongly held beliefs about the guideline topics. We will also screen potential NutriRECS members for strong personal or religious beliefs related to the guideline remit. Each panel member will submit a full conflict of interest form, which will include declarations of financial, intellectual and other potential conflicts.

We will also closely manage the conflicts of interests among members of the systematic review team and the guideline panel team (no member can have financial conflicts of interest and no more than one-fourth of members can have intellectual conflicts). Up to one third of authors on the systematic review team can participate on the guideline panel to help ensure that panellists are fully informed on the results and nuances of the systematic review. The methods editor will manage interactions between systematic review team and the NutriRECS panel, and submit content to a journal.

Initial NutriRECS research question and evidence of effects based on systematic reviews

The initial target question for the systematic review to inform the first NutriRECS project on red and processed meat is as follows:

> *Among adults, what is the impact of dietary patterns higher in red and processed meat* versus *diets lower in red and processed meat intake (replacement with fish, white meats or vegetarian or vegan diet) on the risk of outcomes important to patients and community members (*i.e. *overall and cardiovascular mortality, cancer, weight, quality of life, satisfaction with diet, type II diabetes, and cardiovascular outcomes [fatal and non-fatal coronary heart disease, non-fatal stroke, non-fatal myocardial infarction, major adverse cardiac events (MACE)]) and on factors that may have a causal relation to cardiovascular outcomes (hypertension and cholesterol), or other adverse outcomes (haemoglobin)?*

With respect to red and processd meat consumption, most dietary guidelines suggest limited consumption of meat because of the reported association with cancer [38–40]. There is, however, a discrepancy between RCTs and observational studies on the topic. Although observational studies tend to show a significant association between red meat consumption and cancer [41], the Women's Health Initiative, one of the largest RCTs conducted assessing dietary patterns, reported that women consuming a low fat diet reduced red meat consumption by 20% compared to controls, yet there was no effect on multiple cancer types, including colorectal cancer [42, 43]. Despite this, the WHO has indicated that consumption of red meat is "probably carcinogenic" to humans while processed meat is considered carcinogenic to humans [44].

Using the GRADE approach we will begin by working with our NutriRECS panelists to structure and refine our health care questions in terms of the population of interest, and the alternative dietary strategies (e.g. restricted versus unrestricted dietary patterns) based on the most important outcomes to the target audience. For all NutriRECS projects, the target outcomes will be selected based on importance to patients and members of the general community, and will be elicited prior to our conducting the systematic reviews of the literature based on discussions with our NutriRECS panel. Each NutriRECS project panel will have

patients and members of the general community to ensure selected outcomes are of importance. Unlike dietary guidelines we are aware of, we will also work with NutriRECS panel to identify subgroups of interest (e.g. age, gender, co-morbidities) and will register the research question and systematic review protocol, including the subgroups of interest, in PROSPERO (https://www.crd.york.ac.uk/prospero/).

In consultation with an expert librarian, we will conduct a systematic search to identify all relevant studies. We will use data from all eligible studies to generate independent estimates of the effect from observational studies and randomized trials, including 95% confidence interval, for all patient or public important outcomes. We will ensure the rigor of the review process by following Cochrane Handbook guidance, including conducting duplicate screening of articles, documenting a priori hypotheses to explain heterogeneity, and conducting formal assessment of risk of bias in duplicate. Further, systematic reviews and meta-analyses of observational studies of food or nutrient intakes (e.g. processed meat), typically presented by generating relative or absolute differences between high consumers (e.g. quantile 5) and low consumers (e.g. quantile 1) of a target exposure will be summarized and evaluated seperately from observational studies that assess dietary patterns (i.e. patterns that are higher in processed meat, and other patterns of food consumption). Subsequently, as a novel method, we will use the summary estimates for each to further assess etiologic causal inferences. To do so, among outcomes with a statistically significant effect for a food or nutrient, if there is also a significant effect (with similar estimates) based on the dietary pattern data, this will be seen as evidence that undermines the casual inference for the target food or nutrient (e.g. processed meat).

After consultation with the NutriRECS panel members, our research question, subgroups of interest and systematic review methods for red and processed meat and health outcomes has been publically registered with PROSPERO (ID=CRD42017074074).

Certainty in body of evidence

Subsequently, in duplicate, we will use GRADE methods to rate the certainty of evidence for each outcome across all eligible studies according to study design (randomized trials or observational studies) and five factors that can reduce certainty of evidence (risk of bias, inconsistency of the results, indirectness of the evidence, imprecision and publication bias) and three that can increase certainty (large effect, dose-response gradient, and direction of plausible confounders). The certainty of evidence will reflect our confidence in the estimate of the effect.

Our certainty in the potential desirable and undesirable effects of the interventions based on the body of evidence will then be considered in making a recommendation.

Values and preferences of patients and community members related to diet restrictions and patterns

Optimal nutritional guideline development requires consideration of patient and community values and preferences associated with dietary patterns. By values and preferences we refer to individuals' predisposition to either favour (like) or not favour (dislike) something such as red meat [45]. Modifying dietary intake may be accompanied by either despondency or pleasure that affects satisfaction or quality of life. The difficulty many individuals have modifying their diet attests to their attachment to particular dietary practices. To inform NutriRECS work based on values and preferences of patients and community members, we will use the following methods: i) systematic reviews of the literature addressing values and preferences related to diet, and ii) inclusion of patient and public participants on the NutriRECS panel.

We will start by conducting a systematic review of the literature for evidence regarding peoples' values and preferences in regards to red meat.

Moving from evidence to recommendations

For moving from the evidence to recommendations we will use the Evidence to Decision (EtD) frameworks. The purpose of Evidence to Decision (EtD) frameworks is to help people use evidence in a structured and transparent way to inform decisions in the context of clinical and public health recommendations. These frameworks summarize evidence, and its certainty, for benefits, harms and burdens, values and preferences, cost considerations, as well as equity, acceptability, and feasibility (Table 4). This approach will ensure that all relevant decisions are transparent to target audiences, thus enabling decision makers in other jurisdictions to adopt or adapt our recommendations [46, 47].

The EtD frameworks have a common structure that includes formulation of the question, an assessment of the evidence for each criterion, and drawing conclusions. EtD frameworks make explicit the criteria that are used to assess interventions or options, the judgments made by each panel member for each criterion, and the research evidence and additional considerations used to inform each judgment. Research evidence refers to facts (actual or asserted) used to inform the panel's judgments that are derived from studies that used systematic and explicit methods. Additional considerations include other evidence, such as routinely collected data, assumptions, and logic used to make a judgment. As a novel innovation in the field of nutrition guideline development, using EtD frameworks we will survey and collect the anonymous judgements of each panel member prior to making the recommendations and use these judgements for the purpose of panel discussions prior to making the final recommendations. This way, panel

Table 4 Evidence to decision framework

	Judgement	Research evidence	Additional considerations
PROBLEM	Is the problem a priority? ○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ○ Don't know		
DESIRABLE EFFECTS	How substantial are the desirable anticipated effects? ○ Trivial ○ Small ○ Moderate ○ Large ○ Varies ○ Don't know		
UNDESIRABLE EFFECTS	How substantial are the undesirable anticipated effects? ○ Large ○ Moderate ○ Small ○ Trivial ○ Varies ○ Don't know		
CERTAINTY OF EVIDENCE	What is the overall certainty of the evidence of effects? ○ Very low ○ Low ○ Moderate ○ High ○ No included studies		
VALUES	Is there important uncertainty about or variability in how much people value the main outcomes? ○ Important uncertainty or variability ○ Possibly important uncertainty or variability ○ Probably no important uncertainty or variability ○ No important uncertainty or variability		
BALANCE OF EFFECTS	Does the balance between desirable and undesirable effects favor the intervention or the comparison? ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ Don't know		
RESOURCES REQUIRED	How large are the resource requirements (costs)? ○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ○ Don't know		
RESOURCES REQUIRED	What is the certainty of the evidence of resource requirements (costs)? ○ Very low ○ Low ○ Moderate ○ High ○ No included studies		
COST EFFECTIVENESS	Does the cost-effectiveness of the intervention favor the intervention or the comparison? ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ○ No included studies		
EQUITY	What would be the impact on health equity? ○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ○ Don't know		
ACCEPTABILITY	Is the intervention acceptable to key stakeholders? ○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ○ Don't know		
FEASIBILITY	Is the intervention feasible to implement? ○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ○ Don't know		

members who may be afraid to voice dissenting views during panel meetings will have an opportunity to make their views known. For instance, panel members may make different judgments for one or more subgroups

(such as patients who are older or who have more severe disease) in relation to some or all of the criteria.

Afterwards, panels review the judgments they have made for all of the criteria in their assessment and consider the implications of those judgments for the recommendation or decision. Based on their assessment, the panel draws conclusions about the strength of recommendation or type of decision; for example, a strong or weak (sometimes called conditional, discretionary, or qualified) recommendation for or against an intervention or option.

Finally, the panel states the recommendation or decision in a concise, clear and actionable manner, and provides the justification for their recommendation or decision. The conclusions also include relevant considerations about subgroups, implementation, monitoring and evaluation, and research priorities.

NutriRECS oversight and group process

We have formed an international NutriRECS Executive made up of systematic review and nutrition/public health experts (Dr. Bradley Johnston, Department of Community Health and Epidemiology, Dalhousie University, Halifax, Canada; Dr. Malgorzata M. Bala, Chair of Epidemiology and Preventive Medicine, Department of Hygiene and Dietetics, Jagiellonian University Medical College, Cracow, Poland; Cochrane Poland), experts in guideline methods (Dr. Pablo Alonso-Coello, Iberoamerican Cochrane Centre, Barcelona, Spain; Dr. Gordon Guyatt, McMaster University, Hamilton, Canada), and a community member with guideline experience (Ms. Catherine Marshall, Cochrane Community Representative, New Zealand). The Executive will determine the nutrition topics, the systematic review and practice guideline methods, review and approve conflicts of interest statements and decide whether they are acceptable and, if acceptable, how they will be managed.

Each NutriRECS question will be addressed by a panel including a chair, a methods editor, and upwards of 15 additional panel members from around the world. The chair will be responsible for the management of the NutriRECS guideline panel meetings, while the methods editor will be responsible for assembling the panel and review team, summarizing conflicts of interest for final assessment by the NutriRECS Executive, and creating relevant content (e.g. research questions, subgroups of interest, summary of findings tables based on systematic reviews, surveys using EtD frameworks, and recommendations contextualized based on panelists values and preferences). To produce the systematic reviews, Evidence Profiles, Evidence to Decision frameworks, and user-friendly multi-layered presentation formats (interactive Summary of Findings tables, decision aids), we will use relevant software that has been developed and user tested via randomized trials, surveys and consensus processes [46–50]. Prior to the release of our recommendations we will post the recommendations on our website (www.nutrirecs.com) and seek feedback from members of the public.

Dissemination plan

Nutritional guidelines and the supporting systematic reviews will be widely disseminated via publication in a high-impact general medicine journal. As well, using GRADE summary of findings tables and decision aids, we will produce user-friendly outputs for clinicians, patients and the community members, including plain language summaries in multiple languages (e.g. Arabic, Cantonese, French, Hindi, Mandarin, Polish, Portuguese, Spanish), and work to ensure these outputs are open-access.

Discussion

Main objectives

NutriRECS and corresponding systematic reviews will bring together patients and community members as well as international experts in nutrition and evidence synthesis and translation. Patients, community members and research experts will have the opportunity to reflect on the values and preferences of the communities for which the recommendations are intended in the context of the summary evidence and arrive at nutritional guideline recommendations. Subsequently the guidelines will be sent for peer-review, and recommendations will be publically available via open-access publication.

Strengths and limitations

The strength of our proposed methods includes our commitment to internationally accepted guideline standards from IoM, GRADE, AGREE and GIN. Our core NutriRECS group includes leading members of these organizations, including GRADE and AGREE. Adherence to these standards will ensure that our recommendations are based on high quality, novel systematic reviews of the literature. Our nutritional recommendations will be put forward by a group of community representatives and experts in nutrition and epidemiology from around the world, representatives and experts with limited to no intellectual or financial conflicts of interest.

Potential limitations of our NutriRECS work include the current lack of resources to ensure that our recommendations remain fully accessible around the world to all potential end-users, including patients and members of the general community, via multiple platforms, and that our systematic reviews and nutritional recommendations remain updated. We are currently seeking funds to regularly update our NutriRECS work, and to have full access to the MAGIC authoring and publication platform (www.magicapp.org) which, based on GRADE evidence summaries, provide

decision aids to clinicians, patients and the community on all electronic devices (e.g. laptops, handheld devices). Should we be successful with our funding applications, we will link the scientific journal articles directly to the content in MAGICapp.

A second limitation is sustained funding for our work. NutriRECS is made up of a growing international network of investigators and trainees based in four centres located in Canada (Dalhousie University and McMaster University), Spain (Iberoamerican Cochrane Centre) and Poland (Cochrane Poland). Among the four centres, we have access to an extensive number of local, national, multi-national grant funding opportunities (e.g. Canadian Institutes of Health Research, Heart and Stoke Foundation, Beatrice Hunter Cancer Research Institute, World Cancer Research Foundation). As with almost all independent research programs, we do not have permanent funding for the NutriRECS program. To secure ongoing funding, our team of investigators and trainees consistently write operational grants, career grants and trainee grants. We also sustain ourselves through a large network of research volunteers in exchange for methods training and publication.

A third limitation of our effort is that we have not yet been in contact with organizations producing nutrition guidelines to try and forge a collaboration. Our strategy is to show what can be accomplished in producing trustworthy guidelines by an independent group with limited resources. Having achieved that goal, we believe that this will place us in a more credible position when interacting with established organizations.

Conclusions

The implications of the NutriRECS project include the promotion of better-informed decision-making by patients, members of the community, clinicians, and public health policy-makers on the desirable and undesirable effects of alternative dietary patterns, as well as foods and nutrients on important health outcomes.

Abbreviations

AGREE: Appraisal of Guidelines Research and Evaluation; EtD: Evidence to Decision; GIN: Guidelines International Network; GRADE: Grading Recommendations, Assessment, Development and Evaluation; INR: International Normalized Ratio; IoM: Institute of Medicine; NutriRECS: Nutritional Recommendations and accessible Evidence summaries Composed of Systematic reviews

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Authors' contributions

BCJ, PAC, MMB, POV, DZ and GG conceptualized the methods. BCJ drafted the manuscript and all authors reviewed several drafts of the manuscript for critical content. All authors approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

BCJ, PAC, POV and GG are members of the GRADE working group. Remaining authors declare no competing interests.

Publisher's Note

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CLINICAL GUIDELINE

Annals of Internal Medicine

Unprocessed Red Meat and Processed Meat Consumption: Dietary Guideline Recommendations From the Nutritional Recommendations (NutriRECS) Consortium

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Description: Dietary guideline recommendations require consideration of the certainty in the evidence, the magnitude of potential benefits and harms, and explicit consideration of people's values and preferences. A set of recommendations on red meat and processed meat consumption was developed on the basis of 5 de novo systematic reviews that considered all of these issues.

Methods: The recommendations were developed by using the Nutritional Recommendations (NutriRECS) guideline development process, which includes rigorous systematic review methodology, and GRADE methods to rate the certainty of evidence for each outcome and to move from evidence to recommendations. A panel of 14 members, including 3 community members, from 7 countries voted on the final recommendations. Strict criteria limited the conflicts of interest among panel members. Considerations of environmental impact or animal welfare did not bear on the recommendations. Four systematic reviews addressed the health effects associated with red meat and processed meat consumption, and 1 systematic review addressed people's health-related values and preferences regarding meat consumption.

Recommendations: The panel suggests that adults continue current unprocessed red meat consumption (weak recommendation, low-certainty evidence). Similarly, the panel suggests adults continue current processed meat consumption (weak recommendation, low-certainty evidence).

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Contemporary dietary guidelines recommend limiting consumption of unprocessed red meat and processed meat. For example, the 2015–2020 Dietary Guidelines for Americans recommend limiting red meat intake, including processed meat, to approximately 1 weekly serving (1). Similarly, United Kingdom dietary guidelines endorse limiting the intake of both red and processed meat to 70 g/d (2), and the World Cancer Research Fund/American Institute for Cancer Research recommend limiting red meat consumption to moderate amounts and consuming very little processed meat (3). The World Health Organization International Agency for Research on Cancer has indicated that consumption of red meat is "probably carcinogenic" to humans, whereas processed meat is considered "carcinogenic" to humans (4).

These recommendations are, however, primarily based on observational studies that are at high risk for confounding and thus are limited in establishing causal inferences, nor do they report the absolute magnitude of any possible effects. Furthermore, the organizations that produce guidelines did not conduct or access rigorous systematic reviews of the evidence, were limited in addressing conflicts of interest, and did not explicitly address population values and preferences, raising questions regarding adherence to guideline standards for trustworthiness (5–9).

A potential solution to the limitations of contemporary nutrition guidelines is for an independent group with clinical and nutritional content expertise and skilled in the methodology of systematic reviews and practice guidelines, methods that include careful management of conflicts of interest, to produce trustworthy recommendations based on the values and preferences of guideline users. We developed the Nutritional Recommendations (NutriRECS) (7) international consortium to produce rigorous evidence-based nutritional recommendations adhering to trustworthiness standards (10–12).

To support our recommendations, we performed 4 parallel systematic reviews that focused both on randomized trials and observational studies addressing the possible impact of unprocessed red meat and processed meat consumption on cardiometabolic and cancer outcomes (13–16), and a fifth systematic review addressing people's health-related values and preferences related to meat consumption (17). On the basis of these reviews, we developed recommendations for unprocessed red meat and processed meat consumption specific to health outcomes.

See also:

Related articles 703, 711, 721, 732, 742
Editorial comment 767

Web-Only
Supplement
CME/MOC activity

METHODS

Guideline Development Process

We developed our recommendations by following the NutriRECS guideline development process (7),

which includes use of GRADE (Grading of Recommendations, Assessment, Development and Evaluation) methodology (18–20). To inform our guideline recommendations, systematic reviews were conducted on the basis of a priori methods (21, 22).

Guideline Team Structure

This work involved 3 teams:

1. A core NutriRECS leadership team was responsible for supervision and coordination of the project and for drafting of the research questions, guideline protocol, and manuscripts.

2. A guideline panel included experts in health research methodology, nutritional epidemiology, dietetics, basic and translational research, family medicine, and general internal medicine. The panel included 3 members from outside the medical and health care communities. Panelists resided in high-income countries (Canada, England, Germany, New Zealand, Poland, Spain, and the United States).

3. A literature review team drafted the protocols for the systematic reviews, completed the literature search and eligibility review, abstracted data and conducted data analysis, and produced narrative and tabular summaries of the results.

Framework for Panel Construction and Guideline Recommendations

The core leadership team applied safeguards against competing interests (7). After generating a list of potential panel members without perceived vested interests, we contacted prospective candidates from North America, Western Europe, and New Zealand. Those who expressed interest completed a detailed form enumerating potential financial or intellectual conflicts during the previous 3 years. If important competing issues were identified (1 interested individual had financial conflicts), the potential panelist was not invited to participate. The **Appendix Table** (available at Annals .org) shows a summary of the authors' conflict of interest forms; a full list of competing interests is available upon request from Dr. Johnston.

Before our initial guideline panel meeting, the methods editor and panel chair contacted panelists, shared the draft questions, and received and incorporated feedback. At the initial meeting, the guideline panel discussed the scope of the project and agreed on the research questions and subgroups of interest. The panel focused on health outcomes thought to be associated with consumption of unprocessed red meat and processed meat and chose not to consider animal welfare and environmental issues related to meat consumption in making recommendations. The panel chose to exclusively focus on health outcomes because environmental and animal welfare concerns are very different issues that are challenging to integrate with health concerns, are possibly more societal than personal issues, and vary greatly in the extent to which people find them a priority. Finally, to consider these issues rigorously would require systematic reviews that we were not resourced to undertake.

The panel also chose to make separate recommendations for unprocessed red meat and processed meat, given the potential for differential health effects and differing values and preferences of members of the public with regard to consumption of unprocessed meat versus processed meat.

Target Audience for Recommendations

The target audience for our guidance statement was individuals who consume unprocessed red meat or processed meat as part of their diet. The panel took the perspective of individual decision making rather than a public health perspective.

Key Principles for PICO Questions and Study Eligibility Criteria

Each NutriRECS project addresses a single nutrition question or topic, in this case guidance regarding the potential harms, benefits, and health-related values and preferences related to consuming unprocessed red meat and processed meat. We conducted a series of systematic reviews to inform our recommendations, addressing the following questions: 1) Among adults, what is the effect of diets and dietary patterns lower in red or processed meat versus diets higher in red or processed meat intake on the risk for outcomes important to community members? and 2) What are their health-related values and preferences for red and processed meat consumption?

The panel considered all-cause mortality, major cardiometabolic outcomes (cardiovascular mortality, stroke, myocardial infarction, and diabetes), cancer incidence and mortality (gastrointestinal, prostate, and gynecologic cancer), quality of life, and willingness to change unprocessed red or processed meat consumption as "critically important" for developing recommendations. "Important" outcomes included surrogate outcomes (weight, body mass index, blood lipids, blood pressure, hemoglobin, anemia) and reasons for eating unprocessed red meat and processed meat.

Methods for Systematic Reviews

In consultation with an expert librarian, we searched the major literature databases to identify all relevant studies on harms, benefits, and health-related values and preferences regarding unprocessed red meat and processed meat. Each database was searched from inception until July 2018 without restrictions on language or date of publication, with MEDLINE searched through to April 2019 (see the systematic reviews in this issue [13–17]).

For harms and benefits, we included any randomized trial, as well as cohort studies including 1000 or more adults, that assessed diets with varying quantities of unprocessed red meat (for example, as servings or times/wk, or g/d) or processed meat (meat preserved by smoking, curing, salting, or addition of preservatives) (23) for a duration of 6 months or more. Studies in which more than 20% of the sample was pregnant or had cancer or a chronic health condition, other than cardiometabolic disease, were excluded. The review articles report our methods for screening, data abstraction, risk of bias assessment, and data analysis (13–17).

Panelists considered 3 servings per week as a realistic reduction in meat consumption (for example, moving from 7 to 4 servings, or 4 to 1 serving) on the basis of the average intake of 2 to 4 servings per week in North America and Western Europe (24–28). We therefore framed the evidence regarding the potential reduced risks associated with a decrease of 3 servings per week of both unprocessed red meat and processed meat.

We used GRADEpro software to formulate GRADE summary of findings tables for each PICO (population, intervention, control, and outcomes) question (29). The overall certainty of evidence was evaluated by using the GRADE approach (18). For estimates of risk with current levels of meat consumption, we used population estimates from the Emerging Risk Factors Collaboration study for cardiometabolic outcomes (30) and population estimates from GLOBOCAN for cancer outcomes (31). Using these resources, we based our estimates for cardiometabolic mortality and incidence outcomes on an average of 10.8 years of follow-up, whereas for cancer mortality and incidence, our estimates are for the overall lifetime risk.

Complementing existing GRADE standards and to determine whether we should rate up for a dose–response effect, we assessed the plausibility of a causal relationship between meat and adverse health outcomes by contrasting results from 2 bodies of evidence (7, 22): cohort studies specifically addressing red meat and processed meat intake, and cohort studies addressing dietary patterns associated with varying red meat and processed meat consumption. We hypothesized that if red meat and processed meat were indeed causally related to adverse health outcomes, we would find stronger associations in studies that specifically addressed red meat and processed meat intake versus studies addressing dietary patterns (7).

To address health-related values and preferences regarding red meat and processed meat, we included qualitative (such as interviews and focus groups) and quantitative (such as cross-sectional surveys) studies conducted in adults. We independently screened studies, abstracted data, and assessed risk of bias (17). We then synthesized the data into narrative themes and tabulated summaries, and again assessed the certainty of evidence by using the GRADE approach (18, 32).

To assist our 3 public panel members without health science backgrounds, the method's editor conducted electronic meetings with them before the guideline panel meetings to explain the systematic review results and the GRADE approach for assessing the certainty of evidence and for moving from evidence to recommendations. During the guideline panel meetings, the leads of each of the systematic reviews shared the summary data and certainty of evidence for each of our outcomes with the guideline panel, and the panel chair answered any questions as necessary.

Moving From Evidence to Recommendations

Before our final guideline panel meeting, we asked each panelist to complete a GRADE Evidence to Decision (EtD) framework. The purpose of EtD frameworks is to help panelists use the evidence summaries in a structured and transparent way to develop the final recommendations. In doing so, the panelists considered evidence summaries for health effects, values, and preferences as well as cost, acceptability, and feasibility of a recommendation to decrease meat consumption (33). During the final meeting, the panel reviewed the results of the EtD survey and considered the implications of those judgments for their recommendations.

RESULTS

Recommendation for Unprocessed Red Meat

For adults 18 years of age or older, we suggest continuing current unprocessed red meat consumption (weak recommendation, low-certainty evidence). Eleven of 14 panelists voted for continuation of current unprocessed red meat consumption, whereas 3 voted for a weak recommendation to reduce red meat consumption.

Recommendation for Processed Meat

For adults 18 years of age or older, we suggest continuing current processed meat consumption (weak recommendation, low-certainty evidence). Again, 11 of 14 panel members voted for a continuation of current processed meat consumption, and 3 voted for a weak recommendation to reduce processed meat consumption.

Evidence Summary for Harms and Benefits of Unprocessed Red Meat Consumption

For our review of randomized trials on harms and benefits (12 unique trials enrolling 54 000 participants), we found low- to very low-certainty evidence that diets lower in unprocessed red meat may have little or no effect on the risk for major cardiometabolic outcomes and cancer mortality and incidence (15). Dose–response meta-analysis results from 23 cohort studies with 1.4 million participants provided low- to very low-certainty evidence that decreasing unprocessed red meat intake may result in a very small reduction in the risk for major cardiovascular outcomes (cardiovascular disease, stroke, and myocardial infarction) and type 2 diabetes (range, 1 fewer to 6 fewer events per 1000 persons with a decrease of 3 servings/wk), with no statistically significant differences in 2 additional outcomes (all-cause mortality and cardiovascular mortality) (16). Dose–response meta-analysis results from 17 cohorts with 2.2 million participants provided low-certainty evidence that decreasing unprocessed red meat intake may result in a very small reduction of overall lifetime cancer mortality (7 fewer events per 1000 persons with a decrease of 3 servings/wk), with no statistically significant differences for 8 additional cancer outcomes (prostate cancer mortality and the incidence of overall, breast, colorectal, esophageal, gastric, pancreatic, and prostate cancer) (13). Similar to studies directly addressing red meat, cohort studies assessing dietary patterns (70 cohort studies with just over 6 million participants) provided mostly uncertain evidence for the risk for adverse cardiometabolic and cancer outcomes. Although statistically significant, low- to very low-certainty evidence indicates that adherence to dietary

Table 1. Causal Inference Assessment Based on Summary of Evidence for Statistically Significant Effects for Red Meat, Processed Meat, and Dietary Patterns

Outcome	Unprocessed Red Meat		Processed Meat		Dietary Patterns	
	Risk Difference	Certainty of Evidence	Risk Difference	Certainty of Evidence	Risk Difference	Certainty of Evidence
Cardiovascular mortality*†	4 fewer per 1000 persons (from 5 fewer to 4 fewer) over 10.8 y	Very low	4 fewer per 1000 persons (from 7 fewer to 1 fewer) over 10.8 y	Very low	6 fewer per 1000 persons (from 9 fewer to 2 fewer) over 10.8 y	Very low
Type 2 diabetes*†	6 fewer per 1000 persons (from 7 fewer to 4 fewer) over 10.8 y	Low	12 fewer per 1000 persons (from 16 fewer to 9 fewer) over 10.8 y	Very low	14 fewer per 1000 persons (from 18 fewer to 8 fewer) over 10.8 y	Very low
Overall cancer mortality†‡	7 fewer per 1000 persons (from 9 fewer to 6 fewer) over lifetime	Low	8 fewer per 1000 persons (from 12 fewer to 6 fewer) over lifetime	Low	12 fewer per 1000 persons (from 18 fewer to 4 fewer) over lifetime	Very low

* Based on reference 16.
† Based on reference 14.
‡ Based on reference 13.

patterns lower in red or processed meat is associated with a very small absolute risk reduction in 9 major cardiometabolic and cancer outcomes (range, 1 fewer to 18 fewer events per 1000 persons), with no statistically significant differences for 21 additional outcomes observed (14). The tables in the **Supplement** (available at Annals .org) show the GRADE summary of findings for all systematic reviews on the harms and benefits associated with red and processed meat.

We summarize people's attitudes on eating meat below in a section on values and preferences. In short, omnivores enjoy eating meat and consider it an essential component of a healthy diet. There is also evidence of possible health benefits of omnivorous versus vegetarian diets on such outcomes as muscle development and anemia (34, 35), but we did not systematically review this literature.

Evidence Summary for Harms and Benefits for Processed Meat

No randomized trials differed by a gradient of 1 serving/wk for our target outcomes (15). With respect to cohorts addressing adverse cardiometabolic outcomes (10 cohort studies with 778 000 participants providing dose–response meta-analysis), we found low- to very low-certainty evidence that decreased intake of processed meat was associated with a very small reduced risk for major morbid cardiometabolic outcomes, including all-cause mortality, cardiovascular mortality, stroke, myocardial infarction, and type 2 diabetes (range, 1 fewer to 12 fewer events per 1000 persons with a decrease of 3 servings/wk), with no statistically significant difference in 1 additional outcome (cardiovascular disease) (16). For cohort studies addressing adverse cancer outcomes (31 cohorts with 3.5 million participants providing data for our dose–response analysis), we also found low- to very low-certainty evidence that a decreased intake of processed meat was associated with a very small absolute risk reduction in overall lifetime cancer mortality; prostate cancer mortality; and the incidence of esophageal, colorectal, and breast cancer (range, 1 fewer to 8 fewer events per 1000 persons with a decrease of 3 servings/wk), with no statistically significant differences in incidence or mortality for 12 additional cancer outcomes (colorectal, gastric, and pancreatic cancer mortality; overall, endometrial, gastric, hepatic, small intestinal, oral, ovarian, pancreatic, and prostate cancer incidence) (13). For cohort studies assessing dietary patterns (70 cohort studies with over 6 million participants), although statistically significant we found low- to very low-certainty evidence that adherence to dietary patterns lower in red or processed meat was associated with a very small absolute risk reduction in 9 major cardiometabolic and cancer outcomes (range, 1 fewer to 18 fewer events per 1000 persons), with no statistically significant differences for 21 additional outcomes observed (14). Again, we assessed the risk for adverse cardiometabolic outcomes on the basis of an average of 10.8 years follow-up, and adverse cancer outcomes over a lifetime.

In our assessment of causal inferences on unprocessed red meat and processed meat and adverse health outcomes, we found that the absolute effect estimates for red meat and processed meat intake (13, 16) were smaller than those from dietary pattern estimates (14), indicating that meat consumption is unlikely to be a causal factor of adverse health outcomes (**Table 1**). We anticipated that if unprocessed red meat or processed meat was indeed a causal factor in raising the risk for adverse outcomes, the observed association between unprocessed red and processed meat and adverse outcomes would be greater in studies directly addressing the lowest versus highest intake of unprocessed red or processed meat versus studies in which meat was only one component of a dietary pattern (7, 22). Using our findings, in our assessment of the certainty of evidence, we did not rate up for dose-response, given the potential for residual confounding (36). The tables in the **Supplement** (available at Annals .org) show the GRADE summary of findings.

Evidence Summary of Health-Related Values and Preferences for Meat

Our systematic review on health-related values and preferences yielded 54 articles from Australia, Canada,

Europe, and the United States, including 41 quantitative and 13 qualitative studies (17). Omnivores reported enjoying eating meat, considered meat an essential component of a healthy diet, and often felt they had limited culinary skills to prepare satisfactory meals without meat. Participants tended to be unwilling to change their meat consumption. The certainty of evidence was low for "reasons for meat consumption" and low for "willingness to reduce meat consumption" in the face of undesirable health effects, owing to issues of risk of bias (for example, unvalidated surveys), imprecision (small number of participants in qualitative studies), and indirectness (failure to specifically ask about the health benefits that would motivate a reduction in red or processed meat consumption) (Table 2).

Rationale for Recommendations for Red Meat and Processed Meat

The rationale for our recommendation to continue rather than reduce consumption of unprocessed red meat or processed meat is based on the following factors. First, the certainty of evidence for the potential adverse health outcomes associated with meat consumption was low to very low (13–16), supported by the similar effect estimates for red meat and processed meat consumption from dietary pattern studies as from studies directly addressing red meat and processed meat intake (13, 14, 16). Second, there was a very small and often trivial absolute risk reduction based on a realistic decrease of 3 servings of red or processed meat per week. Third, if the very small exposure effect is true, given peoples' attachment to their meat-based diet (17), the associated risk reduction is not likely to provide sufficient motivation to reduce consumption of red meat or processed meat in fully informed individuals, and the weak, rather than strong, recommendation is based on the large variability in peoples' values and preferences related to meat (17). Finally, the panel focused exclusively on health outcomes associated with meat and did not consider animal welfare and environmental issues. Taken together, these observations warrant a weak recommendation to continue current levels of red meat and processed meat consumption.

Table 2. Summary of Findings for Health-related Values and Preferences*

Outcomes	Studies (Participants), *n (n)*	Certainty of Evidence	Plain-Language Summary
Reasons for meat consumption	38 quantitative studies (62 963)	Low (rated down for risk of bias and indirectness)	Most omnivores were highly attached to their meat. Men had a more positive attitude than women toward meat consumption. Elderly omnivores were generally concerned about health with respect to their food choices. All vegetarians/low meat consumers reported health as one of the main reasons for not eating meat.
	10 qualitative studies (419)	Low (rated down for risk of bias, indirectness, and imprecision)	Most omnivores are highly attached to their meat consumption. Elderly omnivores believed that aging is associated with a decline in food intake. For many vegetarians, health concerns were the primary motivation to stop eating meat.
Willingness to change meat consumption in the face of undesirable health effects	5 quantitative studies (8983)	Low (rated down for risk of bias and indirectness)	Most omnivores reported low willingness to reduce meat consumption. In general, participants reported an overall mistrust related to the given information. Many participants believed that the presence of additives used in the production process was the real health problem rather than red meat consumption itself. Many participants already reduced their meat consumption in the past and did not plan any further changes.
	4 qualitative studies (616)	Low (rated down for risk of bias, indirectness, and imprecision)	Most omnivores reported low willingness to reduce meat consumption. Omnivores were concerned with reducing meat consumption because they perceived meat as an important component of a healthy diet, they enjoyed eating meat, and they believed they needed protein and the enjoyment of eating meat. Some omnivores believed they only ate small quantities of meat and did not need to reduce it (more often this referred to reducing red meat than all types of meat), and some believed they already reduced their meat consumption in the past. Some omnivores believed that the consequences of meat consumption were trivial compared with other behaviors (e.g., smoking tobacco). Some omnivores did not trust the available scientific information.

* Based on reference 17.

Other Considerations

The panel judged that although for some people in some circumstances, issues of cost, acceptability, feasibility, and equity may be relevant, these issues were not major considerations in making their judgments. Considerations of animal welfare, and particularly of environmental impact, will certainly be important to some individuals; the latter might be of particular importance from a societal perspective (37–41). The panel, at the outset, decided that issues of animal welfare and potential environmental impact were outside the scope of this guideline.

DISCUSSION

We developed recommendations for unprocessed red meat and processed meat by following the NutriRECS guideline development process, which adheres to the Institute of Medicine and GRADE working group standards. On the basis of 4 systematic reviews assessing the harms and benefits associated with red meat and processed meat consumption and 1 systematic review assessing people's health-related values and preferences on meat consumption, we suggest that individuals continue their current consumption of both unprocessed red meat and processed meat (both weak recommendations, low-certainty evidence).

Our weak recommendation that people continue their current meat consumption highlights both the uncertainty associated with possible harmful effects and the very small magnitude of effect, even if the best estimates represent true causation, which we believe to be implausible. Despite our findings from our assessment of intake studies versus dietary pattern studies suggesting that unprocessed red meat and processed meat are unlikely to be causal factors for adverse health outcomes (13, 14, 16), this does not preclude the possibility that meat has a very small causal effect. Taken together with other potential causal factors (for example, such preservatives as sodium, nitrates, and nitrites) (42) among dietary patterns with very small effects, this may explain the larger reductions among dietary patterns high in red meat and processed meat (14). The guideline panel's assessment was based on the available evidence regarding values and preferences suggesting that the majority of individuals, when faced with a very small and uncertain absolute risk reduction in cardiometabolic and cancer outcomes, would choose to continue their current meat consumption. People considering a decrease in their meat consumption should be aware of this evidence.

Our analysis has several strengths. We conducted 5 separate rigorous systematic reviews addressing both evidence from randomized trials and observational studies regarding the impact of unprocessed red meat and processed meat on cardiovascular and cancer outcomes (13–16), and community values and preferences regarding red meat and processed meat consumption (17). By using the GRADE approach, our reviews explicitly addressed the uncertainty of the underlying evidence. We present results focusing on absolute estimates of effects associated with realistic decreases in meat consumption of 3 servings per week (**Tables 4** through **7** in the **Supplement**), and these estimates informed our recommendations. Our panel included nutrition content experts, methodologists, health care practitioners, and members of the public, and we minimized conflicts of interest by prescreening panel members for financial, intellectual, and personal conflicts of interest and providing a full account of potential competing interests.

Our guideline also has limitations. We considered issues of animal welfare and potential environmental impact to be outside the scope of our recommendations. These guidelines may therefore be of limited relevance to individuals for whom these issues are of major importance. Related to this, we took an individual rather than a societal perspective. Decision makers considering broader environmental issues may reasonably consider evidence regarding the possible contribution of meat consumption to global warming and suggest policies limiting meat consumption on that basis.

Regarding the uncertainty of the evidence, randomized trials were limited by the small differences in meat consumption between the intervention and control groups, whereas observational studies were limited in the accuracy of dietary measurement and possible residual confounding related both to aspects of diet other than red meat and processed meat consumption and nondietary confounders, making decisions regarding meat consumption particularly value- and preference-dependent. With respect to our review on dietary patterns, studies did not typically report data separately for red and processed meat. Moreover, although all dietary patterns discriminated between participants with low and high red and processed meat intake, other food and nutrient characteristics of dietary patterns varied widely across studies (14). Evidence was also limited in that we found information insufficient to conduct planned subgroup analyses regarding the method of meat preparation (for example, grilling versus boiling) in terms of possible carcinogenic compounds from grilling, such as polycyclic aromatic hydrocarbons and heterocyclic amines (43). Finally, our panel was not unanimous in its recommendation: Three of the 14 panel members favored a weak recommendation in favor of decreasing red meat consumption.

As noted in our introduction, other dietary guidelines and position statements suggest limiting consumption of red and processed meat because of the reported association with cancer (1, 2, 44–46). There are 3 major explanations for the discrepancy between these guidelines and ours. First, other guidelines have not used the GRADE approach for rating certainty of evidence that highlight the low or very low certainty of evidence to support the potential causal nature of the association between meat consumption and health outcomes. As a result, we are less convinced of meat consumption as a cause of cancer. Because of the likelihood of residual confounding (that is, confounding that exists after adjustment for known prognostic factors)

the GRADE approach we used for assessing causation considers that, in the absence of a large effect or a compelling dose–response gradient, observational studies provide only low- or very low-certainty evidence for causation (47, 48). Second, even if one assumes causation, other guidelines have not calculated, or if calculated have not highlighted, the very small magnitude of the absolute adverse effects over long periods associated with meat consumption. Third, other guidelines have paid little or no attention to the reasons people eat meat, and the extent to which they would choose to reduce meat consumption given small and uncertain health benefits. Indeed, no prior dietary guideline has attended with care to evidence bearing on values and preferences, and in particular has not conducted a systematic review addressing the issue.

Nutritional guidelines are challenging because each potential source of evidence has substantial limitations. Randomized trials are limited by sample size, duration of follow-up, and the difficulties participants have in adhering to prescribed diets. These limitations make showing an intervention effect very challenging. Observational studies are limited in the inevitable residual confounding (unmeasured differences in prognosis that remain after adjusted analyses). These limitations in randomized trials and observational studies are evident in studies addressing meat consumption and health outcomes. Studies focusing on intermediate outcomes (such as cholesterol and triglyceride levels) have additional limitations, in that changes in biomarkers often fail to deliver the anticipated benefits in patient-important health outcomes. Therefore, our reviews focused only on those outcomes important to patients. Nutritional recommendations must, therefore, acknowledge the low-certainty evidence and avoid strong "just do it" recommendations that can, as evidenced by the many low-fat recommendations worldwide (9, 12, 49), be very misleading.

In terms of how to interpret our weak recommendation, it indicates that the panel believed that for the majority of individuals, the desirable effects (a potential lowered risk for cancer and cardiometabolic outcomes) associated with reducing meat consumption probably do not outweigh the undesirable effects (impact on quality of life, burden of modifying cultural and personal meal preparation and eating habits). The weak recommendation reflects the panel's awareness that values and preferences differ widely, and that as a result, a minority of fully informed individuals will choose to reduce meat consumption.

Our studies have implications for future research. Generating higher-certainty evidence regarding the impact of red meat and processed meat on health outcomes would be, were it possible, both desirable and important. It may not, however, be possible. Randomized trials will always face challenges with participants complying with diets that differ sufficiently in meat consumption, adhering to these diets for very long periods, and being available for follow-up over these long periods (12). These challenges are all the more formidable because results of observational studies may well represent the upper boundary of causal effects of meat consumption on adverse health outcomes, and the estimated effects are very small. Observational studies will continue to be limited by challenges of accurate measurement of diet, the precise and accurate measurement of known confounders (50), and the likelihood of residual confounding after adjusted analyses (13, 14, 16).

This assessment may be excessively pessimistic; indeed, we hope that is the case. What is certain is that generating higher-quality evidence regarding the magnitude of any causal effect of meat consumption on health outcomes will test the ingenuity and imagination of health science investigators.

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Reproducible Research Statement: *Study protocol:* Available at PROSPERO (www.crd.york.ac.uk/prospero/) (CRD 42017074074). *Statistical code and data set:* Available upon request from Dr. Johnston (e-mail, bjohnston@dal.ca).

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Appendix Table. Summary of Panelists' Potential Conflicts of Interest

Panel Member	Role	Financial Conflicts	Intellectual Conflicts	Other Relevant Disclosures
Pablo Alonso-Coello	Voting panel member; methodologist	No	No	Consumes 3 to 4 servings of both red or processed meat per week
Malgorzata Bala	Voting panel member; methodologist	No	No	Consumes 0.5 serving of both red or processed meat per week
Carlos Brotons	Voting panel member; primary care physician	No	No	Consumes 1 to 2 servings of both red or processed meat per week
Faiz Bhatia	Voting panel member; nonmedical public-partner	No	No	Consumes 2 to 3 servings of both red or processed meat per week; does not eat pork
Russell de Souza	Voting panel member; nutrition epidemiologist	No	No	Consumes 3 to 4 servings of red or processed meat per week
Susan Fairweather-Taitt	Voting panel member; human nutritionist	No	No	Consumes 2 to 3 servings of red meat per week and 1 to 2 servings of processed meat per month
Gordon Guyatt	Chair of panel; voting panel member; general internist; methodologist	No	No	Pescatarian; does not consume red or processed meat
Bradley Johnston	Guideline methods editor; voting panel member; methodologist	No	No	Consumes 1 to 2 servings of both red or processed meat per week
Catherine Marshall	Voting panel member; nonmedical public-partner; guideline consultant	No	No	Consumes 3 to 4 servings of both red or processed meat per week
Joerg Meerpohl	Voting panel member; pediatrician; methodologist	No	No	Consumes 3 to 5 servings of both red or processed meat per week
Chirag Patel	Voting panel member; bioinformatician	No	No	Consumes 0.5 serving of both red or processed meat per week
Patrick Stover	Voting panel member; basic nutrition scientist	No	No	Consumes 2 to 3 servings of both red or processed meat per week
Grzegorz Wójcik	Voting panel member; nonmedical public-partner	No	No	Consumes 3 to 4 servings of both red or processed meat per week
Dena Zeraatkar	Voting panel member; PhD student; methodologist	No	No	Consumes 6 to 7 servings of red meat per week

Correction: Nutritional Recommendations (NutriRECS) on Consumption of Red and Processed Meat

On the author disclosure forms accompanying recent related articles on red and processed meat consumption and health outcomes (1-6), Bradley Johnston did not indicate a grant from Texas A&M AgriLife Research to fund investigator-driven research related to saturated and polyunsaturated fats. This funding is for work in the field of nutrition and the start of funding period was within the 36-month reporting period required in Section 3 of the disclosure form of the International Committee of Medical Journal Editors (ICMJE). Dr. Johnston has updated his disclosure form to include this research funding and also to note funding received from the International Life Science Institute (North America) that ended before the 36-month ICMJE reporting period. The corrected disclosure forms now accompany the articles (1-6).

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STUDY PROTOCOL

REVISED Evaluating adults' health-related values and preferences about unprocessed red meat and processed meat consumption: protocol for a cross-sectional mixed-methods study [version 2; peer review: 2 approved]

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Abstract

Background: People need to choose from a wide range of foods, and in addition to availability and accessibility, people's values and preferences largely determine their daily food choices. Given the potential adverse health consequences of red and processed meat and the limited knowledge on individuals' health-related values and preferences on the topic, such data would be useful in the development of recommendations regarding meat consumption.
Methods and analysis: We will perform a cross-sectional mixed methods study. The study population will consist of adult omnivores currently consuming a minimum of three weekly servings of either

Open Peer Review

Approval Status ✓ ✓

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version 2 (revision) 13 May 2021	✓ view	✓ view
version 1 11 May 2020	? view	? view

1. **Mary Dicklin**, Midwest Biomedical Research,

unprocessed red meat or processed meat. We will explore participants' willingness to stop or reduce their unprocessed red meat, or their processed meat consumption through a direct-choice exercise. This exercise will consist of presenting a scenario tailored to each individual's average weekly consumption. That is, based on a systematic review and meta-analysis of the best estimate of the risk reduction in overall cancer incidence and cancer mortality, we will ask participants if they would stop their consumption, and/or reduce their average consumption. We will also present the corresponding certainty of the evidence for the potential risk reductions. Finally, we will measure their meat consumption three months after the interview and determine if they have made any changes to their average consumption.

Ethics and dissemination: The research protocol was approved by the ethics committees in Canada (Research Ethics Board, Dalhousie University), Spain (Comitè Ètic d'Investigació Clínica de l'IDIAP Jordi Gol), Poland (The Bioethics Committee of the Jagiellonian University), and Brazil (National Research Ethics Commission). The study is based on voluntary participation and informed written consent. Results from this project will be disseminated through publications and presentations.

Keywords
health, values and preferences, red meat, processed meat, cross-sectional study, mixed methods

This article is included in the Global Public Health gateway.

This article is included in the Sociology of Health gateway.

This article is included in the Agriculture, Food and Nutrition gateway.

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Any reports and responses or comments on the article can be found at the end of the article.

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REVISED **Amendments from Version 1**

We would like to thank the reviewers for taking the time to review our protocol (version 1) and for their comments. We have considered each comment in the new published version (version 2).

We would like to clarify that due to the COVID-19 pandemic, all sites are conducting the study remotely; only the pilot study was conducted in-person since it was implemented before the start of the pandemic.

We have improved the manuscript by clarifying the difference between the pilot study and the sites in which the study was actually conducted.

Further, given the pandemic, some changes in the study's methods and procedures were made, which are now reported in the new published version of the protocol (version 2). For this reason, all methodological aspects related to the in-person interviews and questionnaire administration have been removed and only the online/remote procedures are instead explained and reported in the manuscript.

Additionally, we have corrected some errors in Table1, we've clarified some procedurals aspects in the "Study procedures" section, and, finally, we have provided additional supplementary material as suggested by the reviewers.

Any further responses from the reviewers can be found at the end of the article

Introduction

Food choices are important for the overall health of each individual[1]. On a daily basis, people need to choose from a wide range of food in order to meet their nutritional requirements[2]. People's dietary values and preferences influence the types of foods they consume, as well as the quantity of consumption[3,4]. However, nutritional guidelines have consistently ignored the systematic identification and incorporation of people's values and preferences in the development of their recommendations[5,6].

In light of recent studies showing an association between unprocessed red meat and processed meat consumption and adverse health outcomes, such as all-cause mortality, cardiovascular mortality, cancer risk, and stroke[7–12], dietary guidelines have generally endorsed limiting meat intake (e.g. limiting processed meat)[13–15]. However, limited information exists regarding how much people value meat in their diet and their willingness to reduce meat consumption in the face of undesirable health effects[16]. Recently, an international panel of 14 members noted the low quality evidence supporting the causal relation of meat and adverse effects, and the small protective effect of reducing meat consumption if indeed such an effect exists. The panel formulated a weak recommendation in favor of continuing usual consumption[17]. The recommendation was also based on a systematic review of studies addressing peoples' values and preferences regarding meat consumption; however, the evidence was also judged to be of low quality given identified issues with risk of bias and indirectness[16].

We have therefore designed a study to evaluate adults' values and preferences regarding meat intake and their willingness to change their consumption in the face of possible undesirable health consequences. Given the general importance of reducing cancer, the recent claims on cancer risk associated with meat consumption from the International Agency for Research in Cancer and the World Cancer Research Fund[8,18], and in an attempt to avoid overwhelming participants with too much information, based on a systematic review of the literature[11], we chose the risk estimates for two cancer outcomes to share with participants, specifically cancer incidence and cancer mortality.

This study is part of NutriRECS (Nutritional Recommendations; www.nutrirecs.com)[19], an initiative that aims to: 1) apply rigorous systematic review and guideline methods using the GRADE approach to investigate the association between diets, foods and nutrients and health outcomes; 2) incorporate patient and community values and preferences to inform guideline recommendations; 3) apply strict and transparent management of conflicts of interest, and; 4) disseminate nutritional recommendations via open-access peer-reviewed publication.

Methods and analysis

Study design and setting

We are conducting an international cross-sectional mixed-methods study including: i) a quantitative assessment through an online survey; ii) a qualitative evaluation through semi-structured interviews and, iii) a follow-up quantitative assessment through a questionnaire in three different sites in three countries (Spain, Brazil, and Poland). Study settings will include universities, and the general community. The study began in 2019 with recruitment and data cleaning ongoing, with expected completion in early 2021. In 2019, we conducted a pilot study in a sample of 32 participants recruited in the general community in Nova Scotia and Prince Edward Island, Canada[20]. The results and feedback of this pilot study were used to inform and improve the study's procedures.

Study population and eligibility criteria

We will enroll adults 18 to 80 years of age who currently consume a minimum of three serving per week of either unprocessed red meat or processed meat. Unprocessed red meat is defined as mammalian meat (e.g. beef, pork, lamb), and processed meat is defined as white or red meat preserved by smoking, curing, salting, or by the addition of preservatives (e.g., hot dogs, charcuterie, sausage, ham, and cold cut deli meats)[21]. We will exclude adults who have active cancer; those who have severe cardiovascular disease (history of stroke, acute coronary syndrome, heart failure, and symptomatic peripheral arterial disease); those who are pregnant; and participants unwilling or unable to provide informed consent.

Recruitment strategy

We will recruit convenience samples of participants from the general population or people studying or working at universities. We will recruit participants from the general population using social media postings on the Cochrane website, Twitter, and Facebook pages. We will recruit people studying or working at universities by email. The social media posting and the emails will include information on study's details, eligibility

criteria, contact information of the researcher carrying out the study, and the related link to access the online survey.

Sample size

For the quantitative assessment, we have made a best estimate of the proportion willing to reduce their meat intake of approximately 0.5 using the response distribution results from our pilot study based on a proportion of 0.53 of pilot participants willing to reduce unprocessed red meat and 0.44 of participants willing to reduce processed meat[20]. We decided that a margin error around this estimate of as much as ± 0.1% is acceptable. We can achieve this precision with a 0.5 estimate in our primary outcome, the proportion of individuals ready to reduce or stop eating meat. Our sample size estimate is 96 participants at each site (95% confidence interval with ± 0.1% margin error)[22,23].

For the qualitative evaluation, through a maximum variation sampling strategy, in each site, we will include participants until data saturation. Data saturation is achieved when no additional concepts emerge[24]. During data collection and analysis, if the research team determines that we have not reached data saturation, recruitment will be extended to include more participants until saturation is achieved. The maximum variation technique consists of the inclusion of a highly heterogeneous sample, and a description of the variability or dispersion for the relevant variables[3,25]. We will attempt to include an approximately equal number of participants with the following characteristics of these variables: gender (men and women); age (those between 18 to 66 years old, and those between 67 and 80 years older); education level (those with some high school or less, those with a high school degree, and those with a college degree) and willingness to stop or reduce meat consumption (willing ≥5 from the Likert-Scale and unwilling ≤4 from the Likert-Scale).

Study procedures

For the quantitative assessment, participants interested in participating will access the online survey and will be able to complete the questionnaire, including demographic characteristics, medical history information and meat consumption beliefs and behavior. The questionnaire will also include a direct choice exercise that will consist in presenting scenarios tailored to each individual's typical weekly meat consumption. These scenarios will reflect the best estimate of absolute risk reduction in overall cancer incidence and cancer mortality over their lifetime based on our systematic review and dose-response meta-analysis[11]. This will allow us to assess participants' willingness to: a) stop or b) reduce their unprocessed red meat and processed meat intake in the face of overall cancer incidence and cancer mortality risks.

After presenting participants with the cancer incidence scenario tailored to their consumption, participants will be asked regarding their willingness to stop their unprocessed red meat intake. If participants will be unwilling to stop (≤4 of the Likert-scale), they will be presented with an additional question about their willingness to reduce. Similarly, participants will be then presented with the cancer mortality scenario and related questions for unprocessed red meat. Finally, participants will be presented with the cancer incidence and mortality scenarios tailored to their processed meat consumption with the same logic of questions explained above.

Participants will be presented with both scenarios of unprocessed red meat and processed red meat. If participants declare to consume less than one serving of one type of meat per week, for example unprocessed red meat, they will skip the questions on red meat and will be presented with the scenarios and questions of processed meat only and vice versa. Finally, we will conduct a follow-up assessment, either by phone or by email, at three months to ask participants, who agreed to be contacted, if they have made any changes in their meat consumption.

Questionnaire. Based on our pilot study, we further developed and piloted a questionnaire in each site to collect the following data: age, sex, socioeconomic status, educational level, employment status, household size, religious beliefs, the presence of chronic and other health conditions, and family history of cancer, and meat consumption beliefs and behavior information. We asked both men and women with different educational backgrounds and of different ages (those between 18 to 66 years old, and those between 67 to 80 years older) to complete the questionnaire in order to identify ways of improving the content and/or structure of the questionnaire.

We will assess participants' current weekly consumption of unprocessed red meat and processed meat. We will facilitate these questions related to their meat consumption habits by providing pictures illustrating types of meats and serving size to determine the typical number of servings they consume of each meat weekly. In addition, we will determine which factors participants take into account when choosing their diet, whether their food choices influence or are influenced by other people (e.g. preparing food for children) and to what extent they are satisfied with their current diet. See *Extended* data for the Spanish version of the online survey.

Serving size estimate and participant's current meat consumption assessment. We estimated that each serving of unprocessed red meat is equal to 120g, and 50g for processed meat[11]. In Spain, the mean ± standard deviation of meat intake, according to 2016 Spanish National dietary survey in adults, conducted by the Spanish Agency for Consumption, Food Safety and Nutrition, is 37 ± 63g/day (2 servings/week) of unprocessed red meat and 32 ± 65g/day (4 servings/week) of processed meat[26]. In Brazil, according to the Health Survey conducted in São Paulo in 2008, the mean ± standard error of meat intake is 71 ± 2 g/day (4 servings/week) of unprocessed red meat and 28 ± 1 g/day (4 servings/week) of processed meat[27]. In Poland, according to the domestic deliveries and consumption report of 2017, the average intake of both unprocessed meat and processed meat is 115 g/day (9 servings/week)[28]. In Canada, according to the Statistics Canada's Canadian Community Health Survey, the mean intake

among Canadians is 52 g/day (3 servings/week) of unprocessed red meat and 22 g/day (3 servings/week) of processed red meat[29]. Based on these data, we defined the average intake of both unprocessed red meat and processed meat as 3 servings per week to calculate the baseline risks of cancer incidence and cancer mortality. In order to assess participant's current meat consumption, we determined the absolute risk reduction for all meat consumption frequency categories (servings/week) as follows: 3 to 4, 5 to 6, 7 to 8, 9 to 10, 11 to 12, 13 to 14, and more than 15 servings per week. We will report in servings per week their current meat consumption for both unprocessed red meat and processed meat.

Direct choice exercise. Following standard methodologies used in previous work in the field of obstetrics from members of our team[30,31], we will use a direct choice experimental design to assess the proportion of people willing to change their consumption when faced with a risk reduction of overall cancer incidence and cancer mortality based on a seven point Likert- scale from 1 (meaning definitely not) to 7 (meaning definitely yes). To ensure that participants have a similar understanding of these two outcomes, we will describe the development of each outcome through the use of health states examples (Table 1 and Table 2). We will present our data from our systematic review that addressed the possible impact of reducing meat intake on overall cancer incidence and mortality[11]. We will first present the baseline risk and the risk reduction participants might achieve by stop eating meat and its certainty. We will develop an interactive electronic decision aid using MagicApp software (http://magicproject.org/research-projects/share-it/) to show the probabilities of reducing the risk of overall cancer incidence if participants' would stop eating unprocessed red or processed meat (three servings/week scenarios in Figure 1 for processed meat and Figure 2 for unprocessed red meat intake – see *Extended data*[32] for all servings/week scenarios). In addition to the risk reductions, the overall certainty of evidence based on the GRADE approach for cancer and incidence and mortality will be shared with the participant[33]. For the direct choice exercise in the online survey, we will provide an explanatory video that will describe to participants how to read and

Table 1. Health states - Cancer incidence.

Cancer incidence	
Symptoms & Signs	• Cancer is wide group of diseases and may cause many signs or symptoms • Some signs and symptoms are common for different cancers while others are more specific for each type of cancer • Not explained loss in body weight, night sweats, fever • Problems with eating, loss of appetite • Weakness/ fatigue • Sometimes bleeding or discharge, blood in stool or urine • Change in bowel habits, difficult or painful urination • Pain • Unexplained anemia • Persistent cough or blood in saliva • Persistent lumps or swollen glands • Changes on the skin
Treatment	• There are different types of treatment that will depend on the type of cancer and how the cancer is advanced. • You may receive only one treatment, but in most cases a combination of subsequent is needed: surgery and/or hormone therapy (giving hormones or drugs that block hormones to slow down cancer growth), chemo or immunotherapy (drugs that kill cancer cells or flag them for immune system to destroy) and/or radiation therapy (radiation in high doses to kill cancer cells or slow their growth).
Consequences	• You can experience side effects of cancer treatment, such as anemia, loss of appetite, fatigue, hair loss, nausea • You can experience pain, gastrointestinal problems, urinary problems • It will affect your social life short term and possibly long term • You can experience long-term consequences of cancer and its treatment, such as problems with heart, lungs, endocrine system, bones and joints, digestion, memory • You may experience anxiety, depression and other emotional problems • You may no longer be able to participate in your regular activities • You may die

Table 2. Health states – Cancer mortality.

Cancer mortality	
Symptoms & Signs	• Before you die you experience symptoms related to cancer and its spread, such as pain, weakness/fatigue; those symptoms may have various duration, you may suffer those symptoms for several years • Before you die you experience unwanted effects of treatment you received for cancer. • You are dead and you do not feel any pain or breathlessness.
Treatment	• There is no need for any treatments and they are stopped
Consequences	• You lose your vital bodily and mental functions, ending your life. • You will leave everything that was important in short time span.

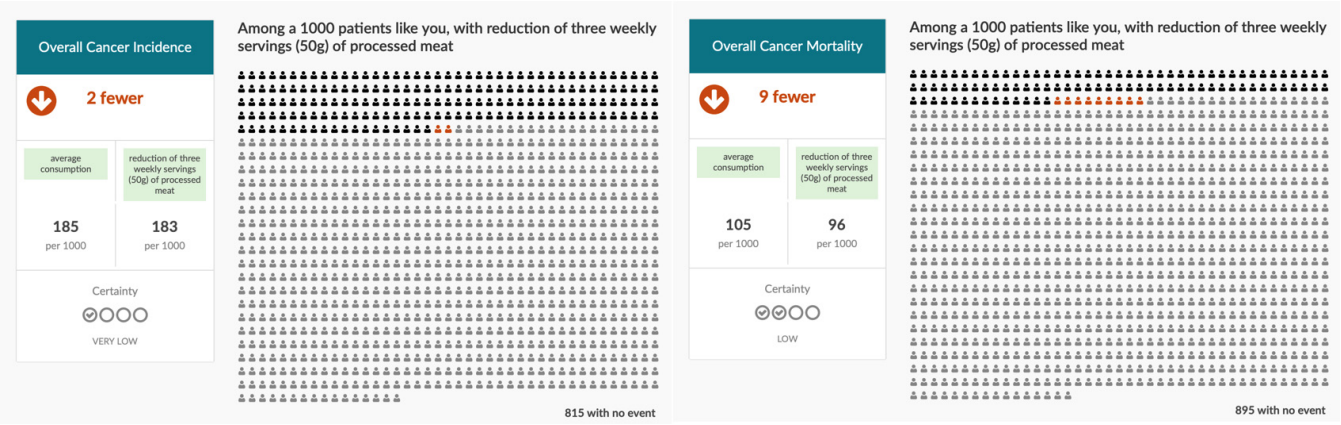

Figure 1. Three servings/week scenarios for processed meat.

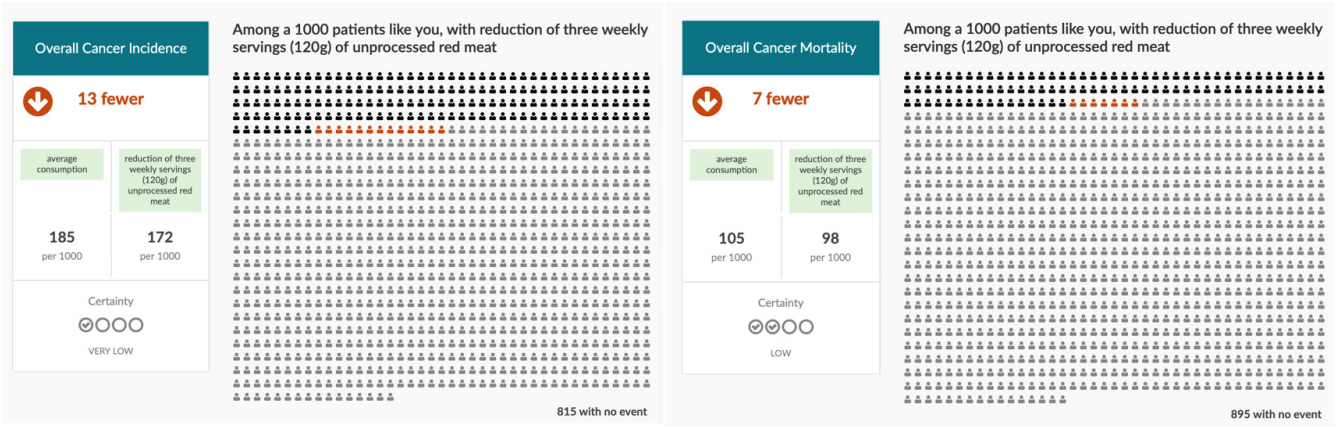

Figure 2. Three servings/week scenarios for unprocessed red meat.

interpret the data presented in the scenarios. In addition, we will provide participants with explicit text tailored to their average weekly meat consumption. If participants are unwilling to stop eating meat to achieve the possible associated health benefits, we will ask them if they would be willing to reduce their meat intake but remind them that the cancer risk

reduction, they might anticipate will be less by reducing their meat intake then stopping completely.

Semi-structured interview. We will also develop and pilot a script in each site for a semi-structured interview. We will conduct these interviews in order to explore peoples' motives regarding their willingness to change their meat consumption. Based on our pilot study, interviews will take approximately 30 minutes. See *Extended data* for the Semi-structured interview script.

Follow-up assessment. We will contact participants by phone or by email three months after the online survey and ask them if they have made any changes in their meat consumption. In case of the phone follow-up, we will follow a semi-structured telephone script previously piloted; in instances where participants prefer to be contacted by email, we will send them a questionnaire with the same content we will use for the phone interview. See *Extended data* for the Follow-up assessment script.

Outcomes

The primary outcome measure for all included participants will be willingness to change meat consumption in the face of the undesirable cancer health risks. We will show participants the cancer risk reduction they may achieve if they would stop eating unprocessed red meat or processed meat tailored to their weekly consumption and ask them if they are willing to stop, on a scale from 1 (meaning "definitely not") to 7 (meaning "definitely yes"). If participants are not willing to stop eating meat (≤4 from the Likert-scale), we will ask them if they will be willing to reduce any amount of their weekly meat intake, on a scale from 1 (meaning definitely not) to 7 (meaning definitely yes). As a secondary outcome, we will explore participants' values and preferences regarding meat intake and the related motives around their willingness or unwillingness to make any changes. We will ask participants in the qualitative evaluation, which factors determine their unprocessed red meat or processed meat intake, and to what extent these factors influence their willingness/unwillingness to stop/reduce their meat consumption. Finally, we will estimate their meat consumption at three months after the online survey and determine if they have made any changes.

Data synthesis and analysis

Quantitative analysis. We will describe participants' demographic and medical history information as well as meat consumption behaviors using means and standard deviations or frequencies and proportions, as appropriate.

We will describe the distribution of the continuous dependent variables: a) "willingness to stop unprocessed red meat consumption in the face of cancer incidence risk"; b) "willingness to stop unprocessed red meat consumption in the face of cancer mortality risk"; c) "willingness to reduce unprocessed red meat consumption in the face of cancer incidence risk"; d) "willingness to reduce unprocessed red meat consumption in the face of cancer mortality risk", by presenting histograms and using means and standard deviations or median and IQR, as appropriate. We will do the same analysis for processed meat. Then, we will conduct an exploratory linear regression analysis using the above dependent variables and the participants' characteristics (sex, age, level of education, occupational status, religious belief, and family history of cancer) as the independent variables. We will calculate the beta coefficients and the associated 95% confidence interval of participants who are willing to avoid, and for those willing to reduce unprocessed red meat and processed meat consumption in the face of undesirable cancer risks.

Additionally, we will conduct an exploratory logistic regression analysis using the dependent variables on willingness as categorical variables: those willing (≥5 from the Likert-Scale) and unwilling (≤4 from the Likert-Scale). We will calculate the odds ratio and the associated 95% confidence interval of participants who are willing to avoid and reduce meat consumption in the face of undesirable cancer risks.

Using our three-month follow-up assessment data, we will calculate the frequency and proportion of participants who made any changes in their meat consumption.

Qualitative analysis. We will audio-record and transcribe verbatim all semi-structured interviews and use thematic analysis for the qualitative analysis[34,35]. For our iterative analysis, we will use constant comparison within and across cases to identify any patterns. We will code all transcripts and then the codes will be sorted into themes. We will subsequently compare the identified themes with demographic and participant characteristic information collected to demonstrate any patterns among groups such as sex, age, and education level.

Integrating qualitative and quantitative analyses. We will conduct a sequential analysis of the quantitative and qualitative components of the data. We will analyze each dataset separately and then, at the end of the study, draw meta-inferences informed by the findings from both data sets. We expect the qualitative results to provide a better understanding of the decision-making process than if the quantitative results were considered alone.

Ethics and dissemination

Research approval was obtained by the Research Ethics Board, Dalhousie University (Canada; 2019-4715), the Clinical Research Ethics Committee of the Jordi Gol University Institute for Primary Care Research (IDIAP; Spain; 19/121-P), the Bioethics Committee of the Jagiellonian University (Poland; 1072.6120.141.2019), and the National Research Ethics Commission (Brazil; CAAE 21826419.4.0000.8527), and if needed will be obtained from all other participating sites. We will explain the entire process of the study to the participants and we will present the potential benefits and risks of participation. The potential benefits of this study to participants include gaining an understanding of the current research regarding overall cancer mortality and incidence based on an up to date high quality dose-response systematic review and meta-analysis[11], which participants could use in future dietary decisions. There are no potential physical or psychological risks to participating in this study.

Participation in the study is voluntary and participants may withdraw from the study at any time without penalty. Should they choose to withdraw; participants will decide whether they want us to discard all or some of the data they have provided. Participants willing to participate will have to sign a written consent form, and they will be assigned a number to anonymize all data collected. Consent forms will be kept separately in a secure cabinet. All interviews will be audio-recorded and transcribed onto a computer file. The recording device will be stored in a secure cabinet and the recordings will be deleted upon completion of the study. Participants will not be identified by name nor otherwise identified when research results are shared. It is possible that a participant could be quoted to highlight results, however, they will be anonymized and neither their name, nor their assigned alphanumeric code, will be shared. Participants will be made aware of this possibility during the consent process and may, if they wish, choose not to allow the use of direct quotations. No compensation will be provided to participants. We will share with participants a copy of our published final results by email or by postal service.

We will adhere to the checklist of good practice in the conduct and reporting of survey research[36] when reporting our results. Results will be disseminated through publications and presentations.

Discussion

Our international mixed-methods study will be the first to explicitly explore peoples' health-related values and preferences, and their willingness to stop and/or reduce meat consumption when informed of the potential adverse cancer risk, and the uncertainty around this evidence. The information patients will receive will be based on a recent systematic review and dose-response meta-analysis[11].

Our study in the context of previous research

Because there is limited information in the literature on how people value their health in relation to their diet, developing nutritional recommendations based on health-related values and preferences of community members is a major challenge. Previous studies addressing people's meat preferences did not adequately present the undesirable health effects of meat consumption in ways that captured the current evidence and its uncertainty[37,38].

In the context of the NutriRECS initiative, our team conducted a systematic review that summarized evidence that omnivores are attached to meat and are reluctant to reduce their meat consumption. However, we rated the certainty of evidence as low due to issues with risk of bias, indirectness, and because of the small number of participants and limited information regarding data analysis[16].

A NutriRECS international panel using an individual patient perspective formulated a weak recommendation in favor of continuing current unprocessed red meat and processed meat consumption, acknowledging the low certainty regarding the values and preferences evidence[17]. This experience triggered the design of the present study, aiming to overcome the limitations of the studies to date[16].

Limitations and strengths

Our study has some potential limitations. Our sample includes participants living in high-income countries or from high income strata in low to middle income countries. Therefore, we cannot generalize these findings to low-income populations. We will, however, collect information on participants' socioeconomic status and education level in order to explore the effect of these characteristics on participants' dietary values and preferences.

A second limitation of our study is the exclusive focus on cancer outcomes, despite evidence suggesting that reducing meat consumption may reduce the risk of diabetes and cardiovascular outcomes[12,39]. However, due to the recent claims of meat consumption and cancer risks[8,40], the inconsistency in data on cardiometabolic risk associated with both unprocessed and processed meat[10,39], and to not overburden participants with too much information, we prioritized two cancer outcomes.

Regarding strengths of our study design, we will address some of the limitations in the previous studies by following a systematic and transparent approach with the use of questionnaires, direct choice exercises and open-ended questions to assess peoples' health values in relation to their unprocessed red meat and processed meat consumption. We will inform people of the most recent evidence of meat consumption and its related cancer risks[11], including the certainty of evidence for these risks, according to their current weekly average consumption. In addition, we will explore their willingness to make any changes to their diet based on the potential risk reduction in cancer.

Our international multicentre study will help ensure generalizability of the results. In addition, the collection of both quantitative and qualitative data will enable an accurate identification of the current health values and preferences regarding meat consumption. In addition to our initial pilot study[20], we have further piloted the questionnaires and scripts in each center among both men and women, both with different educational backgrounds, and of different ages to ensure readability and understandability in the general population. We have trained research staff and we will monitor study procedures to ensure quality implementation throughout the interview process. Ultimately, we will follow-up participants to determine if they have made any changes in their meat consumption according to what they have reported during the initial interview; this will allow us to assess the consistency and reliability of our study findings.

Implications for practice and research

Our international study has direct implications for decision makers, guideline developers and policy makers in the development of nutritional recommendations. Up to now, this aspect

has been neglected when formulating recommendations. Panels will now have access to international research evidence on values and preferences specific to actual estimated risk reductions in cancer, and the relevant certainty, associated with decreased meat intake. Based on international GRADE standards[41], this information will prove crucial for guideline panels moving from the evidence to recommendations on red and processed meat.

One potential area of further research will be the evaluation of how panels are using this new evidence when formulating recommendations. This work will also inform clinicians regarding community values and preferences when considering the implementation of diet related changes with their patients. Our proposal will use innovative approaches to assess people's health values and preferences in relation to their diet. The study will provide a rigorous and transparent methodology that can be further utilized in the context of other nutritional scenarios.

Data availability

Underlying data

No data are associated with the article.

Extended data

- Open Science Framework: https://doi.org/10.17605/OSF.IO/4HKXQ[32]
    - All servings/week scenarios for processed meat and for unprocessed red meat intake,
    - Semi-structured interview script
    - Follow-up assessment script.
- Spanish version of the online survey available here.

Acknowledgments

This study will be conducted using MagicApp software (http://magicproject.org/research-projects/share-it/). MAGIC (Making GRADE the Irresistible Choice) is a non-profit Foundation, aiming to increase value and reduce waste in healthcare through a digital and trustworthy evidence ecosystem. MAGICapp is the core platform in the evidence ecosystem bringing digitally structured guidelines, evidence summaries and decision aids to clinicians and patients.

Claudia Valli is a doctoral candidate for the PhD in Methodology of Biomedical Research and Public Health (Department of Paediatrics, Obstetrics, Gynaecology and Preventive Medicine), Universidad Autònoma de Barcelona, Barcelona, Spain.

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ANNEX A. Evidence profile for "Reasons for meat consumption"

Review finding	Explanation	Certainty assessment with GRADE/ GRADE CERQual						Certainty
		№ of studies (participants)	Study design	Risk of bias/ Methodological limitations	Inconsistency/ Coherence	Indirectness/ Relevance	Imprecision/ Adequacy	
Reasons for meat consumption								
Most omnivores were highly attached to meat. **Men** had a more positive attitude towards meat consumption than women. **Elderly omnivores** were generally concerned about health in respect to their food choices. **All vegetarians/low meat consumers** reported health as one of the main reasons for not eating meat.	**Most omnivores** consumed meat because they enjoy eating it, meat is perceived as part of a healthy diet, and as part of their culture. Lack of food alternatives/cooking skills to prepare a tasty dish without meat were often mentioned as barriers. **Men** considered meat as part of a healthy diet, and as part of their culture. **Women** appeared substantially more concerned than men about health consequences. Health promotion was more important among the **elderly omnivores** than the younger population as a reason to start limiting animal products in their diet. **Elderly omnivores** were not more concerned about health than the other age groups: all age groups had strong health concerns. **Many vegetarians/low meat consumers** reported also other reasons such as animal welfare or environmental concerns as motives to avoid meat consumption.	38 (N=62,963)	Quantitative studies[1]	Serious[2]	Not serious	Serious[3]	Not serious	⊕⊕◯◯ **LOW**

[1] Countries: Finland, France, Ireland, Norway UK, Belgium, Australia, Germany, New Zeeland, Poland, Slovenia, Spain, Switzerland, USA, and Croatia.
[2] Twenty studies at high risk of bias due to the lack of validation of the measurement instruments.
[3] Indirectness due to the likely selectivity of study populations.

Review finding	Explanation	Certainty assessment with GRADE/ GRADE CERQual						Certainty
		№ of studies (participants)	Study design	Risk of bias/ Methodological limitations	Inconsistency/ Coherence	Indirectness/ Relevance	Imprecision/ Adequacy	
Most omnivores were highly attached to meat consumption. **Elderly omnivores** believed that ageing is associated with a decline in food intake. For **many vegetarians**, health concern was the primary motivation to stop eating meat.	**Most omnivores** consumed meat because they enjoy eating it, perceived meat as part of a healthy diet, and as part of their culture. Lack of food alternatives/cooking skills to prepare a tasty dish without meat were often mentioned as barriers in reducing meat consumption. **Elderly omnivores** reported a reduction in red meat compared to when they were younger, and many participants viewed fish as a healthier alternative to red meat. For **many vegetarians**, other reasons were also often reported as a major reason to adopt a vegetarian diet such as ethical concerns (e.g., animal welfare).	10 (N= 419)	Qualitative studies[4]	Minor concerns[5]	No concerns	Minor concerns[6]	Minor concerns[7]	⊕⊕◯◯ **LOW**

[4] Countries: Greece, Australia, USA, and UK.
[5] Three studies did not provide a description of the data analysis process and eight studies had minor methodological limitations due to lack of reporting of the investigator-participants relationship.
[6] Minor relevance concerns due to the likely selectivity of study populations.
[7] Minor adequacy concerns because of the small number of participants.

ANNEX B. Evidence profile for "Willingness to change meat consumption in the face of health concerns".

Review finding	Explanation	Certainty assessment with GRADE/ GRADE CERQual						Certainty
		№ of studies (participants)	Study design	Risk of bias/ Methodological limitations	Inconsistency/ Coherence	Indirectness/ Relevance	Imprecision/ Adequacy	
Willingness to change meat consumption in the face of undesirable health effects								
Most omnivores reported low willingness to reduce meat consumption.	**Generally participants** reported an overall mistrust related to the given information. **Many participants** believed that the presence of additives used in the production process was the real health problem rather than red meat consumption itself. **Many participants** already believed they reduced their meat consumption in the past and did not plan any further changes.	5 (N= 8,983)	Quantitative studies[8]	Serious[9]	Not serious	Serious[10]	Not serious	⊕⊕◯◯ **LOW**

[8] Countries: Spain, Germany, Finland Croatia, and Canada.

[9] Five studies at high risk of bias due to the lack of validation of the measurement instruments.

[10] It was downgraded for indirectness because three studies did not inform participants about the undesirable health effects of meat consumption and the likely selectivity of populations.

Review finding	Explanation	Certainty assessment with GRADE/ GRADE CERQual						Certainty
		№ of studies (participants)	Study design	Risk of bias/ Methodological limitations	Inconsistency/ Coherence	Indirectness/ Relevance	Imprecision/ Adequacy	
Most omnivores reported low willingness to reduce meat consumption.	**Omnivores** were concerned in reducing meat consumption because they perceived meat as an important component of a healthy diet, they enjoyed eating meat and they believed they needed protein and the enjoyment of eating meat. **Some omnivores** believed they only ate small quantities of meat and did not need to reduce it (more often this referred to reducing red meat than all types of meat) and some believed they already reduced their meat consumption in the past. **Some omnivores** believed that the consequences of meat consumption were trivial compared to other behaviours (e.g., smoking tobacco). **Some omnivores** lack of trust in the available scientific information.	4 (N= 616)	Qualitative studies[11]	Minor concerns[12]	No concerns	Moderate concerns[13]	Minor concerns[14]	⊕⊕◯◯ **LOW**

[11] Countries: Portugal, Scotland, and Australia.
[12] Three studies with minor methodological limitations due to lack of reporting of the investigator-participants relationship
[13] Four studies with moderate concerns about relevance because the studies did not inform participants about the undesirable health effects of meat consumption and the likely selectivity of populations.
[14] Minor adequacy concerns because of the small number of participants.

ANNEX A. Reasons for meat consumption for unprocessed red meat and processed meat

Reasons for meat consumption	URM n (%)	PM n (%)
1. Cost - I can afford to buy it	183 (60.2)	130 (42.8)
2. Health - It's healthy	124 (40.8)	10 (3.3)
3. Taste - I like the taste of it	240 (78.9)	149 (49.0)
4. Availability - I can find the selection of the products I want	180 (59.2)	158 (52.0)
5. Family preference - My family favours its consumption	151 (49.7)	100 (32.9)
6. Tradition - It's part of my tradition	174 (57.2)	99 (32.6)
7. Religion - My religion favours its consumption	37 (12.2)	15 (4.9)
8. Cooking time - I have the time to cook it	131 (43.1)	106 (34.9)
9. Social context - I consume it in social contexts like barbecues	159 (52.3)	121 (39.8)
10. Animal welfare issues - I consume animal welfare products. For example, they have been fed on grassland, bred outdoors and have been well-treated at the slaughterhouse, transported and priced.	101 (33.2)	21 (6.9)
11. Environmental issues -I consume products with a low environmental impact to favour the environment.	72 (23.7)	15 (4.9)
Other	7 (2.3)	7 (2.3)

Abbreviations: URM= unprocessed red meat, PM= processed meat

ANNEX B. Sociodemographic and medical history of semi-structured interview participants

	Overall (N=7)
Sex, n (%)	
Women	3 (43.0)
Men,	4 (57.0)
Age, years	
Mean (SD)	38.6 (5.03)
Median [Q1, Q3]	39.0 [36.0, 40.0]
Education level, n (%)	
Primary education	0 (0)
Secondary education	0 (0)
Professional education	0 (0)
University education	7 (100)
No studies	0 (0)
Employment status, n (%)	
Employed	0 (0)
Unemployed	0 (0)
Student	0 (0)
Marital status, n (%)	
Married	4 (57.1)
Common-law couple	2 (28.6)
Living with partner or family	1 (14.3)
Separated	0 (0)
Divorced	0 (0)
Widow/widower	0 (0)
Single	0 (0)
Children, n (%)	
One child	5 (71.4)
Two children	1 (14.3)
Three or more children	0 (0)
None	1 (14.3)
Religion, n (%)	
Catholicism	0 (0)
Other	0 (0)
None	7 (100)
Physical activity intensity¥, n (%)	
Low	0 (0)
Moderate	5 (71.4)
High	2 (28.6)
Weight (kg)	
Mean (SD)	77.0 (14.2)
Median [Min, Max]	71.0 [58.0, 95.0]
Height (m)	
Mean (SD)	1.73 (0.103)
Median [Min, Max]	1.75 [1.62, 1.90]
BMI	
Mean (SD)	25.4 (2.48)
Median [Min, Max]	26.3 [22.1, 28.7]
Comorbidities, n (%)	
Hormonal system disorders	
Digestive diseases	1 (14.3)
Musculoskeletal disorders	
Other	
None	6 (85.7)
Family history of cancer, n (%)	
Yes	4 (57.1)
No	3 (42.9)
I don't know	0 (0)

Abbreviations: SD= standard deviation; Q1= Quartile 1; Q3= Quartile 3, Kg= Kilograms; m= meters; BMI=body mass index.

¥ Physical activity (PA) intensity was categorized as follows: participants who reported doing PA every day were categorized in the “high” category, who reported doing PA at least once a week was categorized in the “moderate” one and the rest of participants were categorized in the “low” category.

ANNEX C. Joint display

Qualitative data	Quantitative data		Representative quotes	Interpretation
Semi-structured interview themes	**Online survey questions**	**Online survey results**		
Social and/or family context meat consumption	What are the most important factors that favour your consumption of red meat and processed meat? Select all that apply*	Social context was selected as a factor favouring unprocessed red meat and processed meat consumption by **52%** and **40%** of participants respectively.	*"I consume meat especially social occasions"*	Participants reported that social gatherings influenced their meat consumption.
		Family preference was selected as a factor favouring unprocessed red meat and processed meat consumption by **50%** and **33%** of participants respectively.	*"I have to adapt to the needs of my children and family"*	Participants reported that family preference influenced their meat consumption.
		Tradition was selected as a factor favouring unprocessed red meat and processed meat consumption by **57%** and **33%** of participants respectively.	*"Even, for tradition, I consume game meat when I return to the family home"*	Participants reported that tradition influenced their meat consumption
Health and non-health related concerns about meat	What are the most important factors that favour your consumption of unprocessed red meat? Select all that apply*	Health was selected by **41%** of participants as a factor favouring unprocessed red meat consumption.	*"I consider red meat necessary to have certain nutritional values such as iron or vitamin B12"*	Participants highlighted the nutritional value of unprocessed red meat as a reason for consuming it.
	In the past, have you cut back on red and / or processed meat for non-health reasons?	Environmental concerns were selected by **22%** of participants. The second highest selected reason as a non-health related reason for having reduced meat consumption in the past.	*"Livestock farming is one of the human activities that generates the most CO2 emissions"*	Non-health related reasons such as environmental concerns play an important role in people's meat consumption habits.
Uncertainty of the evidence	What are the most important factors that favour your consumption of unprocessed red meat and processed meat? Select all that apply*	Taste was selected as a factor favouring unprocessed red meat and processed meat consumption by **79%** and **49%** of participants respectively. The most selected factor.	*"I like meat, and it is for sure a barrier to reduce or quit its consumption, especially when the evidence is unclear"*	Taste was one of the most voted factors for consuming meat, and this could explain why in the face of uncertain evidence, participants were unwilling to stop and/or reduce their intake.

* 11 factors were provided to choose from, see **Annex A. Reasons for meat consumption for unprocessed red meat and processed meat**.

ANNEX A. Integrated evidence and related confidence (Evidence profile table) for reasons for eating/buying meat

Review finding	N° of studies (participants)	Methodological limitations	Coherence	Relevance	Adequacy of data	Confidence of evidence
Reasons for eating and/or buying meat - Integrated evidence						
Consumers chose meat with a lower footprint, when provided with carbon footprint information of meat production. However, other characteristics such as type of meat, fat content and price were considered more important. **The environment (for example, carbon footprint information on the label) was not considered a significant aspect when buying/consuming meat**; other aspects such as: nutritional values, freshness of the meat, food safety, eating enjoyment/taste, and animal welfare were considered more important. **Consumers bought meat products based on tangible aspects such as colours and appearance rather than intangible characteristics such as environmental aspects of production;** only some participants bought environmentally friendly meat products, the main barriers were the higher price of these products and the unwillingness to change their diet.	9 (N=28,953)[1]	Moderate concerns[2]	No concerns	Serious concerns[3]	No concerns	LOW ⊕⊕◯◯

Abbreviations: QUAL=Qualitative, QUANT= Quantitative.

[1] **QUANT:** Eight studies (N=28,923) conducted in Finland, France, Germany, Ireland, Netherlands, Poland, Spain, and United Kingdom. **QUAL:** One study (N=30) conducted in Scotland.

[2] **QUANT:** Three studies (38%) were at high risk of bias for lack of validation of the measurement instruments, 2 (25%) at moderate risk of bias, and 3 (37%) at low risk of bias. **QUAL:** Moderate methodological limitations due to lack of reporting of the investigator and participants' relationship, lack of reporting of ethical issues, and limited information on the analysis process.

[3] **QUANT:** Serious concerns because five studies (63%) did not inform participants about the environmental impact of meat consumption. **QUAL:** Serious concerns because one study (100%) did not inform participants about the environmental impact of meat consumption.

ANNEX B. Integrated evidence and related confidence (Evidence profile table) for reasons for avoiding meat

Review finding	N° of studies (participants)	Methodological limitations	Coherence	Relevance	Adequacy of data	Confidence of evidence
Reasons for avoiding meat – Integrated evidence						
For vegetarians and low meat consumers/meat reducers, the reasons for adopting a vegetarian diet or limiting their meat intake. For many people, environmental concerns were among the most important reasons for avoiding meat consumption whereas for others, environmental concerns were not considered one of the main reasons for avoiding meat. **Environmental concerns were considered a contributory factor rather than the primary driver for avoiding meat**. However, environmental impact of meat production was mentioned as one reason for avoiding meat intake by some participants, along with other reasons, for example perceived health. Other reasons such as: animal welfare; health concerns; self-fulfilment and taste or aesthetics were considered among the main reasons for avoiding meat. **Women were more likely to avoid meat or eating smaller portions of meat for environmental reasons**, except for one study where men were more likely to report environmental concerns as a reason for avoiding meat. **The younger population was more likely to agree that a vegetarian diet leads to environmental benefits**. **People's meat consumption behaviour influenced their motivations for avoiding meat intake**. The stricter the diet in terms of avoiding meat consumption and animal products, the more important environmental concerns were reasons for avoiding meat. Similarly, one study reported that all vegans found the environment an important issue for meat consumption, while only a minority of omnivores mentioned it.	37 (N=63,208)[1]	Minor concerns[2]	Minor concerns[3]	Serious concerns[4]	No concerns	LOW ⊕⊕◯◯

Abbreviations: MM=Mixed-methods, QUAL=Qualitative, QUANT= Quantitative.

[1] **QUANT:** Twenty-nine studies (N=61,219) conducted in Australia, Austria, Belgium, Czech Republic, Finland, France, Ireland Germany, Macedonia, Netherlands, New Zeeland, Norway, Slovenia, Serbia Spain, Sweden, Switzerland, United Kingdom, and United Stated of America. **QUAL:** Seven studies (N=457) conducted in Australia, Austria, Canada, China, Brazil, United Kingdom, United States of America.**MM**: One study (1,532) conducted in The Netherlands.

[2] **QUANT:** Sixteen studies (54%) were at high risk of bias for lack of validation of the measurement instruments, 7 (23%) were at moderate risk of bias, and 7 (23%) were at low risk of bias. **QUAL:** Minor methodological limitations to lack of reporting of the investigator and participants' relationship, lack or limited information on ethical issues, and lack or limited information on the analysis process. **MM:** No concerns, clear and detailed information, and justification to use the mixed-methods approach are provided.

[3] Reasons for avoiding meat intake changed and varied across studies, no clear reasons for this variability were identified.

[4] **QUANT:** Serious concerns because 29 studies (100%) did not inform participants about the environmental of meat consumption. **MM** study contributing to QUANT evidence did not provide information to participants. **QUAL:** Serious concerns because 6 studies (86%) did not inform participants about the environmental impact of meat consumption.

ANNEX C. Integrated evidence and related confidence (Evidence profile table) for willingness to change meat consumption

Review finding	N° of studies (participants)	Methodological limitations	Coherence	Relevance	Adequacy of data	Confidence of evidence
Willingness to change meat consumption – Integrated evidence						
Most of the omnivores were reluctant to reduce meat consumption in the future, even when informed on the environmental impact of meat consumption. Similarly, **when provided with an information sheet** about the impact of food production on climate change, **most of the participants showed low awareness of the association between climate change and meat consumption, and some participants reported considering reducing their meat consumption or had already reduce their intake in the past.** However, environmental concerns tended to be a contributory factor rather than the primary driver; other aspects were considered more important for the environment rather than reducing meat consumption. **Most of omnivores were willing to adopt other strategies to reduce the climate impact rather than reducing meat intake**: eating more organic food, driving less, eating local foods; using alternate transportation, recycling, using eco-friendly products, reporting the ecological impact on the food's labels. On the contrary, three studies reported that **most of the participants, when presented with different sustainable food behaviours they could choose from, they were willing to reduce their meat intake in terms of quantity** rather than eating plant-based meat substitutes and proteins from insects or buying specific meat such as organic meat or replace most of the meat by vegetables. **Omnivores considered meat consumption to have a trivial effect on the environment and believed that other behaviours were more effective.** Food packaging, food waste, transportation of food, and production and processing of food in relation to the environmental impact of food were considered more important. **Women** perceived higher environmental benefit of eating less meat than men and **were more willing to reduce meat intake**. **Young women were most incline to change their meat consumption** **Frequent meat consumers were less positive towards a reduction of meat,** whereas those with higher concerns for environmental problems were much more likely to intend to stop eating meat. On the contrary, one study found that gender, as well as age, meat consumption behaviour (high vs. low intake) and socio-economic status had no impact on peoples' belief that eating less meat would help reducing climate change.	38 (N=57,148)[1]	Minor concerns[2]	Minor concerns[3]	Serious concerns[4]	No concerns	LOW ⊕⊕◯◯

Abbreviations: MM=Mixed-methods, QUAL=Qualitative, QUANT= Quantitative.

[1] **QUANT:** Twenty-seven (N=56,555) conducted in Australia, Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zeeland, Poland, Portugal, Romania, Slovakia, Slovenia, Southwest Scotland, Spain, Sweden, Switzerland, United Kingdom, United Sates of America. **QUAL:** Seven studies (N=527) conducted in Australia, Brazil, China, Norway, Portugal, Scotland, Sweden, United Kingdom, and United States of America. **MM:** Two studies (N=66) conducted in Spain and Norway.

[2] **QUANT:** Eighteen studies (60%) were at high risk of bias for lack of validation of the measurement instruments, 6 (20%) at moderate risk of bias and 6 (20%) at low risk of bias. **QUAL:** Minor methodological limitations due to lack of reporting of the investigator and participants' relationship and lack of information on ethical issues. **MM:** One study were no concerns, clear and detailed information and justification to use the mixed-methods approach are provided. For the second study, no information is provided for using a mixed-methods approach, unclear how the quantitative evidence contributed to the findings.

[3] **QUANT:** Minor concerns because three studies reported contradictory data regarding the willingness to adopt other strategies to reduce climate impact, representing 45% of the overall population.

[4] **QUANT:** Serious concerns because 27 studies (100%) did not inform participants about the environmental impact of meat consumption. **QUAL:** Serious concerns because seven studies (87%) did not inform participants about the impact of meat consumption on the environment. Two **MM** studies contributing to qualitative evidence did not provide information to participants.

ANNEX D. Integrated evidence and related confidence (Evidence profile table) for willingness to pay more for environmentally friendly meat

Review finding	N° of studies (participants)	Methodological limitations	Coherence	Relevance	Adequacy of data	Confidence of evidence
Willingness to pay more for environmentally friendly meat- Quantitative evidence						
Most consumers were willing to pay more for meat products if the product was produced with a significantly lower environmental impact. Also, labels indicating that the beef mince had a low or moderate fat content, was organic meat produced locally and with animal welfare standards were significant for consumers. **Women** and older people showed higher willingness to pay more for meat with minimal environmental impact.	2 (N=2,702)	No or minor concerns[2]	No concerns	Serious concerns [3]	No or minor concerns	MODERATE ⊕⊕◯◯

Abbreviations: QUANT= Quantitative.

[1] **QUANT:** Two studies 2 (N=2,702) conducted in United Kingdom and Spain.

[2] **QUANT:** All studies (100%) were at high risk of bias for lack of validation of the measurement instruments; however, findings were consistent across studies.

[3] **QUANT:** Serious concerns of relevance because all studies (100%) did not inform participants about the environmental impact of meat consumption.