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Heddie Mejborn, Sanne Pagh Møller, Lau Caspar Thygesen
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November 2019

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Preface

Meat is an important part of the diet of many Danes, and it contributes importantly to the intake of several essential nutrients, but cutting down on meat intake might become a trend among subgroups of Danes. It may be because several studies have shown a positive association between red and processed meat intake and disease risk, e.g. heart diseases and colorectal cancer. However, not all studies find this association. The conclusions about red and processed meat being unhealthy foods mainly come from population studies of varying scientific quality, where several confounders may affect the results. Important confounding may be persons with a high meat intake often have an unhealthy diet and lifestyle. In particular, other dietary components than meat and the context in which meat is eaten may affect the disease risk normally associated with a high meat intake. Also, most published studies on associations between meat intake and health are performed in populations with a food culture and lifestyle that differs from the Danish. This complicates the discussion on the role of meat in a healthy Danish diet.

At the National Food Institute, Technical University of Denmark, we have high quality data on Danes' dietary habits from our survey, The Danish National Survey on Diet and Physical Activity. The data enable us to characterise the diet of subgroups of the population with different dietary quality and different meat intake, and previous analyses of Danes' dietary patterns have shown that a subgroup of the population eat a healthy diet with a high meat content. In Denmark we have very good quality data about Danes' diseases and death from nationwide public registers. Thus, we have the possibility to combine

high quality data on dietary patterns and disease or death to estimate the association between different dietary patterns and disease risk among Danes. The results will be a valuable contribution to the debate between health professionals on the role of meat in a healthy Danish diet.

The project was funded by "Promilleafgiftsfonden for landbrug", and the Danish Agriculture and Food Council financed a pre-project to prepare intake data for the analyses. The project management was handled by the National Food Institute, Technical University of Denmark. A steering group consisting of representatives from the Danish Agriculture and Food Council; the National Institute of Public Health, University of Southern Denmark; and the National Food Institute, Technical University of Denmark followed the project to ensure its progress. Neither "Promilleafgiftsfonden for landbrug" nor the Danish Agriculture and Food Council had any influence on the project's scientific content, the interpretation of data or conclusions. The report was not presented to "Promilleafgiftsfonden for landbrug", nor to the Danish Agriculture and Food Council before publication.

The report presents the results in two parts that can be read independently: Part I. Food and nutrient characteristics of 15-75 year old Danes' healthy or unhealthy diets with different meat content; and Part II. Meat intake and health.

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Summary

Part I

Based on data from The Danish National Survey on Diet and Physical Activity 2000-2002, 2003-2008 and 2011-2013, including 10,013 participants 15-75 years old, we have examined dietary patterns in subgroups of participants with different meat content in healthy and unhealthy diets. Data about food intake is obtained via self-administered, quantitative seven-day pre-coded food diary.

We define red meat as unprocessed muscle tissue from mammals such as beef, veal, pork, lamb and hare. The meat can be minced and/or frozen. It is usually eaten cooked. Processed meat is red meat or poultry that undergo a transformation and contain approved ingredients and may be subject to some form of preservation that may be combined with cooking. Due to its heterogeneous character, processed meat is further divided in subgroups. Poultry includes primarily meat from chicken, hen and turkey. Total meat is the sum of red meat, processed meat and poultry.

We compare groups having a healthy diet (based on a dietary guideline score) and a low or a high dietary meat content (lowest or highest quartile). In addition, we compared groups with a healthy diet and high dietary meat content with groups having an unhealthy diet and high dietary meat content. Meat can be red meat, processed meat, poultry or total meat.

In general, there are more men in the high meat groups than in the low meat groups, and the mean age of the high meat groups is lower compared with the low meat groups. This is particularly the case for the groups with the unhealthy diets.

Even though the groups with the healthy diets are divided based on a dietary guideline score including fruit, vegetables and whole grain content, the dietary content of these foods differ between the low and high meat groups with a healthy diet. Fish is also included in the dietary guideline score, but dietary fish content is similar in healthy diet, low and high meat groups.

The results show that a high dietary meat content can be associated with both a healthy and unhealthy diet. High meat content is always lower in the healthy

diet, high meat groups compared with the unhealthy diet, high meat groups. A high meat content, independent of meat type, in an unhealthy diet is always associated with a high content of fast food, fried potatoes, salt and sugar-sweetened beverages, when compared with both healthy diet-groups.

The groups' dietary saturated fatty acid content and added sugars content differs. As expected, the unhealthy diet, high meat groups have the highest content of both nutrients. The saturated fatty acid content differs slightly between the low and high meat groups with a healthy diet. Sometimes the low meat groups have the highest content, and sometimes the high meat groups have the highest content. However, the healthy diet, low meat groups always have the highest dietary content of added sugars. The healthy and unhealthy diet groups have different alcoholic beverage pattern but there is no difference between groups in percent energy from alcohol.

A healthy diet with a high **red meat** content is characterised by a high content of vegetables, a relatively high content of boiled/baked potatoes and a low content of sugary foods. The diet's red meat content is equally represented by beef/veal and pork.

A healthy diet with a high **processed meat** content is characterised by a high content of bread and whole grain and a low content of sugary, solid foods. The processed meat is mainly "other processed meat", some salamis and sausages and very little bacon.

A healthy diet with a high **poultry** content is characterised by a low content of red and processed meat and beer and a high content of fruit, vegetables and water. The diet's red meat content is equally represented by beef/veal and pork, and the processed meat is mainly "other processed meat".

A healthy diet with a high **total meat** content is characterised by a high content of poultry and vegetables, a relatively high content of boiled/baked potatoes and low content of fat spread, milk and sugary foods. Pork represents approximately half of the red meat in this diet, and the processed meat is mainly "other processed meat".

Part II

We have estimated the associations between intake of meat and health, partly in the total adult population and partly in subgroups with different dietary quality that minimize the influence of confounding. This part of the report focuses on the health effects of the dietary content of red and processed meat.

The analyses were based on information about diet composition from The Danish National Survey on Diet and Physical Activity 2000-2002, 2003-2008, and 2011-2013 and information about ischemic heart disease, acute coronary syndrome, colorectal cancer and cause of death obtained from the National Patient Register on primary and secondary diagnoses, the Danish Cancer Registry and the Register of Causes of Death.

Incident cases of disease were estimated, and therefore separate cohorts had to be included for each of the studied outcomes. The cohort was followed from baseline (date of survey interview) or from age 37 years for ischemic heart disease and acute coronary syndrome and from age 50 years for colorectal cancer, whichever came last. Consumption of red and processed meat were analysed on both a continuous scale and categorically. Association between meat consumption and outcomes distributed on dietary quality or meat consumption were also estimated, and results on associations between meat consumption and the studied outcomes are presented.

For several associations between meat intake and disease or mortality risk, the estimates were above 1. However, none of the associations were statistically significant, and therefore trends and associations should be interpreted with caution.

For red meat intake and heart diseases, cancer and mortality, the associations (HR) varied from 0.89 to 1.23 per 100 g increased red meat intake per day. Corresponding values for processed meat were 0.99 to 1.16 per 50 g increased processed meat intake per day.

Although not statistically significant, low dietary quality independent of meat intake also increased disease risk (HR from 1.04 to 1.09) and mortality risk (HR=1.26).

When associations between meat consumption and disease risk were stratified by dietary quality, HR for red meat varied from 0.78 to 1.93 per 100 g in-

creased red meat intake per day in a healthy diet, and from 0.94 to 1.30 per 100 g increased red meat intake per day in an unhealthy diet. Per 50 g increased processed meat intake per day HR varied from 0.91 to 1.15 in a healthy diet, and from 0.82 to 1.24 in an unhealthy diet. None of the estimates were statistically significant.

When associations between meat consumption and disease risk were stratified by meat intake, the results were generally not statistically significant. HR for low dietary quality varied from 0.77 to 1.25 in a low red meat diet and from 0.91 to 1.11 in a high red meat diet. HR for low dietary quality varied from 0.76 to 1.29 in a low processed meat diet and from 0.88 to 1.38 in a high processed meat diet.

The associations between meat consumption and the outcomes ischemic heart disease, acute coronary syndrome, colorectal cancer, and all-cause mortality may show a trend of higher risk of ischemic heart disease and acute coronary syndrome with higher consumption of red meat and to some degree processed meat. These trends are, however, not statistically significant. When stratified by dietary quality, there are no statistically significant differences in the associations between meat intake and outcomes in those with a healthy dietary quality and those with an unhealthy dietary quality.

Even though none of our estimates were statistically significant, the direction and magnitudes were often comparable with findings from other cohort studies showing an increased disease risk with higher meat intake. Our study was performed with a relatively young population (15-75 years at baseline in 2000-2013), so a large proportion of the population was too young to be at real risk of developing the studied diseases. Therefore, the low number of outcomes could be an explanation why the associations between red and processed meat and the outcomes were non-significant.

It was concluded that intake of red meat is not consistently associated with increased risk of ischemic heart disease, acute coronary syndrome, colorectal cancer and all-cause mortality. However, for some associations between meat intake and disease outcomes, a trend comparable with findings from other cohort studies is suggested. There is no indication that the association between a high dietary meat intake and disease outcomes are affected by the dietary quality.

Part I

Food and nutrient characteristics of 15-75 year old Danes' healthy or unhealthy diets with different meat content

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Introduction

A healthy diet is composed of foods from several food groups like fish, meat, vegetables and grains, but a healthy diet can be composed in many different ways to comply with the nutrient recommendations. Thus, different dietary patterns can provide the essential nutrients in sufficient amount. On the other hand, an unhealthy and unbalanced diet can potentially be a risk factor for non-communicable diseases and mortality.

Several, but not all, prospective, population based studies from different countries have associated high red and processed meat consumption with increased risk of mortality (Abete et al., 2014; Etemadi et al., 2017) and non-communicable diseases, in particular type-2 diabetes (Pan et al., 2011; Sluik et al., 2013), cardiovascular diseases (Kim et al., 2017) and cancer (Alexander et al., 2011; Egeberg et al., 2013; Farvid et al., 2018; World Cancer Research Fund/American Institute for Cancer Research, 2018). On the other hand, poultry and fish are often shown to have the opposite effect or no such effect (Norat et al., 2005; Spencer et al., 2010; Daniel et al., 2011; Egeberg et al., 2013; Abete et al., 2014; Kim et al., 2017). Some studies show that diets based on animal or plant protein, respectively, may affect disease risk and mortality differently (Orlich et al., 2013; Richter et al., 2015; Song et al., 2016; Virtanen et al., 2019). Likewise, plant based diets and vegetarian diets is shown to reduce type-2 diabetes risk factors and the risk of cardiovascular diseases and certain cancers compared with meat based diets (Key et al., 2014; Hemler & Hu, 2019; Viguiouk et al., 2019).

The official Danish dietary guidelines from The Danish Veterinary and Food Administration (Fødevarestyrelsen, 2013) include ten guidelines for a healthy, balanced diet that meets the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2012). One of the guidelines says, "Choose lean meat and processed meat". Further explanation tells you to choose meat and processed meat products with no more than 10% fat, and that you should keep your intake of cooked red meat at 500 g per week or less and just eat a small amount of processed meat. There is no guideline regarding dietary poultry content.

The health effect of red and processed meat may depend on other compounds in the diet, e.g. dietary fibres that may protect against carcinogenic compounds from meat (Oh et al., 2019). Associations between characteristic dietary patterns like "Western"

or "Mediterranean" diets and health outcome are often described in the literature (Grosso et al., 2017; Tabung et al., 2017; Lemming et al., 2018; Ericson et al., 2018; Castelló et al., 2019). Normally, the Western diet is characterised by a high content of high-fat dairy products, red and processed meat, refined grains, sweet caloric beverages and fast foods and a low content of low-fat dairy products, fish, whole grains, fruit and vegetables. A Mediterranean dietary pattern is characterised by high content of fish, vegetables, legumes, boiled potatoes, fruits and vegetable oils, mainly from olives and a low content of red meat. Thus, a high dietary content of red and processed meat is most often referred to as an unhealthy diet. However, red and processed meat contribute significant to the intake of several essential nutrients in a normal Danish diet (Biltoft-Jensen et al., 2016), and a significant part of Danes eat a healthy diet with a high red and/or processed meat content (Mejborn et al., 2016).

Describing health effects of different dietary patterns can be useful, because it is difficult to separate the health effects of the individual dietary components, since some are inter-correlated, e.g. a high content of boiled potatoes is correlated with a high gravy content in the diet. Besides, in adult Danes a high intake of red and processed meat is often associated with an unhealthy lifestyle, overweight, smoking, age, sex and short education (Biltoft-Jensen et al., 2016). Similar characteristics of meat eaters and non-meat-eaters from the UK was found by Papier et al. (2019). Thus, in analyses of associations between meat intake and disease risk and mortality, it is necessary to take this into account. At the National Food Institute, we have detailed data on Danes' dietary habits obtained from a seven day total diet registrations, and, thus, are able to characterise dietary patterns with different levels of meat content.

The aim of the present study is to compare the diet composition and nutrient content of participants with low or high meat intake in a healthy diet that to a high extent follow the Danish dietary guidelines. We also want to compare healthy and unhealthy diets with high meat content. In this report, characterisation of the diet is performed for four types of meat: red meat, processed meat, poultry, and total meat. We do not consider vegetarian diets.

The knowledge gained from the analyses of dietary patterns can be used in the discussion of effects of dietary meat content on health (e.g. part II of this report).

Method

Definitions

We define red meat as unprocessed muscle tissue from mammals such as beef, veal, pork, lamb and hare. A small intake of unprocessed edible offal, e.g. liver and heart is included. The meat can be minced and/or frozen. It is usually eaten cooked.

Processed meat is red meat or poultry that undergo a transformation and contain approved ingredients and may be subject to some form of preservation that may be combined with cooking; in other words: smoking, drying, curing, fermentation or roasting. Due to its heterogeneous character, processed meat may be further divided in subgroups, e.g. to bacon, sausages, salamis and other processed meat (Mejborn et al., 2019).

Poultry includes meat from chicken, hen, turkey, goose, dove, duck and pheasant. Total meat is the sum of red meat, processed meat and poultry.

Population

The data used for this study is from The Danish National Survey on Diet and Physical Activity 2000-2002, 2003-2008 and 2011-2013. This project includes 10,013 participants 15-75 years old from the three survey rounds. Data for food intake is obtained via self-administered, quantitative seven-day pre-coded food diary (Biltoft-Jensen et al., 2009).

The diet of each participant is given a dietary guideline score based on how well the diet comply with five of the official Danish dietary guidelines: 1) eat 600 g fruit and vegetables/day, 2) eat 50 g fish/day, 3) eat at least 75 g whole grain/10 MJ/day, 4) <10% of total dietary energy should come from saturated fatty acids, and 5) <10% of total dietary energy should come from added sugars. For each dietary guideline, a score of 0-1 is given by dividing the dietary content of the actual component with the recommended dietary content (scores >1 are truncated at 1). The scores of the individual components are added to yield the total score, which assumes values between 0 and 5.

In this study, we compare the diet of “meat groups”. Participants from the total population are divided in quartiles based on their dietary guideline score, and the lowest quartile (0-25 percentile) is named the “unhealthy diet group”, while the highest quartile (75-100 percentile) is named the “healthy diet group”. The two groups are further divided in quartiles based on the participants’ dietary meat content, and the lowest

quartile is named the “low “x” meat group”, while the highest quartile is named the “high “x” meat group”. Meat (x) can be red meat, processed meat, poultry or total meat.

Calculations and statistics

To be able to compare food intake of participants with different energy intake, all estimates of food intake are expressed as gram food/10 MJ. Thus, it is not the actual food intake rather the relative intake that is compared (the diet content of foods). Since dietary composition does not follow a normal distribution, results are expressed as median value, and 25- and 75-percentiles are shown in angular brackets: [25;75].

Estimate of dietary fruit content includes fruit juice, and estimate of vegetable content includes pulses and vegetable juice. However, for the estimate of total fruit and vegetable content used in the dietary guideline score, juice content >100 g/10 MJ is truncated at 100 in accordance with the Danish “six-a-day” recommendation.

Dietary added sugars are refined or industrially produced sugars used as ingredients in foods. Added sugars do not include fruit juice, juice concentrate or honey in this study.

Energy distribution (% of total energy) is estimated as energy-% without alcohol.

A micronutrient score bases on 19 micronutrients is estimated for each participant. For each micronutrient, the food content is recoded to a score between 0 and 100 by dividing the content with the age- and sex-specific recommended intake (content) (Nordic Council of Ministers, 2012) and multiplying by 100 (scores >100 are truncated at 100). The total score is the mean score for the 19 different nutrients and a higher score represents a higher compliance to recommendations.

Values <10 are displayed with one decimal.

Statistical analyses (non-parametric tests of independent samples) were performed with Kruskal-Wallis’ test for pairwise comparison (SAS version 9).

In the presentation of the results, differences between groups that are mentioned in the text are always statistically significant. However, to increase the readability, the words “statistically significant” are not mentioned.

Results

Groups are compared according to type of meat. Groups having a healthy diet and a low or high dietary meat content are compared; and the group having an unhealthy diet and a high dietary meat content is compared with the group with a healthy diet and a high dietary meat content. A compilation of the results within type of meat is shown in appendix 1-4.

Red meat

Food composition and nutrient content in diets of participants with a healthy diet and a low or high red meat content, respectively, are shown in table 1 and 2.

There are more men in the high red meat group than in the low red meat group, and the mean age in the high red meat group is higher.

Both red meat groups are selected from the quartile of the population with the highest dietary guideline score. However, the score is slightly lower in the high red meat group compared with the low red meat group.

The high red meat group's diet has a red meat content that is five times the content in the low red meat group's diet. The median total meat content is approximately twice as high in the high red meat group compared with the low red meat group.

The dietary content of both beef and veal, and pork is higher in the high red meat group compared with the low red meat group.

Even though the dietary content of fruit, vegetables and added sugars is included in the dietary guideline score, that was the first selection criteria, the groups

differ in dietary content of these foods. The diet of the high red meat group contains more vegetables but less fruit compared with the low red meat group, and their diet has a lower content of sugary foods.

The dietary content of several other foods/food groups differ between red meat groups. The high red meat group's diet is characterised by higher content of processed meat (only other processed meat content differs, not bacon, salamis or sausages), potatoes and gravy. Their diet has a lower content of poultry, bread (without difference in whole-grain content), milk, water, juice, sugar-sweetened beverages and sugary, solid foods (e.g. sweets, cakes). Not surprisingly, fewer participants in the high red meat group has meatless days than the low red meat group.

Even though a high dietary guideline score was the selection criteria for both groups, their diets differ in macronutrient composition.

Fat provides more energy in the diet of the high red meat group (both saturated and monounsaturated fatty acids, but not polyunsaturated fatty acids), energy from protein is higher as well, and thus energy from carbohydrate is lower. Fibre content is slightly lower in the high red meat group diet but close to recommended level, even though the high red meat group has a diet with more vegetables and the same amount of whole grain, but lower fruit content, compared with the low red meat group. Energy from added sugars is lower in the high red meat group in spite of sugar being part of the dietary guideline score that is initially used for selection of participants with a healthy diet for both groups. Salt intake is higher in the high red meat group than in the low red meat group. Micronutrient score does not differ; neither does percent energy from alcohol.

Table 1. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary red meat content

Food groups and subgroups	Healthy diet		Chi-Square test
	Low red meat content	High red meat content	p
Number	626	626	
% men	30	43	<0.0001
Age, mean	47.2	50.4	0.0003
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	3.7-5.0	3.7-5.0	
Total meat	90 [62;119]	187 [161;222]	<0.0001
Red meat	26 [15;34]	121 [108;146]	<0.0001
Beef and veal	10 [3.6;18]	59 [35;84]	<0.0001
Pork	8.4 [0.2;19]	62 [39;88]	<0.0001
Processed meat	28 [15;45]	36 [20;56]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.96
Salamis	0.0 [0.0;3.0]	0.0 [0.0;2.9]	0.66
Sausages	0.0 [0.0;1.4]	0.0 [0.0;2.1]	0.09
Other processed meat	22 [12;35]	29 [16;45]	<0.0001
Poultry	28 [6.2;54]	13 [0.7;33]	<0.0001
Fish	47 [29;66]	47 [29;67]	0.72
Vegetables incl. legumes and juice	238 [169;330]	254 [181;356]	0.02
Fruit incl. juice	351 [225;491]	289 [186;428]	<0.0001
Potatoes, boiled or baked	37 [0.0;86]	72 [23;133]	<0.0001
Potatoes, fried	0.0 [0.0;21]	0.0 [0.0;30]	0.001
Gravy, high fat	0.0 [0.0;8.0]	3.9 [0.0;15]	<0.0001
Gravy, low fat	0.0 [0.0;5.8]	0.0 [0.0;9.9]	0.0004
Bread	167 [131;214]	153 [114;192]	<0.0001
Whole grain	62 [43;83]	62 [44;81]	0.84
Fat spread	3.2 [0.0;10]	2.8 [0.0;9.0]	0.11
Fast foods	0.0 [0.0;41]	0.0 [0.0;43]	0.42
Cheese	35 [22;52]	33 [20;51]	0.07
Milk ¹	199 [51;396]	158 [8.4;308]	<0.0001
Fermented dairy products	16 [0.0;104]	0.0 [0.0;97]	0.24
Water	1326 [729;1973]	1155 [608;1890]	0.01
Juice	51 [0.0;162]	0.0 [0.0;93]	<0.0001
Sugar-sweetened beverages	0.0 [0.0;94]	0.0 [0.0;70]	0.02
Wine ²	66 [0.0;169]	78 [0.0;165]	0.28
Beer	24 [0.0;118]	47 [0.0;141]	0.13
Sugary, solid foods ³	63 [38;95]	50 [25;84]	<0.0001
Percent with 1 meatless day per week ⁴	28	20	0.001
Percent with >1 meatless day per week ⁴	28	7.4	<0.0001

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Table 2. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary red meat content

Nutrient	Healthy diet		Chi-Square test p
	Low red meat content	High red meat content	
Number	626	626	
Energy, kJ/d	8221 [6700;9649]	7941 [6420;9640]	0.10
Fat	31 [28;35]	34 [31;37]	<0.0001
Saturated fatty acids	12 [10;14]	13 [12;14]	<0.0001
Monounsaturated fatty acids	11 [9.3;13]	12 [11;14]	<0.0001
Polyunsaturated fatty acids	5.4 [4.8;6.2]	5.5 [4.9;6.1]	0.93
Protein	15 [14;17]	18 [17;20]	<0.0001
Carbohydrate	53 [49;57]	48 [44;52]	<0.0001
Added sugars	6.9 [4.7;9.3]	5.7 [3.8;7.9]	<0.0001
Fibres, g/10 MJ	30 [26;35]	28 [25;33]	0.0001
Salt, g/d	7.5 [6.1;9.3]	8.0 [6.4;10]	0.0004
Alcohol	3.5 [0.3;7.0]	3.6 [0.9;7.4]	0.19
Micronutrient score ¹	93 [87;96]	93 [87;96]	0.36

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Table 3 and 4 show food composition and nutrient content in diets of participants with an unhealthy or healthy diet, respectively, and a high red meat content.

There are more men in the unhealthy diet, high red meat group than in the healthy diet, high red meat group, and the mean age in the unhealthy diet, high red meat group is lower.

The two groups are selected from the lowest or highest quartile of the dietary guideline score (the unhealthy and the healthy diet group, respectively), and thereafter for their high dietary red meat content. Thus, the dietary guideline score in the unhealthy diet, high red meat group is half the score in the healthy diet, high red meat group. The dietary guideline score reflects the lower fish, fruit, vegetable and whole-grain content in the unhealthy diet, high red meat group.

Even though both groups are selected for their high dietary red meat content, the diet of the group with the unhealthy, high red meat diet contains more red meat, especially pork, than healthy diet, high

red meat group. The total meat content and the processed meat content (all subgroups of processed meat) is also higher in the unhealthy diet, high red meat group but the poultry content is lower. Fewer participants in the unhealthy diet, high red meat group have one meatless day per week but there is no difference between groups in the percentage having two or more meatless days per week.

The dietary content of several other foods/food groups differ between two diet groups. The unhealthy diet, high red meat group has a higher fast food content, a higher content of sugary, solid foods, sugar-sweetened beverages and beer, but a lower content of water and wine than the healthy diet, high red meat group. The higher red meat content in the unhealthy diet, high red meat group is accompanied by a higher potato content (both boiled/baked and fried potatoes), higher gravy content (both high and low fat) and lower bread content. In spite of a lower dietary bread and whole-grain content in the unhealthy diet, high red meat group, the group has a higher fat spread content compared with the healthy diet, high red meat group.

Table 3. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary red meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary red meat content

Food groups and subgroups	Unhealthy diet	Healthy diet	Chi-Square test
	High red meat content	High red meat content	p
Number	626	626	
% men	70	43	<0.0001
Age, mean	40.8	50.4	<0.0001
Median dietary guideline score	2.0 [1.7;2.2]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	0.5-2.4	3.7-5.0	
Total meat	217 [182;259]	187 [161;222]	<0.0001
Red meat	144 [125;175]	121 [108;146]	<0.0001
Beef and veal	65 [40;96]	59 [35;84]	0.0019
Pork	81 [50;109]	62 [39;88]	<0.0001
Processed meat	45 [27;67]	36 [20;56]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.05
Salamis	0.4 [0.0;5.4]	0.0 [0.0;2.9]	<0.0001
Sausages	0.7 [0.0;12]	0.0 [0.0;2.1]	<0.0001
Other processed meat	34 [21;51]	29 [16;45]	0.0001
Poultry	3.8 [0.0;28]	13 [0.7;33]	<0.0001
Fish	4.0 [0.0;13]	47 [29;67]	<0.0001
Vegetables incl. legumes and juice	120 [85;163]	254 [181;356]	<0.0001
Fruit incl. juice	64 [24;124]	289 [186;428]	<0.0001
Potatoes, boiled or baked	85 [36;144]	72 [23;133]	0.0034
Potatoes, fried	24 [0.0;49]	0.0 [0.0;30]	<0.0001
Gravy, high fat	19 [7.4;34]	3.9 [0.0;15]	<0.0001
Gravy, low fat	0.0 [0.0;0.0]	0.0 [0.0;9.9]	<0.0001
Bread	112 [79;146]	154 [114;192]	<0.0001
Whole grain	23 [14;34]	62 [44;81]	<0.0001
Fat spread	14 [5.2;26]	2.8 [0.0;9.0]	<0.0001
Fast foods	39 [0.0;102]	0.0 [0.0;43]	<0.0001
Cheese	31 [17;46]	33 [20;51]	0.11
Milk ¹	161 [21;375]	158 [8.4;308]	0.14
Fermented dairy products	0.0 [0.0;9.0]	0.0 [0.0;97]	<0.0001
Water	335 [64;784]	1160 [608;1890]	<0.0001
Juice	0.0 [0.0;51]	0.0 [0.0;93]	<0.0001
Sugar-sweetened beverages	141 [0.0;397]	0.0 [0.0;70]	<0.0001
Wine ²	17 [0.0;113]	78 [0.0;165]	<0.0001
Beer	94 [0.0;330]	47 [0.0;141]	<0.0001
Sugary, solid foods ³	67 [35;105]	50 [25;84]	<0.0001
Percent with 1 meatless day per week ⁴	12	20	0.0001
Percent with >1 meatless day per week ⁴	5.6	7.4	0.20

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Table 4. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary red meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary red meat content

Nutrient	Unhealthy diet	Healthy diet	Chi-Square test p
	High red meat content	High red meat content	
Number	626	626	
Energy, kJ/d	9599 [7331;11823]	7941 [6420;9640]	<0.0001
Fat	40 [36;43]	34 [31;37]	<0.0001
Saturated fatty acids	17 [15;19]	13 [12;14]	<0.0001
Monounsaturated fatty acids	15 [13;16]	12 [11;14]	<0.0001
Polyunsaturated fatty acids	5.1 [4.4;5.7]	5.5 [4.9;6.1]	<0.0001
Protein	16 [15;18]	18 [17;20]	<0.0001
Carbohydrate	44 [40;48]	48 [44;52]	<0.0001
Added sugars	10 [5.5;16]	5.7 [3.8;7.8]	<0.0001
Fibres, g/10 MJ	16 [14;18]	28 [25;33]	<0.0001
Salt, g/d	9.2 [6.9;12]	8 [6.4;10]	<0.0001
Alcohol	3.4 [0.1;8.6]	3.6 [0.9;7.4]	0.73
Micronutrient score ¹	87 [78;93]	93 [87;96]	<0.0001

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

The two groups' dietary nutrient composition reflects the large difference in food composition between the groups; the only nutrient that does not differ is energy from alcohol. Energy from fat (both saturated and monounsaturated fatty acids) and added sugars is higher in the unhealthy diet, high red meat group, while energy from polyunsaturated fatty acids, protein and carbohydrate is lower. The lower dietary content of fruit, vegetables and whole grain in the unhealthy diet, high red meat group is clearly reflected in the diet's low fibre content, which is approximately half the recommended level. Salt intake is

lower in the healthy diet, high red meat group than in the unhealthy diet, high red meat group. As expected, the micronutrient score is lower for the unhealthy diet, high red meat group. The total daily energy intake is 20% higher in the unhealthy diet, high red meat group.

Processed meat

Table 5 and 6 show food composition and nutrient content in diets of participants with a healthy diet and a low or high processed meat content, respectively.

Table 5. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary processed meat content

Food groups and subgroups	Healthy diet		Chi-Square test
	Low processed meat content	High processed meat content	p
Number	626	626	
% men	23	51	<0.0001
Age, mean	49.5	47.6	0.01
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	3.7-5.0	3.7-5.0	
Total meat	102 [72;141]	170 [142;211]	<0.0001
Red meat	61 [34;92]	77 [49;108]	<0.0001
Beef and veal	28 [12;52]	30 [13;53]	0.12
Pork	23 [5.1;41]	36 [18;60]	<0.0001
Processed meat	11 [5.9;15]	66 [56;81]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	<0.0001
Salamis	0.0 [0.0;0.0]	2.0 [0.0;7.1]	<0.0001
Sausages	0.0 [0.0;0.0]	3.4 [0.0;17]	<0.0001
Other processed meat	9.0 [4.9;13]	52 [41;65]	<0.0001
Poultry	25 [2.1;47]	17 [1.4;35]	<0.0001
Fish	49 [33;74]	43 [26;62]	<0.0001
Vegetables incl. legumes and juice	279 [198;368]	217 [157;305]	<0.0001
Fruit incl. juice	353 [238;483]	273 [166;387]	<0.0001
Potatoes, boiled or baked	48 [14;106]	57 [15;112]	0.32
Potatoes, fried	0.0 [0.0;25]	0.0 [0.0;27]	0.37
Gravy, high fat	0.0 [0.0;10]	1.7 [0.0;11]	0.59
Gravy, low fat	0.0 [0.0;6.6]	0.0 [0.0;8.3]	0.10
Bread	152 [112;189]	173 [137;214]	<0.0001
Whole grain	59 [40;79]	69 [52;88]	<0.0001
Fat spread	2.8 [0.0;10]	3.7 [0.0;10]	0.07
Fast foods	0.0 [0.0;21]	24 [0.0;59]	<0.0001
Cheese	34 [21;53]	34 [20;50]	0.31
Milk ¹	180 [25;352]	168 [21;319]	0.40
Fermented dairy products	25 [0.0;132]	0.0 [0.0;67]	<0.0001
Water	1365 [829;2117]	1082 [564;1725]	<0.0001
Juice	31 [0.0;130]	22 [0.0;119]	0.29
Sugar-sweetened beverages	0.0 [0.0;66]	0.0 [0.0;91]	0.0094
Wine ²	87 [0.0;189]	66 [0.0;161]	0.02
Beer	0.0 [0.0;94]	47 [0.0;189]	<0.0001
Sugary, solid foods ³	66 [36;97]	51 [28;78]	<0.0001
Percent with 1 meatless day per week ⁴	30	14	<0.0001
Percent with >1 meatless day per week ⁴	37	3.4	<0.0001

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

There are more men in the high processed meat group than in the low processed meat group, and the mean age in the high processed meat group is lower.

Both processed meat groups are selected from the quartile of the population with the highest dietary guideline score. However, the score is slightly lower in the high processed meat group compared with the low processed meat group.

The high processed meat group's diet has a processed meat content that is six times the content in the low processed meat group's diet. The dietary content of the processed meat subgroups bacon, salamis and sausages differ between the two groups but dietary content of these types of processed meat is low for both groups (median content 0.0 g/10 MJ for the low processed meat group and <3.4 g/10 MJ for the high processed meat group). The difference in dietary processed meat content is mainly in "other processed meat" (e.g. cold cuts, liver paste), where the median content in the low processed meat group is 9.0 g/10 MJ and in the high processed meat group 52 g/10 MJ.

The median total meat content and the red meat content is also higher in the high processed meat group's diet compared with the low processed meat group's diet.

Even though the dietary content of fruit, vegetables and added sugars is included in the dietary guideline score, that was the first selection criteria, the groups differ in dietary content of these foods. The diet of the high processed meat group contains less vegetables, fruit and sugary, solid foods compared with the low processed meat group. The content of sugar-sweetened beverages differ between groups but is low.

The dietary content of several other foods/food groups differ between processed meat groups. The high processed meat group's diet is characterised by higher content of bread and whole grain and of fast foods and beer. Their diet has a lower content of poultry, fish, fermented dairy products, water and wine and sugary, solid foods (e.g. sweets, cakes). Reflecting the high processed meat group's higher processed and red meat content, fewer participants in the high processed meat group has meatless days than in the low processed meat group.

Table 6. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary processed meat content

Nutrient	Healthy diet		Chi-Square test p
	Low processed meat content	High processed meat content	
Number	626	626	
Energy, kJ/d	7774 [6477;9317]	8471 [6785;10327]	<0.0001
Fat	32 [29;36]	34 [31;37]	<0.0001
Saturated fatty acids	12 [11;14]	13 [12;14]	<0.0001
Monounsaturated fatty acids	11 [9.7;13]	12 [11;14]	<0.0001
Polyunsaturated fatty acids	5.4 [4.8;6.0]	5.6 [5.0;6.2]	<0.0001
Protein	16 [15;18]	17 [16;18]	<0.0001
Carbohydrate	51 [48;56]	49 [45;53]	<0.0001
Added sugars	6.7 [4.6;9.0]	5.8 [4.0;7.9]	<0.0001
Fibres, g/10 MJ	30 [26;34]	28 [25;33]	<0.0001
Salt, g/d	7.1 [5.6;8.7]	9.0 [7.2;11]	<0.0001
Alcohol	3.8 [0.8;7.2]	3.7 [0.9;7.8]	0.96
Micronutrient score ¹	93 [87;96]	93 [87;97]	0.04

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Even though a high dietary guideline score was the selection criteria for both groups, their diets differ in macronutrient composition.

The total daily energy intake is higher, and fat provides more energy in the diet of the high processed meat group (both saturated, monounsaturated and polyunsaturated fatty acids), energy from protein is higher as well, and thus energy from carbohydrate is lower. Fibre content is slightly lower in the high processed meat group's diet but close to recommended level, even though the high processed meat group has a diet with less vegetables and fruit and approximately the same amount of bread and whole grain compared with the low processed meat group. Energy from added sugars is lower in the high processed meat group in spite of added sugars being part of the dietary guideline score that is initially used for selection of participants with a healthy diet for both groups. Salt intake is higher in the high processed meat group than in the low processed meat group. Energy from alcohol does not differ. Micronutrient score differs slightly, despite the median value in the two groups being identical.

Food composition and nutrient content in diets of participants with an unhealthy or healthy diet, respectively, and a high dietary processed meat content are shown in table 7 and 8.

There are more men in the unhealthy diet, high processed meat group than in the healthy diet, high processed meat group, and the mean age in the unhealthy diet, high processed meat group is lower.

The two groups are selected from the lowest or highest quartile of the dietary guideline score (the unhealthy and the healthy diet group, respectively), and thereafter for their high dietary processed meat content. Thus, the dietary guideline score in the unhealthy diet, high processed meat group is less than half the score in the healthy diet, high processed meat group. The dietary guideline score reflects the lower fish, fruit, vegetable and whole-grain content in the unhealthy diet, high processed meat group.

Even though both groups are selected for their high dietary processed meat content, the diet of the group with the unhealthy, high processed meat diet contains more processed meat than the healthy diet, high processed meat group's diet. Mainly the content of sausages differs: median content in the unhealthy diet, high processed meat group is 24 g/10 MJ and in the healthy diet, high processed meat group 3.4 g/10 MJ. In addition, content of salamis and other processed meat differs, but not the bacon content. The dietary content of total meat is also higher in the unhealthy diet, high processed meat group but the poultry content is lower. There is no difference between the unhealthy diet, high processed meat and the healthy diet, high processed meat groups in the diet's red meat content. There is no difference between the two groups in the percentage having meatless days.

The diet of the unhealthy diet, high processed meat group has a higher content of fast foods and fried potatoes, sugary solid foods, sugar-sweetened beverages and beer, but a lower content of bread, water, juice and wine than the healthy diet, high processed meat group.

Even though the unhealthy diet, high processed meat group has the same red meat content and less poultry and fish content in their diet than the healthy diet, high processed meat group, they have a higher boiled/baked potato content, and their high-fat gravy content is higher as well. Moreover, even though the unhealthy diet, high processed meat group's dietary bread content is lower, their fat spread content is higher compared with the healthy diet, high processed meat group.

There are more participants in the healthy diet, high processed meat group having one meatless day per week than in the unhealthy diet, high processed meat group but no difference between groups in the number of participants having two or more meatless days per week.

Table 7. Food composition (g/10 MJ); median [25 percentile;75 percentile] in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary processed meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary processed meat content

Food groups and subgroups	Unhealthy diet	Healthy diet	Chi-Square test
	High processed meat content	High processed meat content	p
Number	626	626	
% men	76	51	<0.0001
Age, mean	41.0	47.6	<0.0001
Median dietary guideline score	2.0 [1.8;2.2]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	0.6-2.4	3.7-5.0	
Total meat	193 [159;237]	170 [142;211]	<0.0001
Red meat	80 [53;112]	77 [49;108]	0.09
Beef and veal	33 [17;55]	30 [13;53]	0.08
Pork	38 [18;65]	36 [18;60]	0.34
Processed meat	87 [75;108]	66 [56;81]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.43
Salamis	3.4 [0.0;9.9]	2.0 [0.0;7.1]	<0.0001
Sausages	24 [8.8;39]	3.4 [0.0;17]	<0.0001
Other processed meat	55 [44;70]	52 [41;65]	0.0009
Poultry	12 [0.4;31]	17 [1.4;35]	0.0062
Fish	5.1 [0.1;13]	43 [26;62]	<0.0001
Vegetables incl. legumes and juice	108 [71;150]	217 [157;305]	<0.0001
Fruit incl. juice	65 [25;127]	273 [166;387]	<0.0001
Potatoes, boiled or baked	73 [25;128]	57 [15;112]	0.0018
Potatoes, fried	17 [0.0;39]	0.0 [0.0;27]	<0.0001
Gray, high fat	14 [2.4;26]	1.7 [0.0;11]	<0.0001
Gravy, low fat	0.0 [0.0;0.0]	0.0 [0.0;8.3]	<0.0001
Bread	130 [99;166]	173 [137;214]	<0.0001
Whole grain	27 [18;38]	69 [52;88]	<0.0001
Fat spread	17 [6.9;27]	3.7 [0.0;10]	<0.0001
Fast foods	67 [32;122]	24 [0.0;59]	<0.0001
Cheese	30 [17;44]	34 [20;50]	0.0011
Milk ¹	181 [35;353]	168 [21;319]	0.15
Fermented dairy products	0.0 [0.0;18]	0.0 [0.0;67]	<0.0001
Water	308 [60;677]	1082 [564;1725]	<0.0001
Juice	0.0 [0.0;47]	22 [0.0;119]	<0.0001
Sugar-sweetened beverages	184 [38;449]	0.0 [0.0;91]	<0.0001
Wine ²	0.0 [0.0;88]	66 [0.0;161]	<0.0001
Beer	141 [0.0;424]	47 [0.0;189]	<0.0001
Sugary, solid foods ³	71 [36;106]	51 [28;78]	<0.0001
Percent with 1 meatless day per week ⁴	11	14	0.05
Percent with >1 meatless day per week ⁴	5.4	3.4	0.10

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Table 8. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary processed meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary processed meat content

Variable	Unhealthy diet	Healthy diet	Chi-Square test p
	High processed meat content	High processed meat content	
Number	626	626	
Energy, kJ/d	10344 [8351;12599]	8471 [6785;10327]	<0.0001
Fat	40 [37;44]	34 [31;37]	<0.0001
Saturated fatty acids	17 [15;19]	13 [12;14]	<0.0001
Monounsaturated fatty acids	15 [13;16]	12 [11;14]	<0.0001
Polyunsaturated fatty acids	5.3 [4.8;6.0]	5.6 [5.0;6.2]	<0.0001
Protein	15 [13;16]	17 [16;18]	<0.0001
Carbohydrate	45 [41;49]	49 [45;53]	<0.0001
Added sugars	11 [6.7;16]	5.8 [4.0;7.9]	<0.0001
Fibres, g/10 MJ	16 [14;18]	28 [25;33]	<0.0001
Salt, g/d	11 [8.2;13]	9.0 [7.2;11]	<0.0001
Alcohol	3.3 [0.7;8.0]	3.7 [0.9;7.8]	0.76
Micronutrient score ¹	89 [80;94]	93 [87;97]	<0.0001

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

The groups' dietary nutrient composition reflects the large difference in food composition between dietary guideline groups; the only nutrient that does not differ is energy from alcohol. Daily total energy intake is 22% higher in the unhealthy diet, high processed meat group. Energy from fat (both saturated and monounsaturated fatty acids) and added sugars is higher in the unhealthy diet, high processed meat group, while energy from polyunsaturated fatty acids, protein and carbohydrates is lower. The diet's low fibre content reflects the lower dietary content of fruit, vegetables and whole grain in the unhealthy diet, high processed meat group; the fibre content is approximately half the recommended level. Salt intake is lower in the healthy diet, high processed meat group than in the unhealthy diet, high processed meat group. As expected, the micronutrient score is lower for the unhealthy diet, high processed meat group.

Poultry

Food composition and nutrient content in diets of participants with a healthy diet and a low or high dietary poultry content, respectively, are shown in table 9 and 10.

There are more men in the low poultry group than in the high poultry group, and the mean age in the low poultry group is higher.

The diet of the low poultry group contains very little poultry: the median content is 0.0 g/10 MJ compared with 62 g/10 MJ in the high poultry group, and the group's total dietary meat content is lower than the high poultry group's. Instead, the diet of the low poultry group contains more red and processed meat. The median content of the processed meat subgroups salamis and sausages is 0.0 g/10 MJ for both the low poultry group and the high poultry group, but the content of other processed meat is slightly higher in the low poultry group (median content 33 g/10 MJ) compared with the high poultry group (28 g/10 MJ). More participants in the low poultry group has meatless days.

Table 9. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary poultry content

Food groups and subgroups	Healthy diet		Chi-Square test
	Low poultry content	High poultry content	p
Number	626	625	
% men	37	32	0.04
Age, mean	52.0	48.0	<0.0001
Median dietary guideline score	4.1 [3.8;4.4]	4.1 [3.9;4.4]	0.02
Dietary guideline score variation	3.7-5.0	3.7-5.0	
Total meat	120 [84;157]	159 [131;192]	<0.0001
Red meat	81 [51;111]	58 [32;84]	<0.0001
Beef and veal	32 [15;54]	25 [9.9;47]	<0.0001
Pork	37 [15;62]	22 [7.0;43]	<0.0001
Processed meat	33 [18;53]	28 [16;45]	0.0007
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.14
Salamis	0.0 [0.0;3.8]	0.0 [0.0;2.3]	<0.0001
Sausages	0.0 [0.0;3.4]	0.0 [0.0;0.8]	0.0003
Other processed meat	25 [15;40]	23 [13;36]	0.04
Poultry	0.0 [0.0;0.8]	62 [50;80]	<0.0001
Fish	46 [29;66]	45 [27;67]	0.94
Vegetables incl. legumes and juice	232 [159;313]	271 [189;385]	<0.0001
Fruit incl. juice	300 [205;453]	341 [226;468]	0.02
Potatoes, boiled or baked	61 [18;126]	57 [15;112]	0.26
Potatoes, fried	0.0 [0.0;23]	0.0 [0.0;29]	0.01
Gravy, high fat	2.4 [0.0;12]	0.8 [0.0;10]	0.16
Gravy, low fat	0.0 [0.0;6.5]	0.0 [0.0;8.8]	0.05
Bread	165 [132;212]	157 [111;198]	<0.0001
Whole grain	64 [47;85]	59 [40;79]	<0.0001
Fat spread	3.8 [0.0;11]	2.1 [0.0;8.5]	<0.0001
Fast foods	0.0 [0.0;44]	0.0 [0.0;39]	0.74
Cheese	34 [22;52]	33 [20;47]	0.07
Milk ¹	180 [38;351]	180 [28;379]	0.94
Fermented dairy products	0.0 [0.0;110]	9.4 [0.0;109]	0.37
Water	1074 [517;1748]	1424 [802;2182]	<0.0001
Juice	32 [0.0;135]	23 [0.0;111]	0.05
Sugar-sweetened beverages	0.0 [0.0;81]	0.0 [0.0;65]	0.16
Wine ²	78 [0.0;175]	71 [0.0;176]	0.27
Beer	47 [0.0;141]	0.0 [0.0;94]	0.02
Sugary, solid foods ³	59 [33;90]	55 [31;90]	0.20
Percent with 1 meatless day per week ⁴	26	22	0.20
Percent with >1 meatless day per week ⁴	20	14	0.0074

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Even though the dietary content of fruit, vegetables and whole grain is included in the dietary guideline score, that was the first selection criteria, the groups differ in dietary content of these foods. The diet of the high poultry group contains more fruit and vegetables but less whole grain compared with the low poultry group.

The two groups' diet has a similar content of several food groups but the high poultry group's diet is characterised by lower bread, fat spread, juice and beer content and higher water content compared with the low poultry group.

Fewer participants in the high poultry group have two or more meatless days per week than in the low poultry group. There is no difference between groups in the percentage having one meatless day per week.

Even though food composition of the two groups is similar for several food groups, their diets differ

in macronutrient composition, and the high poultry group as a lower daily energy intake.

Fat provides less energy in the diet of the high poultry group (both saturated and monounsaturated fatty acids), energy from carbohydrate and added sugars is lower as well, and energy from protein and polyunsaturated fatty acids is higher. Fibre content is similar (and at the recommended level) in the two poultry groups in spite of differences in dietary fruit, vegetable and whole-grain content. However, the fibre composition in the two diets differ, since the high poultry group mainly gets fruit and vegetable fibres, while the low poultry group gets whole-grain fibres. Micronutrient score does not differ; neither does percent energy from alcohol nor salt intake.

Table 11 and 12 show food composition and nutrient content in diets of participants with an unhealthy or healthy diet, respectively, and a high dietary poultry content.

Table 10. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary poultry content

Nutrient	Healthy diet		Chi-Square test
	Low poultry content	High poultry content	p
Number	626	625	
Energy, kJ/d	8134 [6584;9828]	7621 [6378;8975]	0.0003
Fat	33 [29;36]	32 [29;36]	0.03
Saturated fatty acids	13 [11;14]	12 [11;14]	<0.0001
Monounsaturated fatty acids	12 [10;13]	11 [9.8;13]	0.01
Polyunsaturated fatty acids	5.3 [4.7;6.0]	5.6 [5.0;6.3]	<0.0001
Protein	16 [15;18]	17 [16;19]	<0.0001
Carbohydrate	51 [47;55]	50 [46;55]	0.03
Added sugars	6.4 [4.4;8.8]	6.0 [4.1;8.0]	0.0029
Fibres, g/10 MJ	29 [26;34]	30 [26;34]	0.33
Salt, g/d	7.7 [6.1;9.6]	7.5 [6.1;9.1]	0.18
Alcohol	3.9 [1.1;7.6]	3.4 [0.6;7.2]	0.10
Micronutrient score ¹	93 [87;96]	92 [86;95]	0.11

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Table 11. Food composition (g/10 Mj); median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary poultry content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary poultry content

Food groups and subgroups	Unhealthy diet	Healthy diet	Chi-Square test
	High poultry content	High poultry content	p
Number	625	625	
% men	60	32	<0.0001
Age, mean	37.6	48.0	<0.0001
Median dietary guideline score	2.0 [1.7;2.2]	4.1 [3.9;4.4]	<0.0001
Dietary guideline score variation	0.6-2.4	3.7-5.0	
Total meat	177 [144;221]	159 [131;192]	<0.0001
Red meat	72 [46;103]	58 [32;84]	<0.0001
Beef and veal	33 [18;52]	25 [9.9;47]	<0.0001
Pork	30 [13;54]	22 [7.0;43]	<0.0001
Processed meat	43 [26;66]	28 [16;45]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	<0.0001
Salamis	0.0 [0.0;4.9]	0.0 [0.0;2.3]	<0.0001
Sausages	1.8 [0.0;15]	0.0 [0.0;0.8]	<0.0001
Other processed meat	31 [19;46]	23 [13;36]	<0.0001
Poultry	50 [40;67]	62 [50;80]	<0.0001
Fish	5.5 [0.5;14]	45 [27;67]	<0.0001
Vegetables incl. legumes and juice	125 [90;166]	271 [189;385]	<0.0001
Fruit incl. juice	83 [36;149]	341 [226;468]	<0.0001
Potatoes, boiled or baked	58 [20;108]	57 [15;112]	0.75
Potatoes, fried	24 [0.0;49]	0.0 [0.0;29]	<0.0001
Gravy, high fat	14 [4.2;26]	0.8 [0.0;10]	<0.0001
Gravy, low fat	0.0 [0.0;2.7]	0.0 [0.0;8.8]	<0.0001
Bread	112 [82;150]	157 [111;198]	<0.0001
Whole grain	20 [12;31]	59 [40;79]	<0.0001
Fat spread	13 [5.1;23]	2.1 [0.0;8.5]	<0.0001
Fast foods	40 [0.0;93]	0.0 [0.0;39]	<0.0001
Cheese	30 [17;44]	33 [20;47]	0.03
Milk ¹	197 [52;400]	180 [28;379]	0.09
Fermented dairy products	0.0 [0.0;29]	9.4 [0.0;109]	<0.0001
Water	400 [90;842]	1424 [802;2182]	<0.0001
Juice	0.0 [0.0;72]	23 [0.0;111]	0.0055
Sugar-sweetened beverages	218 [54;514]	0.0 [0.0;65]	<0.0001
Wine ²	0.0 [0.0;110]	71 [0.0;176]	<0.0001
Beer	47 [0.0;283]	0.0 [0.0;94]	<0.0001
Sugary, solid foods ³	84 [47;128]	55 [31;90]	<0.0001
Percent with 1 meatless day per week ⁴	16	22	0.0027
Percent with >1 meatless day per week ⁴	5.6	14	<0.0001

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

There are more men in the unhealthy diet, high poultry group than in the healthy diet, high poultry group, and the mean age is lower in the unhealthy diet, high poultry group.

The two groups are selected from the lowest or highest quartile of the dietary guideline score (the unhealthy and the healthy diet group, respectively), and thereafter for their high dietary poultry content. Thus, the dietary guideline score in the unhealthy diet, high poultry group is less than half the score in the healthy diet, high poultry group. The dietary guideline score reflects the lower fish, fruit, vegetable and whole-grain content in the unhealthy diet, high poultry group.

Even though both groups are selected for their high dietary poultry content, the diet of the group with the unhealthy, high poultry diet contains less poultry than the diet of the healthy diet, high poultry group. The total meat content and the red meat (both beef and veal, and pork) and processed meat content is

higher in the unhealthy diet, high poultry group. The median content of the processed meat subgroups bacon, salamis and sausages is 0.0 g/10 MJ for both groups, except for the unhealthy diet, high poultry group, which have a median sausages content of 1.8 g/10 MJ. The content of other processed meat is slightly higher in the unhealthy diet, high poultry group (median content 31 g/10 MJ) compared with the healthy diet, high poultry group (23 g/10 MJ). A lower percentage of participants in the unhealthy diet, high poultry group have meatless days.

The dietary content of several other foods/food groups differ between two diet groups. The unhealthy diet, high poultry group has a higher fast food and fried potato content, a higher content of fat gravy and fat spread, sugary, solid foods (e.g. sweets, cakes), sugar-sweetened beverages and beer, but a lower content of bread, fermented dairy products, juice, water and wine than the healthy diet, high poultry group.

Table 12. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary poultry content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary poultry content

Nutrient	Unhealthy diet	Healthy diet	Chi-Square test p
	High poultry content	High poultry content	
Number	625	625	
Energy, kJ/d	9692 [7928;11610]	7621 [6378;8975]	<0.0001
Fat	38 [34;41]	32 [29;36]	<0.0001
Saturated fatty acids	16 [14;18]	12 [11;14]	<0.0001
Monounsaturated fatty acids	13 [12;15]	11 [9.8;13]	<0.0001
Polyunsaturated fatty acids	5.1 [4.6;5.8]	5.6 [5.0;6.3]	<0.0001
Protein	15 [13;16]	17 [16;19]	<0.0001
Carbohydrate	47 [43;52]	50 [46;55]	<0.0001
Added sugars	13 [7.8;18]	6.0 [4.1;8.0]	<0.0001
Fibres, g/10 MJ	16 [14;18]	30 [26;34]	<0.0001
Salt, g/d	9.0 [6.7;12]	7.5 [6.1;9.1]	<0.0001
Alcohol	2.8 [0.0;7.5]	3.4 [0.6;7.2]	0.32
Micronutrient score ¹	86 [78;93]	92 [86;95]	<0.0001

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

The large difference in food composition between dietary guideline groups is reflected in the groups' dietary nutrient composition; the only nutrient that does not differ is energy from alcohol. Daily total energy intake is 27% higher in the unhealthy diet, high poultry group.

Energy from fat (both saturated and monounsaturated fatty acids) and added sugars is higher in the unhealthy diet, high poultry group, while energy from polyunsaturated fatty acids, protein and carbohydrates is lower. The diet's low fibre content clearly reflects the lower dietary content of fruit, vegetables and whole grain in the unhealthy diet, high poultry group; the fibre content is approximately half the recommended level. Salt intake is lower in the healthy diet, high poultry group than in the unhealthy diet, high poultry group. As expected, the micronutrient score is lower for the unhealthy diet, high poultry group.

Total meat

Table 13 and 14 show food composition and nutrient content in diets of participants with a healthy diet and a low or high total meat content, respectively.

There are more men in the high total meat group than in the low total meat group; the mean age does not differ between groups.

Both total meat groups are selected from the quartile of the population with the highest dietary guideline score. However, the score is slightly lower in the high total meat group compared with the low total meat group.

The high total meat group's diet has a total meat content that is 2.5 times the content in the low total meat group's diet, and a lower percentage of the participants in the high total meat group has meatless days. Both the red meat, processed meat and poultry content is higher in the high total meat group's diet compared with the diet of the low total meat group. Both beef and veal, and pork content differ between meat groups, and the content of all subgroups of processed meat differ. The median content of bacon, salamis and sausages is 0.0 g/10 MJ for both groups, but the content of other processed meat is higher in the high total meat group (median content 40 g/10 MJ) compared with the low total meat group (16 g/10 MJ).

Even though the dietary content of fruit, vegetables and added sugars is included in the dietary guideline score, that was the first selection criteria, the groups differ in dietary content of these foods. The diet of the high total meat group contains more vegetables but less fruit and sugary, solid foods compared with the low total meat group, while there is no difference in fish and whole-grain content.

The dietary content of other foods/food groups differ between total meat groups. The high total meat group's diet is characterised by higher content of boiled/baked potatoes and high fat gravy. Their diet has a lower content of bread, fat spread, milk, fermented dairy products, cheese and juice but a higher beer content.

Not surprisingly, a lower percentage of participants in the high total meat group has meatless days than the low total meat group.

Table 13. Food composition (g/10 Mj; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary total meat content

Variable	Healthy diet		Chi-Square test
	Low total meat content	High total meat content	p
Number	625	626	
% men	26	47	<0.0001
Age, mean	49.0	48.7	0.76
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	3.7-5.0	3.7-5.0	
Total meat	77 [60;89]	200 [183;230]	<0.0001
Red meat	36 [20;51]	114 [86;145]	<0.0001
Beef and veal	15 [5.9;27]	50 [27;75]	<0.0001
Pork	14 [1.3;25]	56 [32;81]	<0.0001
Processed meat	19 [10;29]	50 [29;74]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0167
Salamis	0.0 [0.0;1.6]	0.0 [0.0;4.2]	<0.0001
Sausages	0.0 [0.0;0.0]	0.0 [0.0;8.0]	<0.0001
Other processed meat	16 [8.0;23]	40 [23;59]	<0.0001
Poultry	8.4 [0.3;26]	32 [4.9;60]	<0.0001
Fish	49 [32;69]	47 [29;69]	0.11
Vegetables incl. legumes and juice	239 [168;322]	255 [183;361]	0.0044
Fruit incl. juice	350 [232;480]	284 [182;417]	<0.0001
Potatoes, boiled or baked	45 [0.0;91]	63 [21;125]	<0.0001
Potatoes, fried	0.0 [0.0;21]	0.0 [0.0;29]	0.0045
Gravy, high fat	0.0 [0.0;9.3]	3.3 [0.0;13]	0.0006
Gravy, low fat	0.0 [0.0;5.2]	0.0 [0.0;9.5]	0.0001
Bread	163 [129;208]	155 [116;196]	0.0016
Whole grain	62 [43;84]	63 [44;81]	0.7731
Fat spread	3.5 [0.0;11]	2.7 [0.0;8.6]	0.0045
Fast foods	0.0 [0.0;34]	0.0 [0.0;45]	0.0008
Cheese	35 [23;54]	32 [19;50]	0.0010
Milk ¹	214 [57;387]	142 [0.0;301]	<0.0001
Fermented dairy products	21 [0.0;105]	0.0 [0.0;84]	0.0146
Water	1211 [705;1885]	1220 [642;2002]	0.72
Juice	57 [0.0;174]	0.0 [0.0;93]	<0.0001
Sugar-sweetened beverages	0.0 [0.0;89]	0.0 [0.0;70]	0.0283
Wine ²	71 [0.0;177]	67 [0.0;163]	0.4736
Beer	0.0 [0.0;94]	35 [0.0;141]	0.0235
Sugary, solid foods ³	69 [41;100]	46 [24;80]	<0.0001
Percent with 1 meatless day per week ⁴	30	15	<0.0001
Percent with >1 meatless day per week ⁴	36	5.7	<0.0001

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Table 14. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary total meat content

Nutrient	Healthy diet		Chi-Square test p
	Low total meat content	High total meat content	
Number	625	626	
Energy, kJ/d	8292 [6786;9844]	7760 [6241;9688]	0.0008
Fat	32 [28;35]	34 [31;37]	<0.0001
Saturated fatty acids	12 [11;14]	13 [12;14]	<0.0001
Monounsaturated fatty acids	11 [9.3;13]	13 [11;14]	<0.0001
Polyunsaturated fatty acids	5.3 [4.6;6.2]	5.7 [5.1;6.3]	<0.0001
Protein	15 [14;16]	18 [17;20]	<0.0001
Carbohydrate	53 [50;57]	47 [44;51]	<0.0001
Added sugars	7.0 [4.9;9.5]	5.6 [3.4;7.2]	<0.0001
Fibres, g/10 MJ	30 [26;34]	28 [25;33]	<0.0001
Salt, g/d	7.4 [6.1;9.1]	8.3 [6.4;10]	<0.0001
Alcohol	3.4 [0.6;7.1]	3.5 [0.7;7.5]	0.5870
Micronutrient score ¹	93 [88;96]	93 [86;96]	0.21

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Even though a high dietary guideline score was the selection criteria for both groups, their diets differ in macronutrient composition, except for energy from alcohol.

The high total meat group has a 7% lower daily energy intake but fat provides more energy in their diet (both saturated, monounsaturated fatty acids and polyunsaturated fatty acids), energy from protein is higher as well, and thus energy from carbohydrate is lower. Fibre content is slightly lower in the high total meat group's diet but close to recommended level, since the high total meat group has a diet with more vegetables but lower content of fruit and whole

grain compared with the low total meat group. Dietary content of added sugars is lower in the high total meat group in spite of sugar being part of the dietary guideline score that is initially used for selection of participants with a healthy diet for both groups. Salt intake is higher in the high total meat group than in the low total meat group. Micronutrient score does not differ between groups.

Table 15 and 16 show food composition and nutrient content in diets of participants with an unhealthy or healthy diet, respectively, and a high total meat content.

Table 15. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary total meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary total meat content

Food groups and subgroups	Unhealthy diet	Healthy diet	Chi-Square test
	High total meat content	High total meat content	p
Number	627	626	
% men	75	47	<0.0001
Age, mean	41.0	48.7	<0.0001
Median dietary guideline score	2.0 [1.7;2.2]	4.0 [3.8;4.3]	<0.0001
Dietary guideline score variation	0.6-2.4	3.7-5.0	
Total meat	230 [211;272]	200 [183;230]	<0.0001
Red meat	136 [102;174]	114 [86;145]	<0.0001
Beef and veal	54 [30;83]	50 [27;75]	0.0055
Pork	69 [38;104]	56 [32;81]	<0.0001
Processed meat	67 [44;98]	50 [29;74]	<0.0001
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0002
Salamis	1.7 [0.0;6.9]	0.0 [0.0;4.2]	<0.0001
Sausages	7.0 [0.0;25]	0.0 [0.0;8.0]	<0.0001
Other processed meat	46 [30;64]	40 [23;59]	<0.0001
Poultry	24 [1.2;49]	32 [4.9;60]	<0.0001
Fish	4.1 [0.0;12]	47 [29;69]	<0.0001
Vegetables incl. legumes and juice	121 [83;159]	255 [183;361]	<0.0001
Fruit incl. juice	56 [21;109]	284 [182;417]	<0.0001
Potatoes, boiled or baked	86 [39;145]	63 [21;125]	<0.0001
Potatoes, fried	24 [0.0;49]	0.0 [0.0;29]	<0.0001
Gravy, high fat	18 [6.4;32]	3.3 [0.0;13]	<0.0001
Gravy, low fat	0.0 [0.0;2.2]	0.0 [0.0;9.5]	<0.0001
Bread	116 [86;155]	155 [116;196]	<0.0001
Whole grain	25 [15;35]	63 [44;81]	<0.0001
Fat spread	14 [6.1;26]	2.7 [0.0;8.6]	<0.0001
Fast foods	47 [0.0;106]	0.0 [0.0;45]	<0.0001
Cheese	29 [16;45]	32 [19;50]	0.05
Milk ¹	158 [24;378]	142 [0.0;301]	0.02
Fermented dairy products	0.0 [0.0;0.0]	0.0 [0.0;84]	<0.0001
Water	323 [63;716]	1220 [642;2002]	<0.0001
Juice	0.0 [0.0;48]	0.0 [0.0;93]	<0.0001
Sugar-sweetened beverages	146 [0.0;383]	0.0 [0.0;70]	<0.0001
Wine ²	14 [0.0;106]	67 [0.0;163]	<0.0001
Beer	94 [0.0;377]	35 [0.0;141]	<0.0001
Sugary, solid foods ³	61 [31;96]	46 [24;80]	<0.0001
Percent with 1 meatless day per week ⁴	8.4	15	0.0002
Percent with >1 meatless day per week ⁴	4.8	5.7	0.44

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

There are more men in the unhealthy diet, high total meat group than in the healthy diet, high total meat group, and the mean age is lower in the unhealthy diet, high total meat group.

The two groups are selected from the lowest or highest quartile of the dietary guideline score (the unhealthy and the healthy diet group, respectively), and thereafter for their high dietary total meat content. The dietary guideline score in the unhealthy diet, high total meat group is half the score in the unhealthy diet, high total meat group. The dietary guideline score reflects the lower fish, fruit, vegetable and whole-grain content in the diet of the unhealthy diet, high total meat group.

Even though both groups are selected for their high dietary total meat content, the diet of the group with the unhealthy, high total meat diet contains more total meat, especially red meat (both beef and veal,

and pork) and processed meat (all subgroups), than the healthy diet, high total meat group. The diet of the unhealthy diet, high total meat group contains less poultry than the diet of the healthy diet, high total meat group and a lower percentage of the participants in the unhealthy diet, high total meat group has one meatless day per week, while there is no difference between groups in the percentage having two or more meatless days per week.

The dietary content of several other foods/food groups differ between two diet groups. The diet of the unhealthy diet, high total meat group contains more fast foods and potatoes (boiled/baked and fried), a higher content of high fat gravy, fat spread, sugary, solid foods and sugar-sweetened beverages, milk and beer, but a lower content of bread, cheese, water and wine than the healthy diet, high total meat group.

Table 16. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary total meat content, and in the group with the highest quartile of dietary guideline score and the highest quartile of dietary total meat content

Nutrient	Unhealthy diet	Healthy diet	Chi-Square test
	High total meat content	High total meat content	p
Number	627	626	
Energy, kJ/d	9884 [7705;11965]	7760 [6241;9688]	<0.0001
Fat	41 [37;44]	34 [31;37]	<0.0001
Saturated fatty acids	17 [16;19]	13 [12;14]	<0.0001
Monounsaturated fatty acids	15 [14;16]	13 [11;14]	<0.0001
Polyunsaturated fatty acids	5.3 [4.7;5.9]	5.7 [5.1;6.3]	<0.0001
Protein	16 [15;18]	18 [17;20]	<0.0001
Carbohydrate	43 [39;47]	47 [44;51]	<0.0001
Added sugars	9.5 [5.0;14]	5.6 [3.4;7.2]	<0.0001
Fibres, g/MJ	16 [14;18]	28 [25;33]	<0.0001
Salt, g/d	10 [7.5;12]	8.3 [6.4;10]	<0.0001
Alcohol	3.3 [0.5;8.5]	3.5 [0.7;7.5]	0.80
Micronutrient score ¹	89 [79;93]	93 [86;96]	<0.0001

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

The large difference in food composition between dietary guideline groups is reflected in the groups' dietary nutrient composition; the only nutrient that does not differ is energy from alcohol, and the daily energy intake is 27% higher in the unhealthy diet, high total meat group than in the healthy diet, high total meat group.

Energy from fat (both saturated and monounsaturated fatty acids) and added sugars is higher in the unhealthy diet, high total meat group, while energy from polyunsaturated fatty acids, protein and carbohydrates is lower. The lower dietary content of fruit, vegetables and whole grain in the diet of the unhealthy diet, high total meat group is clearly reflected in the diet's low fibre content, which is approximately half the recommended level. Salt intake is lower in the healthy diet, high total meat group than in the unhealthy diet, high total meat group. As expected, the micronutrient score is lower for the unhealthy diet, high total meat group.

Discussion

When groups are compared across diet quality and meat intake, it is important to notice that no statistical analyses were performed to compare the healthy diet, low meat groups with the unhealthy diet, high meat groups. Discussion of differences between such groups are solely to be viewed as apparent differences.

It is also important to notice that gender distribution and mean age differ considerably between some groups. This is likely to affect the groups' energy intake and food preferences and may explain some of the observed differences between groups.

In the discussion, we make few references to other studies on healthy and unhealthy dietary patterns with different meat content, simply because we have not been able to locate such studies. In general, dietary patterns are defined as healthy or unhealthy based on the combination of foods they contain, and no subdivisions due to content of a single food or type of food, are made. Thus, our way of presenting dietary patterns with different meat content is new and can be useful in discussions of effects of meat intake on health outcomes. Estimating associations between meat intake and disease risk based on more specifically defined dietary patterns will diminish confounding.

Red meat

It is worth noting that a high dietary red meat content corresponds to a different red meat level in a healthy

and an unhealthy diet (121g/10MJ and 144 g/10 MJ, respectively). The higher the dietary red meat content, the higher the proportion of pork in the diets.

Both the diet quality and to some extent the red meat content affect the macronutrient composition of the diet. The diet of the two groups with healthy diet and low or high red meat content both comes close to comply with the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2012). The low red meat group has a slightly lower saturated fatty acids content and higher added sugars content than the healthy diet, high red meat group, the saturated fatty acids exceeding the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2012). Not surprisingly, the unhealthy diet, high red meat group does not comply with the recommendations for total fat and saturated fatty acids and fibres. The median salt intake exceeds the recommended level in all groups.

The micronutrient score and total energy intake is only affected by the diet quality. The unhealthy diet, high red meat group has the lowest micronutrient score, which reflects the groups lower dietary fruit, vegetable, fish and whole-grain content. The group has a 21% higher daily energy intake compared with the healthy diet, high red meat group, which could at least be partly explained by the group consisting of more males and slightly younger participants with a higher energy need and therefore higher energy intake.

Overall, it is possible to eat a healthy diet with a high red meat content that comply relatively good with the Danish dietary guidelines and the nutrient recommendations. The diet is characterised by a high content of vegetables, a relatively high content of boiled/baked potatoes and a low content of sugary foods. The groups' red meat content is equally divided between beef and veal, and pork. Their processed meat intake is mainly other processed meat, and to a lesser extent bacon, salamis and sausages. Compared with a healthy diet with low red meat content, the healthy, high red meat diet has similar fish, whole-grain, fat spread, fast foods, cheese, fermented dairy products, wine and beer content, but lower poultry, fruit, bread, milk, water, juice and solid sugary food content, and higher processed meat, vegetable, boiled/bakes potato and high-fat gravy content. Only the two groups' other processed meat content differ, while the content of bacon, salamis and sausages is similar.

Processed meat

The dietary processed meat content differs between the two high processed meat groups (66 g/10 MJ in

the healthy diet group and 87 g/10 MJ in the unhealthy diet group, respectively). The processed meat is mainly “other processed meat” in all groups, except the unhealthy diet group, which has a high content of sausages.

Both the processed meat content and in particular the diet quality affect the macronutrient composition of the diet. The diet of the two groups with healthy diet and low or high processed meat content both comes close to comply with the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2012). The low processed meat group has a slightly lower saturated fatty acids content and higher added sugars content than the healthy diet, high processed meat group. For both groups the saturated fatty acid content is exceeding the Nordic Nutrition Recommendations (Nordic Council of Ministers, 2012). Not surprisingly, the unhealthy diet, high processed meat group does not comply with the recommendations for total fat and saturated fatty acids, added sugars and fibres. The median salt intake exceeds the recommended level in all groups. The unhealthy diet, high processed meat group has a 22% higher daily energy intake compared with the healthy diet, high processed meat group, which could at least be partly explained by the group consisting of more males and slightly younger participants with a higher energy need and therefore higher energy intake.

The micronutrient score is mainly affected by the diet quality. The unhealthy diet, high processed meat group has a lower micronutrient score compared with the healthy diet, high processed meat group, which reflects the latter group’s higher dietary fruit, vegetable, fish and whole-grain content.

Overall, it is possible to eat a healthy diet with a high processed meat content that comply relatively good with the Danish dietary guidelines and the nutrient recommendations. The diet is characterised by a high content of bread and whole grain and a low content of sugary, solid foods. Pork represents approximately half of the red meat. The group’s processed meat intake is mainly other processed meat, some salamis and sausages and very little bacon. Compared with a healthy diet with low processed meat content, the healthy, high processed meat diet has similar boiled/baked potato, high-fat gravy, fat spread, cheese, milk and juice content, lower poultry, fish, fruit and vegetable, water, wine and sugary, solid foods content and higher red meat, bread, whole-grain, fast food and beer content. All the subgroups of processed meat differ between the two groups’ diet.

Poultry

The poultry content in the three groups show a different pattern than for other meat types. The healthy diet, low poultry group has a median poultry content of 0 g/10 MJ, and the poultry content in the diet of the unhealthy diet, high poultry group is *lower* (50 g/10 MJ) compared with the healthy diet, high poultry group (62 g/10 MJ). The healthy diet, low poultry group has the highest red meat content of all groups. Interestingly, there are more men and the mean age of the participants is higher in healthy diet, low poultry group compared with the healthy diet, high poultry group, whereas the percentage of men in the unhealthy diet, high poultry group is much higher than the two other groups and the mean age is much lower.

The dietary fat content (total fat, saturated and monounsaturated fatty acids) is lower in the healthy diet, high poultry group compared with the healthy diet, low poultry group, and the saturated fatty acid content exceed the recommended level in both groups (Nordic Council of Ministers, 2012). The dietary fibre content is at the recommended level in both healthy diet groups. In contrast, the diet of the unhealthy diet, high poultry group has a high dietary content of total fat and saturated fatty acids: both are above the recommended level, while the fibre level is close to half the recommended level (Nordic Council of Ministers, 2012). The added sugars content is slightly lower (6.0% of energy) in the healthy diet, high poultry group compared with the healthy diet, low poultry group (6.4%), and much lower than the unhealthy diet, high poultry group (1.3%). The median salt intake exceeds the recommended level in all groups. The unhealthy diet, high poultry group has a 27% higher daily energy intake compared with the healthy diet, high poultry group, which could at least be partly explained by the group consisting of more males and much younger participants with a higher energy need and therefore higher energy intake.

The micronutrient score is only affected by the diet quality; the unhealthy diet, high poultry group has the lowest micronutrient score of all groups, which reflects the groups lower dietary fruit, vegetable, fish and whole-grain content.

Overall, a healthy diet with a high poultry content is characterised by complying relatively good with the Danish dietary guidelines and the nutrient recommendations. The diet is characterised by a low content of red and processed meat and beer, and a high content of fruit, vegetables and water. Beef/veal and pork represents a similar proportion of the red meat. Their

processed meat intake is mainly other processed meat, and to a lesser extent bacon, salamis and sausages. Compared with a healthy diet with low poultry content, the healthy, high poultry diet has similar fish, boiled/baked potato, high-fat gravy, cheese, milk, fermented dairy product, wine and sugary, solid foods content, but lower red and processed meat, bread, whole-grain, fat spread, juice and beer content and higher fruit and vegetable content.

Total Meat

The total meat content differs between the two high total meat groups: in the healthy diet group it is 200 g/10 MJ and in the unhealthy diet group, it is 230 g/10 MJ; both red and processed meat being higher in the latter group, while poultry is lower.

Both the total meat content and in particular the diet quality affect the macronutrient composition of the diet. The dietary fat content (total fat, saturated and monounsaturated fatty acids) is lower in the healthy diet, low total meat group compared with the healthy diet, high total meat group, and the saturated fatty acid content exceed the recommended level in both groups (Nordic Council of Ministers, 2012). The dietary fibre content is at the recommended level in both healthy diet groups. In contrast, the diet of the unhealthy diet, high total meat group has a high dietary content of total fat and saturated fatty acids: both are above the recommended level, while the fibre level is close to half the recommended level (Nordic Council of Ministers, 2012). Overall, the added sugar content is lower in the healthy diet, high total meat group compared with the healthy diet, low total meat group and the unhealthy diet, high total meat group. The median salt intake exceeds the recommended level in all groups. The unhealthy diet, high total meat group has a 27% higher daily energy intake compared with the healthy diet, high total meat group, which could at least be partly explained by the group consisting of more males and much younger participants with a higher energy need and therefore higher energy intake

The micronutrient score is only affected by the diet quality. The unhealthy diet, high total meat group has a lower micronutrient score, which reflects the groups lower dietary fruit, vegetable, fish and whole-grain content.

Overall, it is possible to eat a healthy diet with a high total meat content that comply relatively good with the Danish dietary guidelines and the nutrient recommendations. The diet is characterised by a high content of poultry and vegetables, a relatively high

content of boiled/baked potatoes and low content of fat spread, milk and sugary foods. Pork represents approximately half of the red meat, and the processed meat content is mainly other processed meat, and to a lesser extent bacon, salamis and sausages. Compared with a healthy diet with low total meat content, the healthy, high total meat diet has similar fish, whole-grain, water and wine content, but lower fruit, bread, fat spread, cheese, milk, fermented dairy products, juice and sugary, solid foods content and higher red and processed meat, poultry, boiled/baked potato, high-fat gravy and beer content.

Overall discussion

Dietary content of fruit and vegetables is part of the dietary guideline score that is used to create the diet-meat groups. Thus, it could be expected that the healthy diet groups with low or high meat content would have a similar high dietary fruit and vegetable content. However, high red and total meat groups with a healthy diet have a higher dietary content of vegetables and potatoes (boiled/baked) but less fruit than the corresponding low meat groups with a healthy diet. The healthy diet, high poultry group has a diet containing more fruit and vegetables but the same amount of potatoes than the low poultry group, and the healthy diet, high processed meat group has a diet with less fruit and vegetables but the same amount of potatoes compared with the healthy diet, low processed meat group. Thus, there is no clear pattern of dietary content of fruit, vegetables and potatoes related to a healthy diet with high dietary meat content.

For the high red meat, processed meat and total meat groups with an unhealthy diet, the dietary fruit and vegetable content is lower (as expected) and the potato content is higher compared with the diet of the corresponding healthy diet, high meat groups. The unhealthy diet, high poultry group is slightly different from the other meat type groups; as their dietary content of fruit and vegetables is also lower but their potato content is the same as the healthy diet, high poultry group. Therefore, for most meat groups a high dietary meat content in an unhealthy diet is associated with a high potato content.

The dietary fish content is also part of the dietary guideline score. Thus, as expected, the fish content is high and not different in the low and high meat groups with a healthy diet. This is true for all meat types except for the low processed meat group that has a slightly higher dietary fish content compared with the high processed meat group, both with a healthy diet. For all meat types, the dietary fish con-

tent is lower in the unhealthy diet, high meat groups compared with the healthy diet, high meat groups. Thus, a high dietary meat content is not necessarily associated with a low fish content.

The dietary whole-grain content, also being a part of the dietary guideline score, shows that for red and total meat there is no difference between low and high meat groups with a healthy diet. However, the low processed meat group has a lower whole-grain content, and the low poultry group has a higher whole-grain content compared with the corresponding high meat groups with a healthy diet. For all meat types, the dietary whole-grain content is lower in the unhealthy diet groups compared with the healthy diet groups. Thus, a high dietary meat content is not associated with the diet's whole-grain content, but an unhealthy, high meat diet is characterised by a low whole-grain content. One could expect a high dietary processed meat content to be associated with a high whole-grain content, since the processed meat to some extent is salamis and other processed meat, which is often eaten in open rye bread (whole grain) sandwiches in a Danish diet. This is also the case for the healthy diet, high processed meat group. However, the unhealthy diet, high processed meat group has a low dietary bread content, a very low whole-grain content, and in addition, a high fat spread content suggesting they take thick slices of processed meat and fat spread on their bread, and that they rarely choose whole-grain bread. Besides, the unhealthy, high processed meat diet has a high sausage content, and sausages are rarely eaten with whole-grain bread in a Danish diet.

A high dietary meat content in an unhealthy diet is always associated with a high content of fast foods, fried potatoes, salt and sugar-sweetened beverages, independent of meat type when compared with a low or high dietary meat content in a healthy diet. On the other hand, the unhealthy, high meat diet contains less bread, more fat spread and less wine compared with the other groups. For those with a high dietary fast food content (with a high saturated fatty acid content) and sugary beverages content it seems to be difficult to include enough vegetables and whole grains in their diet, and thus to get a high dietary guideline score.

The healthy diet, low meat groups have a higher dietary content of sugary, solid foods compared with the healthy diet, high meat groups (although not significant for the poultry groups), and the unhealthy diet, high meat groups diets always have a higher content of sugary, solid foods compared with the

healthy diet, high meat groups. The dietary content of sugar-sweetened beverages is low (median content 0.0) for all meat types with a healthy diet and a low or high meat content. However, the content is significantly higher in the low red meat and the low total meat groups compared with the corresponding high meat groups, all with a healthy diet, but the content of sugar-sweetened beverages is lower in the healthy diet, low processed meat group compared with the healthy diet, high processed meat group. There is no difference between the low and high poultry groups with healthy diets. The dietary content of sugar-sweetened beverages is always much higher in the unhealthy diet, high meat groups, compared with the healthy diet, high meat groups, whatever meat type. Overall, even though energy from added sugars is part of the dietary guideline score, the dietary energy-% from added sugars is always highest in the low meat groups compared with the high meat groups, both with a healthy diet score, but it is even higher in the unhealthy diet, high meat groups, whatever meat type. Energy from added sugars varies from 6.4 E% (poultry) to 7.0 E% (total meat) in the healthy diet, low meat groups, compared with 9.5 E% (total meat) to 13 E% (poultry) in groups with an unhealthy diet and a high meat content.

The dietary water content is higher in the low red and processed meat groups with a healthy diet compared with the corresponding high meat groups with a healthy diet. For the healthy diet, total meat groups there is no difference between low and high meat groups, but for the healthy diet, low poultry group, the dietary water content is lower than for the healthy diet, high poultry group. For all meat types, the dietary water content is always lower in the unhealthy diet, high meat groups compared with the healthy diet, high meat groups. Thus, an unhealthy diet with high meat content is characterised by a low water and high sugar-sweetened beverage content.

The dietary content of alcoholic beverages in the different groups shows an interesting pattern. Those with a healthy diet and high meat content have a higher dietary beer content compared with the low meat groups, but a lower beer content compared with the unhealthy diet, high meat group. It is true for both red meat (though not significant), processed meat and total meat groups. The exception is the poultry groups, where the healthy diet, low poultry group has a higher beer content compared with the healthy diet, high poultry group; the beer content apparently is at the same level as for the unhealthy diet, high poultry group (statistical comparison not performed). On the other hand, the dietary wine content does not differ

between the low and high meat groups (red meat, poultry and total meat) with healthy diets. However, the healthy diet, low processed meat group has a higher wine content compared with the healthy diet, high processed meat group. For all meat types, the unhealthy diet, high meat groups have a lower wine content compared with the healthy diet, high meat groups. Thus, having an unhealthy diet with a high meat content is associated with a low dietary wine, but high dietary beer content. Altogether, there is no difference between all groups in dietary energy from alcohol, which is unusual, since a low dietary alcohol content is often associated with healthy types of diet (e.g. DASH diet, Healthy Nordic diet and Mediterranean diet), including diets with a low red or processed meat content (Tabung et al., 2017; Lemming et al., 2018).

Data shows no clear picture regarding total energy intake in participants with a healthy diet and different dietary meat content. This is also difficult to evaluate because of the different sex and age distribution in the different groups of healthy/unhealthy, high and low meat content. For red meat, there is no difference in energy intake between the low and high content groups, while the low processed meat group has a lower energy intake compared with the high processed meat group. The low poultry group and the low total meat group both have a higher energy intake compared with the corresponding high meat groups with a healthy diet. For all meat types, the energy intake is 21-27% higher in the unhealthy diet groups with high meat content compared with the healthy diet groups with high meat content. Thus, independent of meat type, those having an unhealthy diet with a high meat content always have a substantial higher energy intake compared with those with a healthy diet and high meat content. It may partly be explained by the fact that the participants in the unhealthy diet groups consist of more males and of younger people with a higher energy need.

Dietary fat content differs slightly between healthy diet, low and high meat groups for all meat types. The dietary energy from total fat is between 31% and 34% in these groups' diet. However, dietary fat content is considerably higher: 38-41% of energy in the unhealthy diet, high meat groups. Therefore, high dietary fat content can be considered a marker for an unhealthy diet. For all groups, including the healthy diet groups, the dietary saturated fatty acid content exceeds the recommended level of 10% of total energy (Nordic Council of Ministers, 2012). For the healthy diet groups, percent energy from saturated fatty acids is 12-13%, but for the unhealthy diet, high

meat groups, saturated fatty acids contribute with 16-17% of total energy.

Strengths and weaknesses

It is a strength of this study that not only the meat intake but also the total diet is registered during seven days, including weekend days. All three dietary surveys included in this study cover all year. Thus, seasonal variations in meat intake are covered as well. The intake data are very detailed. Thus, we are able not only to divide the meat intake in red, white and processed meat but also to subdivide red meat intake in beef and pork and subdivide processed meat intake in subgroups. Another strength is that the participants can be considered a representative sample of the Danish population based on age and sex. Therefore, the results have a high level of generalizability.

The analysis of dietary patterns at sublevels (first a division into healthy and unhealthy diets and thereafter a subdivision according to dietary meat content) adds to the strength of the study by revealing the presence of inter-correlated foods in the different dietary patterns more clearly.

A large part of the Danish population eat meat several days a week. The fact that a low dietary level of one type of meat often is associated with a high dietary level of another type of meat makes it difficult to compare results across meat types. For example, several participants in the group having a healthy diet with a low poultry content, will also be part of the group having a healthy diet with a high red meat content. Thus, a conclusion on the characterisation of a diet with low dietary poultry content may be misinterpreted, since in reality it may be a characterisation of a diet with high dietary red meat content, which can be considered a weakness in descriptions of dietary patterns.

Conclusion

The groups eating a healthy diet with a high meat content (red meat, processed meat, poultry or total meat) consist of 32-51% men, while men represent 60-76% of the groups eating an unhealthy diet with high meat content and 23-37% of the groups eating a healthy diet with a low meat content. The mean age in the unhealthy diet, high meat groups is also lower than the other groups, which altogether affect the diet composition and energy intake in these groups.

A healthy diet with a high **red meat** content is characterised by a high content of vegetables, a relatively high content of boiled/baked potatoes and a low content of sugary foods. The diet's red meat content is

equally represented by beef/veal and pork. Compared with a healthy diet with low red meat content, the healthy, high red meat diet has similar fish, whole-grain, fat spread, fast foods, cheese, fermented dairy products, wine and beer content, but lower poultry, fruit, bread, milk, water, juice and sugary, solid food content, and higher processed meat, vegetable, boiled/bakes potato and high-fat gravy content.

A healthy diet with a high **processed meat** content is characterised by a high content of bread and whole grain and a low content of sugary, solid foods. The processed meat is mainly "other processed meat", some salamis and sausages and very little bacon. The diet contains a similar amount of boiled/baked potatoes, high-fat gravy, fat spread, cheese, milk and juice as a healthy diet with low processed meat content, but has lower poultry, fish, fruit and vegetable, water, wine and sugary, solid foods content and higher red meat, bread, whole-grain, fast food and beer content. All the subgroups of processed meat differ between the two groups' diet.

A healthy diet with a high **poultry** content is characterised by a low content of red and processed meat and beer and a high content of fruit, vegetables and water. The diet's red meat content is equally represented by beef/veal and pork, and the processed meat is mainly "other processed meat". Compared with a healthy diet with low poultry content, the healthy, high poultry diet has similar fish, boiled/baked potato, high-fat gravy, cheese, milk, fermented dairy product, wine and sugary, solid foods content, but lower red and processed meat, bread, whole-grain, fat spread, juice and beer content and higher fruit and vegetable content.

A healthy diet with a high **total meat** content is characterised by a high content of poultry and vegetables, a relatively high content of boiled/baked potatoes and low content of fat spread, milk and sugary foods. Pork represents approximately half of the red meat in this diet, and the processed meat is mainly "other pro-

cessed meat". The diet contains a similar amount of fish, whole-grain, water and wine but lower amount of fruit, bread, fat spread, cheese, milk, fermented dairy products, juice and sugary, solid foods content and higher amount of red and processed meat, poultry, boiled/baked potato, high-fat gravy and beer compared with a healthy diet with low total meat content.

A high dietary meat content in an unhealthy diet is always associated with a high content of fast foods, fried potatoes, high-fat gravy, fat spread and sugar-sweetened beverages and a low content of bread and whole grain, when compared with low or high meat content, healthy diets. Thus, the total dietary fat content is always considerably higher (38-41% of the total energy) in the unhealthy diet groups compared with the other groups (31-34% of total energy). Because the unhealthy diet groups' dietary fruit, vegetable and whole-grain content is low, their diet's fibre content is low, 16 g/10 MJ.

The content of alcoholic beverages show different patterns for different groups but there is no difference between groups in dietary energy from alcohol.

The results show that a high dietary meat content can be associated with both a healthy and unhealthy diet. Dietary patterns are characterised by combinations and substitutions of food groups, of which some are inter-correlated. Thus, appropriate control of inter-correlated foods in different dietary patterns is essential in studies investigating individual foods as potential risk factors, but often it is not possible to control for all lifestyle factors and all inter-correlated foods. To eliminate some confounding it is relevant to investigate the association between meat intake and disease risk in the subgroups of high/low meat content and healthy diets compared with unhealthy diets. It may shed light on whether these groups also have increased risk of disease or whether their otherwise healthy diet protects them.

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Appendices

Appendix 1A. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary red meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary red meat content

Food groups and subgroups	Healthy diet		Unhealthy diet
	Low red meat content	High red meat content	High red meat content
Number	626	626	626
% men	30	43	70
Age, mean	47.2	50.4	40.8
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	2.0 [1.7;2.2]
Dietary guideline score variation	3.7-5.0	3.7-5.0	0.5-2.4
Total meat	90 [62;119]	187 [161;222]	217 [182;259]
Red meat	26 [15;34]	121 [108;146]	144 [125;175]
Beef and veal	10 [3.6;18]	59 [35;84]	65 [40;96]
Pork	8.4 [0.2;19]	62 [39;88]	81 [50;109]
Processed meat	28 [15;45]	36 [20;56]	45 [27;67]
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0 [0.0;0.0]
Salamis	0.0 [0.0;3.0]	0.0 [0.0;2.9]	0.4 [0.0;5.4]
Sausages	0.0 [0.0;1.4]	0.0 [0.0;2.1]	0.7 [0.0;12]
Other processed meat	22 [12;35]	29 [16;45]	34 [21;51]
Poultry	28 [6.2;54]	13 [0.7;33]	3.8 [0.0;28]
Fish	47 [29;66]	47 [29;67]	4.0 [0.0;13]
Vegetables incl. legumes and juice	238 [169;330]	254 [181;356]	120 [85;163]
Fruit incl. juice	351 [225;491]	289 [186;428]	64 [24;124]
Potatoes, boiled or baked	37 [0.0;86]	72 [23;133]	85 [36;144]
Potatoes, fried	0.0 [0.0;21]	0.0 [0.0;30]	24 [0.0;49]
Gravy, high fat	0.0 [0.0;8.0]	3.9 [0.0;15]	19 [7.4;34]
Gravy, low fat	0.0 [0.0;5.8]	0.0 [0.0;9.9]	0.0 [0.0;0.0]
Bread	167 [131;214]	153 [114;192]	112 [79;146]
Whole grain	62 [43;83]	62 [44;81]	23 [14;34]
Fat spread	3.2 [0.0;10]	2.8 [0.0;9.0]	14 [5.2;26]
Fast foods	0.0 [0.0;41]	0.0 [0.0;43]	39 [0.0;102]
Cheese	35 [22;52]	33 [20;51]	31 [17;46]
Milk ¹	199 [51;396]	158 [8.4;308]	161 [21;375]
Fermented dairy products	16 [0.0;104]	0.0 [0.0;97]	0.0 [0.0;9.0]
Water	1326 [729;1973]	1155 [608;1890]	335 [64;784]
Juice	51 [0.0;162]	0.0 [0.0;93]	0.0 [0.0;51]
Sugar-sweetened beverages	0.0 [0.0;94]	0.0 [0.0;70]	141 [0.0;397]
Wine ²	66 [0.0;169]	78 [0.0;165]	17 [0.0;113]
Beer	24 [0.0;118]	47 [0.0;141]	94 [0.0;330]
Sugary, solid foods ³	63 [38;95]	50 [25;84]	67 [35;105]
Percent with 1 meatless day per week ⁴	28	20	12
Percent with >1 meatless day per week ⁴ (=at least 2 meatless days)	28	7.4	5.6

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Appendix 1B. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary red meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary red meat content

Nutrient	Healthy diet		Unhealthy diet
	Low red meat content	High red meat content	High red meat content
Number	626	626	626
Energy, kJ/d	8221 [6700;9649]	7941 [6420;9640]	9599 [7331;11823]
Fat	31 [28;35]	34 [31;37]	40 [36;43]
Saturated fatty acids	12 [10;14]	13 [12;14]	17 [15;19]
Monounsaturated fatty acids	11 [9.3;13]	12 [11;14]	15 [13;16]
Polyunsaturated fatty acids	5.4 [4.8;6.2]	5.5 [4.9;6.1]	5.1 [4.4;5.7]
Protein	15 [14;17]	18 [17;20]	16 [15;18]
Carbohydrate	53 [49;57]	48 [44;52]	44 [40;48]
Added sugars	6.9 [4.7;9.3]	5.7 [3.8;7.9]	10 [5.5;16]
Fibres, g/10 MJ	30 [26;35]	28 [25;33]	16 [14;18]
Salt, g/d	7.5 [6.1;9.3]	8.0 [6.4;10]	9.2 [6.9;12]
Alcohol	3.5 [0.3;7.0]	3.6 [0.9;7.4]	3.4 [0.1;8.6]
Micronutrient score ¹	93 [87;96]	93 [87;96]	87 [78;93]

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Appendix 2A. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary processed meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary processed meat content

Food groups and subgroups	Healthy diet		Unhealthy diet
	Low processed meat content	High processed meat content	High processed meat content
Number	626	626	626
% men	23	51	76
Age, mean	49.5	47.6	41.0
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	2.0 [1.8;2.2]
Dietary guideline score variation	3.7-5.0	3.7-5.0	0.6-2.4
Total meat	102 [72;141]	170 [142;211]	193 [159;237]
Red_meat	61 [34;92]	77 [49;108]	80 [53;112]
Beef and veal	28 [12;52]	30 [13;53]	33 [17;55]
Pork	23 [5.1;41]	36 [18;60]	38 [18;65]
Processed meat	11 [5.9;15]	66 [56;81]	87 [75;108]
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0 [0.0;0.0]
Salamis	0.0 [0.0;0.0]	2.0 [0.0;7.1]	3.4 [0.0;9.9]
Sausages	0.0 [0.0;0.0]	3.4 [0.0;17]	24 [8.8;39]
Other processed meat	9.0 [4.9;13]	52 [41;65]	55 [44;70]
Poultry	25 [2.1;47]	17 [1.4;35]	12 [0.4;31]
Fish	49 [33;74]	43 [26;62]	5.1 [0.1;13]
Vegetables incl. legumes and juice	279 [198;368]	217 [157;305]	108 [71;150]
Fruit incl. juice	353 [238;483]	273 [166;387]	65 [25;127]
Potatoes, boiled or baked	48 [14;106]	57 [15;112]	73 [25;128]
Potatoes, fried	0.0 [0.0;25]	0.0 [0.0;27]	17 [0.0;39]
Gravy, high fat	0.0 [0.0;10]	1.7 [0.0;11]	14 [2.4;26]
Gravy, low fat	0.0 [0.0;6.6]	0.0 [0.0;8.3]	0.0 [0.0;0.0]
Bread	152 [112;189]	173 [137;214]	130 [99;166]
Whole grain	59 [40;79]	69 [52;88]	27 [18;38]
Fat spread	2.8 [0.0;10]	3.7 [0.0;10]	17 [6.9;27]
Fast foods	0.0 [0.0;21]	24 [0.0;59]	67 [32;122]
Cheese	34 [21;53]	34 [20;50]	30 [17;44]
Milk ¹	180 [25;352]	168 [21;319]	181 [35;353]
Fermented dairy products	25 [0.0;132]	0.0 [0.0;67]	0.0 [0.0;18]
Water	1365 [829;2117]	1082 [564;1725]	308 [60;677]
Juice	31 [0.0;130]	22 [0.0;119]	0.0 [0.0;47]
Sugar-sweetened beverages	0.0 [0.0;66]	0.0 [0.0;91]	184 [38;449]
Wine ²	87 [0.0;189]	66 [0.0;161]	0.0 [0.0;88]
Beer	0.0 [0.0;94]	47 [0.0;189]	141 [0.0;424]
Sugary, solid foods ³	66 [36;97]	51 [28;78]	71 [36;106]
Percent with 1 meatless day per week ⁴	30	14	11
Percent with >1 meatless day per week ⁴ (=at least 2 meatless days)	37	3.4	5.4

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Appendix 2B. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary processed meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary processed meat content

Nutrient	Healthy diet		Unhealthy diet
	Low processed meat content	High processed meat content	High processed meat content
Number	626	626	626
Energy, kJ/d	7774 [6477;9317]	8471 [6785;10327]	10344 [8351;12599]
Fat	32 [29;36]	34 [31;37]	40 [37;44]
Saturated fatty acids	12 [11;14]	13 [12;14]	17 [15;19]
Monounsaturated fatty acids	11 [9.7;13]	12 [11;14]	15 [13;16]
Polyunsaturated fatty acids	5.4 [4.8;6.0]	5.6 [5.0;6.2]	5.3 [4.8;6.0]
Protein	16 [15;18]	17 [16;18]	15 [13;16]
Carbohydrate	51 [48;56]	49 [45;53]	45 [41;49]
Added sugars	6.7 [4.6;9.0]	5.8 [4.0;7.9]	11 [6.7;16]
Fibres, g/10 MJ	30 [26;34]	28 [25;33]	16 [14;18]
Salt, g/d	7.1 [5.6;8.7]	9.0 [7.2;11]	11 [8.2;13]
Alcohol	3.8 [0.8;7.2]	3.7 [0.9;7.8]	3.3 [0.7;8.0]
Micronutrient score ¹	93 [87;96]	93 [87;97]	89 [80;94]

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Appendix 3A. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary poultry content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary poultry content

Food groups and subgroups	Healthy diet		Unhealthy diet
	Low poultry content	High poultry content	High poultry content
Number	626	625	625
% men	37	32	60
Age, mean	52.0	48.0	37.6
Median dietary guideline score	4.1 [3.8;4.4]	4.1 [3.9;4.4]	2.0 [1.7;2.2]
Dietary guideline score variation	3.7-5.0	3.7-5.0	0.6-2.4
Total meat	120 [84;157]	159 [131;192]	177 [144;221]
Red meat	81 [51;111]	58 [32;84]	72 [46;103]
Beef and veal	32 [15;54]	25 [9.9;47]	33 [18;52]
Pork	37 [15;62]	22 [7.0;43]	30 [13;54]
Processed meat	33 [18;53]	28 [16;45]	43 [26;66]
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0 [0.0;0.0]
Salamis	0.0 [0.0;3.8]	0.0 [0.0;2.3]	0.0 [0.0;4.9]
Sausages	0.0 [0.0;3.4]	0.0 [0.0;0.8]	1.8 [0.0;15]
Other processed meat	25 [15;40]	23 [13;36]	31 [19;46]
Poultry	0.0 [0.0;0.8]	62 [50;80]	50 [40;67]
Fish	46 [29;66]	45 [27;67]	5.5 [0.5;14]
Vegetables incl. legumes and juice	232 [159;313]	271 [189;385]	125 [90;166]
Fruit incl. juice	300 [205;453]	341 [226;468]	83 [36;149]
Potatoes, boiled or baked	61 [18;126]	57 [15;112]	58 [20;108]
Potatoes, fried	0.0 [0.0;23]	0.0 [0.0;29]	24 [0.0;49]
Gravy, high fat	2.4 [0.0;12]	0.8 [0.0;10]	14 [4.2;26]
Gravy, low fat	0.0 [0.0;6.5]	0.0 [0.0;8.8]	0.0 [0.0;2.7]
Bread	165 [132;212]	157 [111;198]	112 [82;150]
Whole grain	64 [47;85]	59 [40;79]	20 [12;31]
Fat spread	3.8 [0.0;11]	2.1 [0.0;8.5]	13 [5.1;23]
Fast foods	0.0 [0.0;44]	0.0 [0.0;39]	40 [0.0;93]
Cheese	34 [22;52]	33 [20;47]	30 [17;44]
Milk ¹	180 [38;351]	180 [28;379]	197 [52;400]
Fermented dairy products	0.0 [0.0;110]	9.4 [0.0;109]	0.0 [0.0;29]
Water	1074 [517;1748]	1424 [802;2182]	400 [90;842]
Juice	32 [0.0;135]	23 [0.0;111]	0.0 [0.0;72]
Sugar-sweetened beverages	0.0 [0.0;81]	0.0 [0.0;65]	218 [54;514]
Wine ²	78 [0.0;175]	71 [0.0;176]	0.0 [0.0;110]
Beer	47 [0.0;141]	0.0 [0.0;94]	47 [0.0;283]
Sugary, solid foods ³	59 [33;90]	55 [31;90]	84 [47;128]
Percent with 1 meatless day per week ⁴	26	22	16
Percent with >1 meatless day per week ⁴ (=at least 2 meatless days)	20	14	5.6

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Appendix 3B. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary poultry content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary poultry content

Nutrient	Healthy diet		Unhealthy diet
	Low poultry content	High poultry content	High poultry content
Number	626	625	625
Energy, kJ/d	8134 [6584;9828]	7621 [6378;8975]	9692 [7928;11610]
Fat	33 [29;36]	32 [29;36]	38 [34;41]
Saturated fatty acids	13 [11;14]	12 [11;14]	16 [14;18]
Monounsaturated fatty acids	12 [10;13]	11 [9.8;13]	13 [12;15]
Polyunsaturated fatty acids	5.3 [4.7;6.0]	5.6 [5.0;6.3]	5.1 [4.6;5.8]
Protein	16 [15;18]	17 [16;19]	15 [13;16]
Carbohydrate	51 [47;55]	50 [46;55]	47 [43;52]
Added sugars	6.4 [4.4;8.8]	6.0 [4.1;8.0]	13 [7.8;18]
Fibres, g/10 MJ	29 [26;34]	30 [26;34]	16 [14;18]
Salt, g/d	7.7 [6.1;9.6]	7.5 [6.1;9.1]	9.0 [6.7;12]
Alcohol	3.9 [1.1;7.6]	3.4 [0.6;7.2]	2.8 [0.0;7.5]
Micronutrient score ¹	93 [87;96]	92 [86;95]	86 [78;93]

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Appendix 4A. Food composition (g/10 MJ; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary total meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary total meat content

Variable	Healthy diet		Unhealthy diet
	Low total meat content	High total meat content	High total meat content
Number	625	626	627
% men	26	47	75
Age, mean	49.0	48.7	41.0
Median dietary guideline score	4.1 [3.9;4.4]	4.0 [3.8;4.3]	2.0 [1.7;2.2]
Dietary guideline score variation	3.7-5.0	3.7-5.0	0.6-2.4
Total meat	77 [60;89]	200 [183;230]	230 [211;272]
Red meat	36 [20;51]	114 [86;145]	136 [102;174]
Beef and veal	15 [5.9;27]	50 [27;75]	54 [30;83]
Pork	14 [1.3;25]	56 [32;81]	69 [38;104]
Processed meat	19 [10;29]	50 [29;74]	67 [44;98]
Bacon	0.0 [0.0;0.0]	0.0 [0.0;0.0]	0.0 [0.0;0.0]
Salamis	0.0 [0.0;1.6]	0.0 [0.0;4.2]	1.7 [0.0;6.9]
Sausages	0.0 [0.0;0.0]	0.0 [0.0;8.0]	7.0 [0.0;25]
Other processed meat	16 [8.0;23]	40 [23;59]	46 [30;64]
Poultry	8.4 [0.3;26]	32 [4.9;60]	24 [1.2;49]
Fish	49 [32;69]	47 [29;69]	4.1 [0.0;12]
Vegetables incl. legumes and juice	239 [168;322]	255 [183;361]	121 [83;159]
Fruit incl. juice	350 [232;480]	284 [182;417]	56 [21;109]
Potatoes, boiled or baked	45 [0.0;91]	63 [21;125]	86 [39;145]
Potatoes, fried	0.0 [0.0;21]	0.0 [0.0;29]	24 [0.0;49]
Gravy, high fat	0.0 [0.0;9.3]	3.3 [0.0;13]	18 [6.4;32]
Gravy, low fat	0.0 [0.0;5.2]	0.0 [0.0;9.5]	0.0 [0.0;2.2]
Bread	163 [129;208]	155 [116;196]	116 [86;155]
Whole grain	62 [43;84]	63 [44;81]	25 [15;35]
Fat spread	3.5 [0.0;11]	2.7 [0.0;8.6]	14 [6.1;26]
Fast foods	0.0 [0.0;34]	0.0 [0.0;45]	47 [0.0;106]
Cheese	35 [23;54]	32 [19;50]	29 [16;45]
Milk ¹	214 [57;387]	142 [0.0;301]	158 [24;378]
Fermented dairy products	21 [0.0;105]	0.0 [0.0;84]	0.0 [0.0;0.0]
Water	1211 [705;1885]	1220 [642;2002]	323 [63;716]
Juice	57 [0.0;174]	0.0 [0.0;93]	0.0 [0.0;48]
Sugar-sweetened beverages	0.0 [0.0;89]	0.0 [0.0;70]	146 [0.0;383]
Wine ²	71 [0.0;177]	67 [0.0;163]	14 [0.0;106]
Beer	0.0 [0.0;94]	35 [0.0;141]	94 [0.0;377]
Sugary, solid foods ³	69 [41;100]	46 [24;80]	61 [31;96]
Percent with 1 meatless day per week ⁴	30	15	8.4
Percent with >1 meatless day per week ⁴ (=at least 2 meatless days)	36	5.7	4.8

1. Includes all types of milk, whipping cream and low fat cream

2. Liquor not included

3. Sweets, cakes, biscuits, muesli bars, ice cream, honey (solid foods)

4. Have not eaten red or processed meat or poultry but may have eaten fish

Appendix 4B. Dietary nutrient content (percentage of total energy without alcohol, except for fibres and salt; median [25 percentile;75 percentile]) in the groups with the highest quartile of dietary guideline score and the lowest or highest quartile of dietary total meat content, and in the group with the lowest quartile of dietary guideline score and the highest quartile of dietary total meat content

Nutrient	Healthy diet		Unhealthy diet
	Low total meat content	High total meat content	High total meat content
Number	625	626	627
Energy, kJ/d	8292 [6786;9844]	7760 [6241;9688]	9884 [7705;11965]
Fat	32 [28;35]	34 [31;37]	41 [37;44]
Saturated fatty acids	12 [11;14]	13 [12;14]	17 [16;19]
Monounsaturated fatty acids	11 [9.3;13]	13 [11;14]	15 [14;16]
Polyunsaturated fatty acids	5.3 [4.6;6.2]	5.7 [5.1;6.3]	5.3 [4.7;5.9]
Protein	15 [14;16]	18 [17;20]	16 [15;18]
Carbohydrate	53 [50;57]	47 [44;51]	43 [39;47]
Added sugars	7.0 [4.9;9.5]	5.6 [3.4;7.2]	9.5 [5.0;14]
Fibres, g/10 MJ	30 [26;34]	28 [25;33]	16 [14;18]
Salt, g/d	7.4 [6.1;9.1]	8.3 [6.4;10]	10 [7.5;12]
Alcohol	3.4 [0.6;7.1]	3.5 [0.7;7.5]	3.3 [0.5;8.5]
Micronutrient score ¹	93 [88;96]	93 [86;96]	89 [79;93]

1. Express how the diet meet the Nordic Nutrition Recommendations (0-100)

Part II

Meat intake and health

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Introduction

In October 2015, the International Agency for Research on Cancer published a summary of a scientific expert meeting, which concluded that processed meat could be classified as “carcinogenic to humans”, and red meat could be classified as “probably carcinogenic to humans” (IARC, 2015). The conclusions were based on epidemiological data and mechanistic evidence. The report of the expert meeting was published in 2018 (IARC, 2018). In 2018 World Cancer Research Fund and American Institute for Cancer Research published their *Continuous Update Project Report* on cancer prevention and stated that there is strong evidence that consuming red and processed meat increases the risk of colorectal cancer (World Cancer Research Fund/American Institute for Cancer Research, 2018).

Red and processed meat intake may also affect heart health. Schwingshackl et al. (2017) found a positive association between red and processed meat intake and hypertension, a risk factor for heart disease. Cui et al. (2019) found a positive association between processed meat but not red meat intake and heart failure, and Lippi et al. (2015) concluded that there was no clear association between red meat intake and risk of myocardial infarction.

Some, but not all, prospective, population based studies from different countries have associated high red and processed meat consumption with increased risk of mortality (Abete et al., 2014; Etemadi et al., 2017; Yip et al., 2018). In a meta-analysis of prospective cohort studies, Wang et al. (2015) found no association between red meat intake and mortality risk (cardiovascular, cancer or all-cause) but an association was found for processed meat. However, a subgroup analysis showed that a red meat-mortality association was found in the US populations but not in European or Asian populations. But not all studies performed in American cohorts show an association between red or processed meat intake and mortality risk (Kappeler et al., 2013).

Thus, a high intake of red and processed meat seems to be associated with health and mortality. However, red and processed meat are only a part of the dietary risk factors affecting human health, and according to the latest update on the Global Burden of Disease Study (Afshin et al., 2019) processed meat, and in particular red meat, has less health impact than several other dietary factors.

Since composition of diets is complex, cohort studies on associations between meat intake and health has

many confounders, e.g. the dietary content of fruit, vegetables and whole grains. Likewise, the dietary content of certain nutrients (e.g. saturated fatty acids or fibres) may affect the health outcome, and it is well known that persons having a high intake of red and/or processed meat often have an unhealthy lifestyle (including physical inactivity and tobacco smoking), which also affect the persons’ disease risk. However, as discussed in Part I of the present report, it is possible to have a high meat content in a healthy diet. Thus, it is of interest to investigate if Danes eating a healthy diet with a high meat content have the same disease and mortality risk as those with a similar dietary pattern but a low dietary meat content.

The aim of the study is to evaluate the associations between intake of meat and disease, both in the total population and in subgroups with different dietary quality that minimize the influence of dietary confounding.

This report focuses on the health effects of the dietary content of red and processed meat. However, data for health effects of dietary poultry and total meat content can be found in appendix 1-14 but it will not be discussed in the present report.

Methods

DANSDA

The analyses were based on information from participants in The Danish National Survey on Diet and Physical Activity (DANSDA) 2000-2002, 2003-2008, and 2011-2013. More details about the data collection can be found in Biloft-Jensen et al. (2009). Information on consumption of meat (red meat, processed meat, poultry, and total meat), dietary quality, energy intake, alcohol energy intake, BMI, smoking, and leisure physical activity were extracted from the surveys. Dietary quality was based on information on fruit and vegetables consumption, fish consumption, whole-grain consumption, energy from saturated fatty acids, and energy from added sugars. For those participants who had answered more than one survey (n=89), information from the first survey was included. Definitions of red meat, processed meat, poultry, total meat, and dietary guideline score is described in Part I of the present report.

Register-based information

Outcomes were identified through linkage of the cohort with information from registers using the unique personal identification number (CPR) (Pedersen, 2011). The outcome ischemic heart disease was based on information from the National Patient Register on primary and secondary diagnoses (ICD-8:

410-414; ICD-10: I20-I25) (Lyngé et al., 2011) and from the Register of Causes of Death on underlying cause of death (ICD-8: 410-414; ICD-10: I20-I25) (Helweg-Larsen, 2011). Information on the outcome acute coronary syndrome was based on information from the National Patient Register on primary diagnoses (ICD-8: 410 and 427.27; ICD-10: I20.0 and I21) (Lyngé et al., 2011) and from the Register of Causes of Death on underlying cause of death (ICD-8: 410 and 427.27; ICD-10: I20.0 and I21) (Helweg-Larsen, 2011). The outcome colorectal cancer was based on information on histologically confirmed cancer from the Danish Cancer Registry (ICD-10: C18 and C20) (Gjerstorff, 2011). Information on the outcome all-cause mortality was based on information on date of death regardless of underlying cause from the Register of Causes of Death (Helweg-Larsen, 2011).

Information on age, sex, ethnicity (Danish, Western non-Danish, Non-Western), and emigration were obtained from the Danish Civil Registration System (Pedersen, 2011). Educational attainment (short, medium, long) was based on information from the Population's Educational Register (Jensen & Rasmussen, 2011). From information on primary diagnosis in the National Patient Register, diabetes up to 10 years before baseline (ICD-8: 249-250; ICD-10: E10-E14) and colorectal polyps up to 10 years before baseline (ICD-10: K62.1 and K63.5) were identified. However, colorectal polyps were so rare in the population that they were not included in the analyses.

Analyses

The aim of the analyses was to study incident cases of disease, and therefore separate cohorts had to be included for each of the studied outcomes. In the analyses on ischemic heart disease, acute coronary syndrome, and colorectal cancer, individuals were excluded if they had been diagnosed with the particular outcome before baseline. In analyses on all-cause mortality, no such criterion was included.

The cohort was followed from baseline (date of survey interview) or from age 37 years for ischemic heart disease and acute coronary syndrome and from age 50 years for colorectal cancer, whichever came last. Delayed entry into the analyses was applied because the outcomes ischemic heart disease, acute coronary syndrome, and colorectal cancer were almost absent among participants younger than the ages 37 years and 50 years, respectively. Follow-up ended at first diagnosis or death due to the studied outcome or at emigration, death or end of follow-up (31 December 2017), whichever came first.

Missing information on country of origin (0.01%) was imputed as Danish origin, missing educational level was imputed as short education (1.5%), missing BMI (1.0%) was imputed as normal BMI (18.5-25), missing smoking status (1.1%) was imputed as never smoker, and missing information on physical activity (0.4%) was imputed as the most common category (moderate/hard).

Meat consumption and dietary quality

Consumption of red meat, processed meat, poultry, and total meat were analysed on both a continuous scale and categorically. Categorisations were based on the observed quartiles of meat consumption. For analyses of ischemic heart disease and all-cause mortality, the measures of meat consumption were categorized in three groups (lower quartile; the two middle quartiles; upper quartile), and for analyses on acute coronary syndrome and colorectal cancer, the measures of meat consumption were categorized in two groups (below median; above median). The choice between two or three groups was based on the number of cases in the analyses, where we evaluated that the number of incident cases of acute coronary syndrome and of colorectal cancer was too low to analyse on three groups of meat consumption. The same methods were applied when categorising the dietary quality. These categorisations are different from those applied in Part I of the report, because we ideally wanted to analyse on three groups, and when we had to apply two groups, we chose to split the population in half because of the small number of cases. For the continuous measures of meat consumption, red meat, poultry, and total meat were included as increases of 100 g/day, and processed meat was included as increases of 50 g/day.

Associations between meat consumption and dietary quality and outcomes

The association between the different measures of meat consumption and the studied outcomes were estimated using Cox regression analyses. As all studied outcomes are strongly associated with age, we used age as the underlying timescale. The different measures of meat consumption were included in different regression models with adjustment for sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake. In analyses on ischemic heart disease and acute coronary syndrome, results were additionally adjusted for history of diabetes 10 years before baseline. To test whether the associations between meat consumption and outcomes were better represented by non-linear effects compared to linear effects, quadratic and cubic terms were included in

the regression models. However, all non-linear effects were non-significant, so meat consumption was only included linearly.

Valid results from Cox regression analyses requires that the hazard ratio between groups does not change with age, i.e. the assumption of proportional hazards. To evaluate if this assumption was fulfilled, we estimated the Schoenfeld Residuals for each of exposure variable. We then tested in a linear regression model whether these residuals were correlated with age (underlying timescale). These analyses indicated that the assumption of proportional hazards was fulfilled. We also visually inspected the log-negative-log survival curves for each of the exposure and outcome variables. These plots did not indicate serious violation of the proportional hazards assumption.

The associations between dietary quality and the studied outcomes were estimated using the same methods as for meat consumption, but dietary quality was only included categorically.

Associations between meat consumption and outcomes distributed on dietary quality

Association between meat consumption and outcomes distributed on dietary quality were also estimated using Cox regression analyses with age as the underlying timescale. The only difference from the analyses described above was the inclusion of dietary quality, where associations between meat consumption and outcomes were stratified by dietary quality. In these analyses, the statistical significance of an interaction between meat consumption and dietary quality was tested by including both meat consumption and dietary quality as separate main effects and as an interaction term with each other. This was done to test if the association between meat consumption and the studied outcomes differed between those with a healthy and an unhealthy dietary quality. These tests were performed both on analyses with meat consumption as a categorical and a continuous variable, but the tests including meat consumption as a continuous variable were considered the main tests. The same analyses were made with dietary quality stratified by meat consumption to evaluate whether the association of dietary quality and the disease outcomes differed between those with high and low meat intake.

All analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina, USA).

Results

Descriptive results

Characteristics of the study population are shown in table 1. A small majority are women, and most of the study population has Danish origin. The distribution on educational level shows that a medium educational level is the most frequent, while long and short education are almost equally frequent in the study population. Very few are underweight, and most are normal weight followed by overweight and obese. About half of the population are either former or current smokers. A small proportion is sedentary, and most have a moderate/hard level of physical activity.

The distribution of the types of meat analysed in the report and of the dietary quality score are shown in table 2.

Table 1. Baseline characteristics of study population, n=9,848

	n (%)
Age, mean (sd)	44 (16)
Sex	
Men	4654 (47.3)
Women	5194 (52.7)
Origin	
Danish	9585 (97.3)
Western	97 (1.0)
Non-western	166 (1.7)
Educational level	
Long	2815 (28.6)
Medium	4165 (42.3)
Short	2868 (29.1)
BMI	
Underweight	240 (2.4)
Normal weight	5469 (55.5)
Overweight	3052 (31.0)
Obese	1087 (11.0)
Smoking	
Never	4752 (48.3)
Former	2493 (25.3)
Current	2603 (26.4)
Leisure physical activity	
Sedentary	893 (9.1)
Light	3807 (38.7)
Moderate/hard	5148 (52.3)

Abbreviations: n, number of participants; sd, standard deviation

Table 2. Distribution of meat consumption and dietary quality score, n=9,848

	Mean (sd)	Q1	Median	Q3
Red meat, g/day	75 (50)	41	65	97
Processed meat, g/day	43 (35)	19	35	58
Poultry, g/day	23 (27)	1	16	34
Total meat, g/day	141 (74)	91	126	176
Dietary quality score	3.0 (0.9)	2.4	3.1	3.7

Abbreviations: sd, standard deviation; Q1, first quartile; Q3, third quartile

In table 3a and 3b characteristics of the population stratified by dietary quality and red meat consumption and processed meat consumption are shown.

Similar results distributed on poultry and total meat are shown in appendix 1 and 2.

Table 3a. Characteristics of study population stratified by dietary quality¹ and consumption of red meat², n=9,848

	Unhealthy diet		Healthy diet	
	Low consumption of red meat	High consumption of red meat	Low consumption of red meat	High consumption of red meat
	n (%)	n (%)	n (%)	n (%)
Age, mean (sd)	40 (16)	42 (16)	46 (16)	49 (15)
Sex				
Men	826 (39.6)	1929 (68.0)	784 (27.6)	1115 (53.4)
Women	1261 (60.4)	908 (32.0)	2053 (72.4)	972 (46.6)
Ethnicity				
Danish	2023 (96.9)	2785 (98.2)	2749 (96.9)	2028 (97.2)
Western	28 (1.3)	13 (0.5)	38 (1.3)	18 (0.9)
Non-western	36 (1.7)	39 (1.4)	50 (1.8)	41 (2.0)
Educational level				
Long	441 (21.1)	582 (20.5)	1043 (36.8)	749 (35.9)
Medium	911 (43.7)	1329 (46.8)	1079 (38.0)	846 (40.5)
Short	735 (35.2)	926 (32.6)	715 (25.2)	492 (23.6)
BMI				
Underweight	72 (3.4)	67 (2.4)	66 (2.3)	35 (1.7)
Normal weight	1251 (59.9)	1426 (50.3)	1711 (60.3)	1081 (51.8)
Overweight	558 (26.7)	988 (34.8)	794 (28.0)	712 (34.1)
Obese	206 (9.9)	356 (12.5)	266 (9.4)	259 (12.4)
Smoking				
Never	929 (44.5)	1234 (43.5)	1519 (53.5)	1070 (51.3)
Former	403 (19.3)	629 (22.2)	791 (27.9)	670 (32.1)
Current	755 (36.2)	974 (34.3)	527 (18.6)	347 (16.6)
Physical activity				
None	272 (13.0)	328 (11.6)	179 (6.3)	114 (5.5)
Light	863 (41.4)	1136 (40.0)	1058 (37.3)	750 (35.9)
Moderate/hard	952 (45.6)	1373 (48.4)	1600 (56.4)	1223 (58.6)

¹ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

² Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

Abbreviations: n, number of participants; sd, standard deviation

Table 3b. Baseline characteristics of study population stratified by dietary quality¹ and consumption of processed meat², n=9,848

	Unhealthy diet		Healthy diet	
	Low consumption of processed meat	High consumption of processed meat	Low consumption of processed meat	High consumption of processed meat
	n (%)	n (%)	n (%)	n (%)
Age, mean (sd)	41 (17)	41 (15)	48 (16)	46 (16)
Sex				
Men	751 (37.0)	2004 (69.2)	747 (25.8)	1152 (56.8)
Women	1278 (63.0)	891 (30.8)	2148 (74.2)	877 (43.2)
Ethnicity				
Danish	1950 (96.1)	2858 (98.7)	2790 (96.4)	1987 (97.9)
Western	22 (1.1)	19 (0.7)	38 (1.3)	18 (0.9)
Non-western	57 (2.8)	18 (0.6)	67 (2.3)	24 (1.2)
Educational level				
Long	444 (21.9)	579 (20.0)	1083 (37.4)	709 (34.9)
Medium	849 (41.8)	1391 (48.0)	1062 (36.7)	863 (42.5)
Short	736 (36.3)	925 (32.0)	750 (25.9)	457 (22.5)
BMI				
Underweight	79 (3.9)	60 (2.1)	73 (2.5)	28 (1.4)
Normal weight	1206 (59.4)	1471 (50.8)	1717 (59.3)	1075 (53.0)
Overweight	552 (27.2)	994 (34.3)	825 (28.5)	681 (33.6)
Obese	192 (9.5)	370 (12.8)	280 (9.7)	245 (12.1)
Smoking				
Never	897 (44.2)	1266 (43.7)	1531 (52.9)	1058 (52.1)
Former	394 (19.4)	638 (22.0)	827 (28.6)	634 (31.2)
Current	738 (36.4)	991 (34.2)	537 (18.5)	337 (16.6)
Physical activity				
None	268 (13.2)	332 (11.5)	180 (6.2)	113 (5.6)
Light	855 (42.1)	1144 (39.5)	1079 (37.3)	729 (35.9)
Moderate/hard	906 (44.7)	1419 (49.0)	1636 (56.5)	1187 (58.5)

¹ Unhealthy diet: Below 3.1 on the dietary quality score; Healthy diet: Above 3.1 on the dietary quality score

² Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

Abbreviations: n, number of participants; sd, standard deviation

The results show that most characteristics differ by both dietary quality and by meat consumption. For example, men make up a larger proportion of those with an unhealthy diet compared to those with a healthy diet, and among both groups they make up a larger proportion of those with a high meat consumption compared to those with a low meat consumption. This can be seen for both red meat consumption and for processed meat consumption.

Association between meat consumption and disease outcomes

In the following, results on associations between meat consumption and the studied outcomes are presented. Estimates indicating trends and associations are commented on, but it should be kept in mind that

none of the results are statistically significant, and therefore trends and associations should be interpreted with caution.

All tables include information on the number of cases, incidence rates (IR) and hazard ratios (HR). The HR estimates the relative risk associated with the exposure and the adjusted HR are therefore the main results commented on. The number of cases represent information on the power to detect associations in the study, and IR represent information on unadjusted associations between exposure and outcome with no adjustment for factors that could influence the association. Results are presented for meat consumption modelled both linearly and categorically (see methods). Only results for meat modelled linearly are

commented on. For red meat, the results represent increases of 100 g/day, and for processed meat, they represent increases of 50 g/day. Results on associations with poultry and with total meat are presented in appendix 3-14 and will not be commented further.

The association between meat consumption and risk of ischemic heart disease is shown in table 4. The results show an estimate above 1 in the association between intake of **red meat** and ischemic heart disease (HR=1.23; 95%CI:0.99-1.53), and this result is close to statistically significant. Consumption of **processed meat** also has an estimate above 1 (HR=1.09; 95%CI:0.93-1.29) but it is statistically non-significant.

Table 4. Association between red meat consumption and processed meat consumption and risk of ischemic heart disease, n=8,007

	No. of cases	IR ¹	HR [95%CI] ²	HR [95%CI] ³
Red meat, low ⁴	96	1.4	1.00 Reference	1.00 Reference
Red meat, medium	226	1.5	1.04 [0.82;1.32]	1.07 [0.84;1.37]
Red meat, high	117	1.8	1.17 [0.88;1.55]	1.26 [0.93;1.69]
Red meat, per 100 g/day			1.14 [0.93;1.40]	1.23 [0.99;1.53]
Processed meat, low ⁵	114	1.7	1.00 Reference	1.00 Reference
Processed meat, medium	205	1.4	0.83 [0.65;1.05]	0.89 [0.70;1.13]
Processed meat high	120	1.8	1.02 [0.77;1.35]	1.10 [0.81;1.50]
Processed meat, per 50 g/day			1.05 [0.91;1.22]	1.09 [0.93;1.29]

¹ Per 100,000 person-years

² Adjusted by sex

³ Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake

⁴ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day

⁵ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

In table 5, the associations between meat consumption and acute coronary syndrome are shown. The estimate for **red meat** is above 1 (HR=1.22;

95%CI:0.91-1.62) but it is statistically non-significant. For **processed meat** the estimate is also above 1 (HR 1.07; 95%CI:0.86-1.33) but non-significant.

Table 5. Association between red meat consumption and processed meat consumption and risk of acute coronary syndrome, n=8,198

	No. of cases	IR ¹	HR [95%CI] ²	HR [95%CI] ³
Red meat, low ⁴	108	0.7	1.00 Reference	1.00 Reference
Red meat, high	134	0.9	1.09 [0.84;1.42]	1.10 [0.83;1.45]
Red meat, per 100 g/day			1.17 [0.90;1.54]	1.22 [0.91;1.62]
Processed meat, low ⁵	111	0.8	1.00 Reference	1.00 Reference
Processed meat high	131	0.9	1.03 [0.79;1.35]	1.05 [0.79;1.40]
Processed meat, per 50 g/day			1.08 [0.89;1.31]	1.07 [0.86;1.33]

¹ Per 100,000 person-years

² Adjusted by sex

³ Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake

⁴ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁵ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Associations between meat consumption and colorectal cancer are shown in table 6. The estimate of an association between **red meat** and colorectal cancer is above 1 (HR=1.04; 95%CI:0.67-1.61), but

statistically non-significant. The estimate is also above 1 for **processed meat** (HR=1.16; 95%CI:0.85-1.59) but it is also statistically non-significant.

Table 6. Association between red meat consumption and processed meat consumption and risk of colorectal cancer, n=6,282

	No. of cases	IR ¹	HR [95%CI] ²	HR [95%CI] ³
Red meat, low ⁴	64	0.6	1.00 Reference	1.00 Reference
Red meat, high	63	0.6	1.00 [0.70;1.44]	1.01 [0.69;1.48]
Red meat, per 100 g/day			1.04 [0.69;1.56]	1.04 [0.67;1.61]
Processed meat, low ⁵	65	0.6	1.00 Reference	1.00 Reference
Processed meat high	62	0.7	1.07 [0.74;1.55]	1.10 [0.74;1.63]
Processed meat, per 50 g/day			1.14 [0.86;1.51]	1.16 [0.85;1.59]

¹ Per 100,000 person-years

² Adjusted by sex

³ Adjusted by sex, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

⁴ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁵ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

The associations between meat consumption and risk of all-cause mortality are shown in table 7. These estimates are below 1, and the estimate for **red meat**

suggests a lower risk with higher intake (HR=0.89; 95%CI:0.72-1.10) but it is statistically non-significant.

Table 7. Association between red meat consumption and processed meat consumption and risk of all-cause mortality, n=9,848

	No. of cases	IR ¹	HR [95%CI] ²	HR [95%CI] ³
Red meat, low ⁴	167	1.6	1.00 Reference	1.00 Reference
Red meat, medium	356	1.8	0.95 [0.79;1.14]	1.02 [0.84;1.23]
Red meat, high	117	1.4	0.77 [0.60;0.98]	0.86 [0.67;1.12]
Red meat, per 100 g/day			0.81 [0.67;0.98]	0.89 [0.72;1.09]
Processed meat, low ⁵	180	1.9	1.00 Reference	1.00 Reference
Processed meat, medium	328	1.6	0.89 [0.73;1.07]	1.04 [0.80;1.36]
Processed meat high	132	1.4	0.88 [0.69;1.12]	1.02 [0.82;1.26]
Processed meat, per 50 g/day			0.95 [0.83;1.08]	0.99 [0.85;1.15]

¹ Per 100,000 person-years

² Adjusted by sex

³ Adjusted by sex, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

⁴ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day

⁵ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Association between dietary quality and disease outcomes

In table 8, results on the association between dietary quality and risk of ischemic heart disease are

presented. These results show the highest estimate among those with a medium dietary quality (HR=1.17; 95%CI:0.92-1.48) but it is statistically non-significant.

Table 8. Association between dietary quality and risk of ischemic heart disease, n=8,007

	No. of cases	IR ¹	HR [95%CI] ²
Dietary quality, low ³	94	1.4	1.04 [0.77;1.41]
Dietary quality, medium	242	1.7	1.17 [0.92;1.48]
Dietary quality, high	103	1.5	1.00 Reference

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake

³ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score
Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

The results on the association between dietary quality and risk of acute coronary syndrome are presented in table 9. They show an estimate above 1 for low

quality (HR=1.06; 95%CI:0.81-1.40) but it is statistically non-significant.

Table 9. Association between dietary quality and risk of acute coronary syndrome, n=8,198

	No. of cases	IR ¹	HR [95%CI] ²
Dietary quality, low ³	125	0.8	1.06 [0.81;1.4]
Dietary quality, high	117	0.8	1.00 Reference

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score
Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Table 10 shows the association between dietary quality and risk of colorectal cancer. The estimate is above

1 with low dietary quality (HR=1.09; 95%CI:0.75-1.58) but it is statistically non-significant.

Table 10. Association between dietary quality and risk of colorectal cancer, n=6,282

	No. of cases	IR ¹	HR [95%CI] ²
Dietary quality, low ³	61	0.7	1.09 [0.75;1.58]
Dietary quality, high	66	0.6	1.00 Reference

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

In table 11, the highest estimate for risk of all-cause mortality is found among those with low dietary

quality (HR=1.26; 95%CI:0.99-1.61), and this is close to statistically significant.

Table 11. Association between dietary quality and risk of all-cause mortality, n=9,848

	No. of cases	IR ¹	HR [95%CI] ²
Dietary quality, low ³	172	1.6	1.26 [0.99;1.61]
Dietary quality, medium	331	1.7	1.07 [0.87;1.31]
Dietary quality, high	137	1.6	1.00 Reference

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Association between meat consumption and disease outcomes stratified by dietary quality

It is possible that association between meat consumption and the studied outcomes may be modified by dietary quality, so that the associations between different meat and disease outcomes differ between those with low-quality diet and those with high-quality diet. To investigate this, the associations between meat consumption and the studied outcomes, stratified by dietary quality, are shown in table 12 to 15. These tables also include p-values for tests of an interaction between dietary quality and meat consumption on the risk of the studied outcome, i.e. does dietary quality influence the association between meat consumption and the studied outcomes.

In table 12, the associations between meat consumption and ischemic heart disease stratified by dietary quality are shown. These results show that the associations between consumption of **red meat** and risk of ischemic heart disease do not statistically differ between those with an unhealthy (HR=1.30; 95%CI:0.98-1.89), medium (HR=0.98; 95%CI:0.71-1.36), or healthy (HR=1.93; 95%CI:1.18-3.17) diet (p=0.10). For **processed meat**, the results also show that the associations between consumption and risk of ischemic heart disease do not statistically differ between those with an unhealthy (HR=1.03; 95%CI:0.77-1.38), medium (HR=1.13; 95%CI:0.90-1.41), or healthy (HR=1.15; 95%CI:0.73-1.80) diet (p=0.99). For both types of meat consumption, the estimates for the three groups of dietary quality do not show a clear trend with stronger estimates among those with an unhealthy diet compared to those with a healthy diet. Rather, the trend seems to be opposite with higher estimates among those with a healthy diet.

Table 12. Association between red meat consumption and processed meat consumption and risk of ischemic heart disease. Stratified by dietary quality⁵, n=8,007

	Unhealthy diet no. of cases	Medium diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Medium diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Medium diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for interaction
Red meat, low ³	9	57	30	0.8	1.7	1.2	1.00 Reference	1.00 Reference	1.00 Reference	
Red meat, medium	48	122	56	1.4	1.5	1.7	2.00 [0.96;4.15]	0.80 [0.58;1.11]	1.34 [0.85;2.11]	0.22
Red meat, high	37	63	17	1.6	2.0	2.0	2.13 [0.99;4.57]	0.97 [0.65;1.45]	1.66 [0.86;3.21]	
Red meat, per 100 g/day							1.30 [0.89;1.89]	0.98 [0.71;1.36]	1.93 [1.18;3.17]	0.10
Processed meat, low ⁴	19	51	44	1.8	1.6	1.8	1.00 Reference	1.00 Reference	1.00 Reference	
Processed meat, medium	35	128	42	1.1	1.6	1.2	0.64 [0.36;1.14]	1.04 [0.74;1.46]	0.75 [0.48;1.17]	0.52
Processed meat high	40	63	17	1.6	1.8	2.2	0.83 [0.44;1.59]	1.19 [0.78;1.83]	1.36 [0.69;2.66]	
Processed meat, per 50 g/day							1.03 [0.77;1.38]	1.13 [0.90;1.41]	1.15 [0.73;1.80]	0.99

¹ Per 100,000 person-years² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.³ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day⁴ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Table 13 shows associations between meat consumption and risk of acute coronary syndrome stratified by dietary quality. For **red meat**, the risks of acute coronary syndrome are not statistically different between those with an unhealthy (HR=1.24; 95%CI:0.86-1.79) and a healthy (HR=1.18; 95%CI:0.73-1.88) diet (p=0.61). The same is observed for the estimates of associations for **processed meat** consumption

among those with an unhealthy (HR=1.09; 95%CI:0.84-1.42) and a healthy (HR=0.96; 95%CI:0.66-1.40) diet (p=0.40). As opposed to the results on ischemic heart disease, these results do show a trend of stronger estimates among those with an unhealthy diet compared to a healthy diet, even though these differences are not statistically significant.

Table 13. Association between red meat consumption and processed meat consumption and risk of acute coronary syndrome. Stratified by dietary quality⁵, n=8,198

	Unhealthy diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value
Red meat, low ³	44	64	0.7	0.7	1.00 Reference	1.00 Reference	0.61
Red meat, high	81	53	1.0	0.9	1.16 [0.78;1.72]	1.11 [0.74;1.66]	
Red meat, per 100 g/day					1.24 [0.86;1.79]	1.18 [0.73;1.88]	0.61
Processed meat, low ⁴	40	71	0.7	0.8	1.00 Reference	1.00 Reference	0.10
Processed meat, high	85	46	1.0	0.8	1.27 [0.84;1.94]	0.83 [0.55;1.27]	
Processed meat, per 50 g/day					1.09 [0.84;1.42]	0.96 [0.66;1.40]	0.40

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁴ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

The associations between meat consumption and colorectal cancer stratified by dietary quality are shown in table 14. This shows that for **red meat**, the estimates are not statistically different between those with an unhealthy (HR=0.94; 95%CI:0.51-1.73) and those with a healthy (HR=1.12; 95%CI:0.59-2.12) diet (p=0.45). For the associations between **processed meat** consumption and risk of colorectal cancer, the estimates are not statistically diffe-

rent among those with an unhealthy (HR=1.24; 95%CI:0.83-1.86) and those with a healthy (HR=1.03; 95%CI:0.62-1.73) diet (p=0.97), but the estimates are stronger among those with an unhealthy diet compared to a healthy diet.

Table 14: Association between red meat consumption and processed meat consumption and risk of colorectal cancer. Stratified by dietary quality⁵, n=6,282

	Unhealthy diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for inter- actions
Red meat, low ³	27	37	0.7	0.6	1.00 Reference	1.00 Reference	0.53
Red meat, high	34	29	0.6	0.7	0.95 [0.55;1.64]	1.06 [0.62;1.81]	
Red meat, per 100 g/day					0.94 [0.51;1.73]	1.12 [0.59;2.12]	0.45
Processed meat, low ⁴	27	38	0.7	0.6	1.00 Reference	1.00 Reference	0.47
Processed meat, high	34	28	0.6	0.7	0.97 [0.55;1.70]	1.22 [0.70;2.12]	
Processed meat, per 50 g/day					1.24 [0.83;1.86]	1.03 [0.62;1.73]	0.97

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁴ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

The associations between meat consumption and all-cause mortality stratified by dietary quality are shown in table 15. For **red meat**, the estimates are not statistically different between those with an unhealthy (HR=1.03; 95%CI:0.73-1.45), medium (HR=0.87; 95%CI:0.64-1.18), or healthy (HR=0.78; 95%CI:0.46-1.32) diet (p=0.85). The associations are not statistically different either between **processed meat** and risk of all-cause mortality among those with an unhealthy (HR=0.82; 95%CI:0.63-1.07), medium (HR=1.12; 95%CI:0.91-1.37), or healthy (HR=0.91; 95%CI:0.59-1.39) diet (p=0.28).

Association between dietary quality and disease outcomes stratified by meat consumption

Table 16-19 show associations between dietary quality and outcomes stratified by meat consumption, and they are included to show associations among those with a high meat consumption. Therefore, results among those with a high meat consumption are commented on in the following.

In table 16, the associations between dietary quality and risk of ischemic heart disease stratified by meat consumption are presented. These results show that the estimate is below 1 for low dietary quality among those with high consumption of **red meat** (HR=0.94; 95%CI:0.51-1.73) but it is statistically non-significant. A similar trend is seen among those with high consumption of **processed meat** (HR=0.88; 95%CI:0.47-1.64), and this is also statistically non-significant.

Table 15. Association between red meat consumption and processed meat consumption and risk of all-cause mortality. Stratified by dietary quality⁵, n=9,848

	Unhealthy diet		Medium diet		Unhealthy diet		Medium diet		Unhealthy diet		Medium diet		p-value for interactions
	no. of cases	no. of cases	no. of cases	no. of cases	IR ¹	IR ¹	IR ¹	IR ¹	HR [95%CI] ²	HR [95%CI] ²	HR [95%CI] ²	HR [95%CI] ²	
Red meat, low ³	29	82	56	1.4	1.7	1.7	1.7	1.00	Reference	1.00	Reference	1.00	
Red meat, medium	99	191	66	1.9	1.6	1.6	1.6	1.18	[0.77;1.80]	1.00	Reference	0.94	0.98
Red meat, high	44	58	15	1.3	1.3	1.3	1.3	1.07	[0.64;1.76]	0.85	[0.59;1.24]	0.76	
Red meat, per 100 g/day								1.03	[0.73;1.45]	0.87	[0.64;1.18]	0.78	0.85
Processed meat, low ⁴	36	86	58	2.0	1.8	1.8	1.8	1.00	Reference	1.00	Reference	1.00	
Processed meat, medium	85	176	67	1.7	1.6	1.6	1.6	1.12	[0.75;1.70]	0.91	[0.70;1.20]	0.98	0.65
Processed meat, high	51	69	12	1.4	1.2	1.2	1.2	0.83	[0.50;1.38]	1.07	[0.74;1.54]	0.80	
Processed meat, per 50 g/day								0.82	[0.63;1.07]	1.12	[0.91;1.37]	0.91	0.28

¹ Per 100,000 person-years² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake³ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day⁴ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Table 16. Association between dietary quality and risk of ischemic heart disease. Stratified by red meat consumption or by processed meat consumption, n=8,007

	Low meat no. of cases	Medium meat no. of cases	High meat no. of cases	Low meat IR ¹	Medium meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	Medium meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Red meat ³										
Dietary quality, low ⁵	9	48	37	0.8	1.4	1.6	0.77 [0.35;1.69]	1.04 [0.68;1.58]	0.94 [0.51;1.73]	
Dietary quality, medium	57	122	63	1.7	1.5	2.0	1.62 [1.02;2.55]	1.04 [0.75;1.44]	1.00 [0.58;1.72]	0.22
Dietary quality, high	30	56	17	1.2	1.7	2.0	1.00 Reference	1.00 Reference	1.00 Reference	
Processed meat ⁴										
Dietary quality, low ⁵	19	35	40	1.8	1.1	1.6	1.03 [0.58;1.83]	1.13 [0.70;1.82]	0.88 [0.47;1.64]	
Dietary quality, medium	51	128	63	1.5	1.6	1.8	0.99 [0.65;1.50]	1.46 [1.02;2.09]	0.91 [0.52;1.60]	0.52
Dietary quality, high	44	42	17	1.8	1.2	2.2	1.00 Reference	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.³ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day⁴ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

The associations between dietary quality and risk of acute coronary syndrome stratified by meat consumption are presented in table 17. The estimate for low dietary quality among those with a high consumption

of **red meat** is above 1 (HR=1.08; 95%CI:0.74-1.56) but it is statistically non-significant. For **processed meat**, the estimate is also above 1 (HR=1.38; 95%CI:0.94-2.03) but also statistically non-significant.

Table 17. Association between dietary quality and risk of acute coronary syndrome. Stratified by red meat consumption or by processed meat consumption, n=8,198

	Low meat no. of cases	High meat no. of cases	Low meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Red meat³							
Dietary quality, low ⁵	44	81	0.7	1.0	1.02 [0.68;1.54]	1.08 [0.74;1.56]	0.61
Dietary quality, high	64	53	0.7	0.9	1.00 Reference	1.00 Reference	
Processed meat⁴							
Dietary quality, low ⁵	40	85	0.7	1.0	0.76 [0.5;1.15]	1.38 [0.94;2.03]	0.10
Dietary quality, high	71	46	0.8	0.8	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁴ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Table 18 shows the associations between dietary quality and risk of colorectal cancer stratified by meat consumption. The estimate for low dietary quality among those with high consumption of **red meat**

is below 1 (HR=0.91; 95%CI:0.53-1.54) but it is statistically non-significant. For **processed meat**, the estimate is also below 1 (HR=0.91; 95%CI:0.53-1.54) and statistically non-significant.

Table 18. Association dietary quality and risk of colorectal cancer. Stratified by red meat consumption or by processed meat consumption, n=6,282

	Low meat no. of cases	High meat no. of cases	Low meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Red meat ³							
Dietary quality, low ⁵	27	34	0.7	0.6	1.25 [0.74;2.12]	0.91 [0.53;1.54]	0.53
Dietary quality, high	37	29	0.6	0.7	1.00 Reference	1.00 Reference	
Processed meat ⁴							
Dietary quality, low ⁵	27	34	0.7	0.6	1.27 [0.75;2.15]	0.91 [0.53;1.54]	0.47
Dietary quality, high	38	28	0.6	0.7	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Low consumption of red meat: < 65 g/day; High consumption of red meat: > 65 g/day

⁴ Low consumption of processed meat: < 35 g/day; High consumption of processed meat: > 35 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

In table 19, the associations between dietary quality and risk of all-cause mortality stratified by meat consumption are presented. These show that for low dietary quality among those with high consumption **red meat** the estimate is above 1 (HR=1.11;

95%CI:0.59-2.08) but statistically non-significant. Likewise, among those with a high consumption of **processed meat** the estimate is above 1 (HR=1.15; 95%CI:0.61-2.14) but not statistically significant.

Table 19. Association between dietary quality and risk of all-cause mortality. Stratified by red meat consumption or by processed meat consumption. n=9,848

	Low meat no. of cases	Medium meat no. of cases	High meat no. of cases	Low meat IR ¹	Medium meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	Medium meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Red meat³										
Dietary quality, low ⁵	29	99	44	1.4	1.9	1.3	1.09 [0.66;1.79]	1.42 [1.02;1.99]	1.11 [0.59;2.08]	
Dietary quality, medium	82	191	58	1.7	1.8	1.4	0.98 [0.69;1.38]	1.17 [0.87;1.56]	1.00 [0.56;1.78]	0.98
Dietary quality, high	56	66	15	1.7	1.6	1.3	1.00 Reference	1.00 Reference	1.00 Reference	
Processed meat⁴										
Dietary quality, low ⁵	36	85	51	2.0	1.7	1.4	1.29 [0.83;2.02]	1.36 [0.96;1.92]	1.06 [0.55;2.04]	
Dietary quality, medium	86	176	69	2.0	1.7	1.4	1.15 [0.82;1.63]	0.98 [0.74;1.31]	1.15 [0.61;2.14]	0.65
Dietary quality, high	58	67	12	1.8	1.6	1.2	1.00 Reference	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Low consumption of red meat: < 41 g/day; Medium consumption of red meat: 41-97 g/day; High consumption of red meat: > 97 g/day

⁴ Low consumption of processed meat: < 19 g/day; Medium consumption of processed meat: 19-58 g/day; High consumption of processed meat: > 58 g/day

⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Discussion

In our analyses, we have studied associations between meat consumption and ischemic heart disease, acute coronary syndrome, colorectal cancer, and all-cause mortality. These outcomes were chosen because we wanted to study diseases and outcomes that have been described in previous studies on associations with meat consumption, and because identification of these diseases has high validity using Danish health registers (Madsen et al., 2003; Joensen et al., 2009; Gjerstorff, 2011). We included both acute coronary syndrome and the more often studied ischemic heart disease because acute coronary syndrome is a narrower definition of heart disease that may be more strongly associated with meat consumption than the broader outcome of ischemic heart disease.

The associations between meat consumption and the outcomes ischemic heart disease, acute coronary syndrome, colorectal cancer, and all-cause mortality showed trends of higher risk of ischemic heart disease and acute coronary syndrome with higher consumption of red meat and to some degree processed meat. However, none of these trends were statistically significant. When stratified by dietary quality, there were no statistically significant differences in the associations between meat intake and outcomes in those with a healthy dietary quality and those with an unhealthy dietary quality.

These results will be discussed in the following order: 1) associations between meat consumption and ischemic heart disease and acute coronary syndrome; 2) associations between meat consumption and colorectal cancer; 3) associations between meat consumption and all-cause mortality. These results will be discussed in relation to red meat and processed meat and in relation to high versus low consumption and to continuous results. Subsequently, the results on associations distributed on dietary quality are discussed.

Ischemic heart disease and acute coronary syndrome

Our results were statistically non-significant but we estimated that high consumption of **red meat** was associated with 26% increased risk of ischemic heart disease compared with low consumption, and that every increase of 100 g/day was associated with 23% increased risk. The first finding was close to statistically significant. The corresponding results for acute coronary syndrome were 10% and 22%, respectively, and they were also statistically non-significant. In a meta-analysis on risk of coronary heart disease, it was found that there was no increased risk associated with red meat consumption, but the authors cite

two prospective studies published after the analysis that found 18-19% increased risk for every consumption increase of 100 g/day (Micha et al., 2012). Thus, the estimates are similar in magnitude to those in our study, though ours were not statistically significant. Other studies have investigated heart related mortality, which is associated with the same risk factors as heart related disease. A meta-analysis found that high consumption versus low consumption (definitions of this varied between studies) was associated with 16% increased risk of cardiovascular mortality but not with ischemic heart disease mortality. The same meta-analysis found that increases of 100 g/day in red meat consumption was associated with 24% increased risk of cardiovascular mortality but not with ischemic heart disease mortality (Abete et al., 2014). In an American prospective study from 2017 it was found that high consumption of red meat was associated with 27% increased risk of heart mortality compared with low consumption (Etemadi et al., 2017). In their study, high consumption was defined as the highest fifth of calorie-adjusted intakes, and lowest consumption was defined as the lowest fifth. The findings are similar to ours on both ischemic heart disease and acute coronary syndrome. However, their estimates are statistically significant.

Although the results were statistically non-significant, we found estimates for high consumption of **processed meat** of 10% increased risk of ischemic heart disease compared to low consumption, and that every increase of 50 g/day was associated with 9% increased risk. The same results for acute coronary syndrome were 5% and 7%, respectively, and they were also statistically non-significant. In a meta-analysis and review from 2012, it was found that every 100 g/day increase in consumption of processed meat was associated with increased risk of cardiovascular events between 44% to 102% (Micha et al., 2012). These associations are stronger than the statistically non-significant associations identified in our study but are based on associations with increases of 100 g/day compared to our 50 g/day, as is customarily used. A meta-analysis found that high consumption compared to low consumption of processed meat was associated with 18% increased risk of cardiovascular mortality and increases of 50 g/day in consumption was associated with 24% increased risk. The analysis did not find associations with ischemic heart disease mortality (Abete et al., 2014). An American study from 2017 found that high consumption compared to low consumption of processed meat was significantly associated with 10% increased risk of heart mortality (Etemadi et al., 2017), which is similar in magnitude to our non-significant findings.

Colorectal cancer

In our study, we found estimates of associations between consumption of **red meat** and colorectal cancer, which were very close to 1. According to the World Cancer Research Fund's meta-analyses, increases of 100 g/day in consumption of red meat is associated with 12% higher risk of colorectal cancer, but it also quotes other pooled analyses not finding an association (World Cancer Research Fund/American Institute for Cancer Research, 2018). One meta-analysis from 2011 found that increases of 100 g/day in consumption of red meat was associated with 17% increased risk of colorectal cancer (Chan et al., 2011), and a meta-analysis from 2015 showed that high consumption compared to low consumption was associated with 11% increased risk (Alexander et al., 2015). These findings indicate stronger estimates of associations than the statistically non-significant estimates in our study. A meta-analysis from 2010 also found that meat consumption was only associated with risk of colon cancer but not with risk of rectal cancer (Smolińska & Paluszkiwicz, 2010). In a prospective study based on the Danish Diet, Cancer and Health cohort study, the authors did not find statistically significant associations between consumption of red meat and risk of colon or rectal cancer, though estimates were positive and ranging between 11% and 18% for those who consumed > 114 g/day compared to ≤ 61 g/day (Egeberg et al., 2013).

Although the results were statistically non-significant, we found estimates for high consumption of **processed meat** of 10% increased risk of colorectal cancer compared to low consumption, and that every increase of 50 g/day was associated with 16% increased risk. The meta-analysis from the World Cancer Research Fund found that increases in consumption of 50 g/day was associated with 16% increased risk of colorectal cancer (World Cancer Research Fund/American Institute for Cancer Research, 2018). Another meta-analysis found that the same increase was associated with 18% increased risk (Chan et al., 2011). These findings show estimates similar to those identified in our study, though our findings were statistically non-significant. The study based on the Danish Diet, Cancer and Health cohort study did not find associations between consumption of processed meat and risk of colon or rectal cancer (Egeberg et al., 2013).

All-cause mortality

We found estimates below 1 for the association of **red meat** and all-cause mortality, but they were statistically non-significant. Two meta-analyses from 2014 found that high consumption compared to low

consumption and increases of 100 g/day were not associated with statistically significant increased risk, though the estimates showed positive associations between consumption and risk of all-cause mortality (Abete et al., 2014; Larsson & Orsini, 2014). An American study with detailed dietary information also found that consumption of red meat was not associated with mortality (Kappeler et al., 2013).

Our estimates for the association between **processed meat** consumption and all-cause mortality were below 1 but they were statistically non-significant. The two above mentioned meta-analyses showed that high consumption compared to low consumption was associated with 22-23% increased risk (Abete et al., 2014; Larsson & Orsini, 2014). One of them found that increases of 50 g/day in consumption was associated with a 25% increased risk (Abete et al., 2014).

Dietary quality

Though we found that the estimates for associations between low dietary quality and the studied outcomes were generally above 1, we did not find statistically significant associations. Previous studies have found associations between dietary quality and disease risk (Bergeron et al., 2019; Kappeler et al., 2013). However, the definitions of dietary quality varies greatly between studies, which also influences the reported effect estimates. Our analyses stratified by unhealthy and healthy dietary qualities did not significantly change the estimated associations between meat consumption and disease risk. A Swedish prospective study found a statistically significant association between consumption of red meat and all-cause mortality and cardiovascular mortality. They studied whether these associations differed depending on the amount of fruit and vegetables consumed, and they found that associations did not differ between those with high and low consumption of fruit and vegetables (Bellavia et al., 2016). These results do not indicate that associations between meat consumption and disease risk are modified by other components of dietary quality, which was our hypothesis, since it has been suggested that other dietary factors including fruit, vegetable, and fiber intake may heavily influence the associations (Fogelholm et al., 2015). However, to our knowledge the associations between meat consumption and disease risk stratified by dietary quality as opposed to adjusted for dietary quality have not been reported previously.

General discussion

Identified associations and differences between study findings will be influenced by differences in study

populations. For example, associations may differ between countries, and these differences can be difficult to identify in meta-analyses. Both red meat and processed meat are broader categories of meat that include different types of meat, and what characterises red meat or processed meat may differ between countries. For example, pork may be a bigger contributor to red meat consumption in some countries compared to others, where beef could be a bigger contributor to red meat consumption. Other differences between countries could be in cooking methods for example how much salt is used or how hard the meat is fried. These differences could be important explanations to differences in observed associations between meat consumption and disease risks in different countries. Other factors that will influence the estimates are the abilities to include influential confounders in the analyses. In our study, we combined register and survey information, which enabled us to include both behavioral factors, socioeconomic factors, and disease history as possible confounders. We also adjusted our analyses for BMI, which is commonly done in nutritional epidemiology but as BMI is also influenced by diet, it could be viewed as a mediator instead of a confounder in the associations between meat consumption and the outcomes. However, as the measures of meat consumption, dietary quality, and BMI are collected cross-sectional, it is not possible to deduce the temporality between these measures.

Our analyses of dietary patterns (Part I of this report) showed that a low dietary content of one type of meat, e.g. poultry, was associated with a high dietary content of other types of meat, e.g. red meat. Thus, dietary content of meat types could be confounders. Before we made the estimates of associations between meat intake and disease risk, it was not known to us, exactly which types of dietary meat content were associated, and therefore we did not include different types of meat in the same analyses. However, in future analyses it may be appropriate to take dietary content of other types of meat into consideration.

Though our analyses indicated directions in the associations, we did not find statistically significant associations between meat consumption and disease risk. However, the ability to reach statistically significant results is influenced by many factors. For example, as the studied population was 15-75 years at baseline (2000-2013), a large proportion of the population was too young to be at real risk of developing the studied diseases. This was especially true for colorectal cancer, which we only studied among individuals aged 50 years and older. Therefore, the

number of outcomes could be an explanation why the associations between red and processed meat and the outcomes were non-significant.

Strengths and limitations

Our study has several strengths. The studied outcomes are based on linking national registers with high validity and completeness and we included complete information on migration and death ensuring complete follow-up of the study cohort. The linkage also enabled us only to include incident cases of disease and to minimise the risk of reverse causality as we excluded those with disease before baseline. The study included comprehensive information on dietary components, which made it possible to evaluate if associations differed with the quality of the overall dietary quality.

This includes registration of the total diet for seven days, including weekend days, and the data collection process covering all season to allow for seasonal variations in dietary quality.

However, the study also had limitations in addition to those already presented. The DANSDA surveys are representative regarding gender and age. However, in the latest surveys, participants with short education are underrepresented, which may limit the generalisability of the findings. In addition, the study only included one dietary registration for each individual. Therefore, it is assumed that the dietary quality does not change during follow-up, but if the population has large variations in dietary quality during follow-up, this would influence the estimated associations. Finally, as mentioned previously the size of the study population affects the power to identify statistically significant associations especially in analyses on interactions between meat consumption and dietary quality.

Another limitation is that the size of the study population restricted our opportunities to study differences between those with very low and those with very high meat consumption. Only in analyses on ischemic heart disease and on all-cause mortality were we able to divide the population's meat consumption in three groups instead of two. This introduces some arbitrariness around cut-off values of meat consumption since we split in two groups without having meaningful differences in the amount of meat consumed around the median. However, in the interpretation of results we focused on estimates of associations with meat consumption on a continuous scale, which do not suffer from this limitation.

Conclusion

We evaluated associations between intake of meat and disease risk in the cohort consisting of participants in The Danish National Survey on Diet and Physical Activity 2000-2002, 2003-2008, and 2011-2013. The cohort was followed in several nationwide registers.

For several associations between meat intake and disease risk, the direction and magnitude were often comparable with findings from other cohort studies showing an increased disease risk with increased meat intake. However, none of the associations in our estimates were statistically significant. For the association between meat intake and mortality risk, the direction suggests a lower risk with higher intake of red meat but it was not significant.

Although not statistically significant, low dietary quality increased disease and mortality risk.

When stratified by dietary quality, there were no statistically significant differences in the associations between meat intake and disease and mortality risk in those with a healthy dietary quality and those with an unhealthy dietary quality.

Our study was performed with a relatively young population (15-75 years at baseline in 2000-2013), so a large proportion of the population was too young to be at real risk of developing the studied diseases. Therefore, the low number of outcomes could be an explanation why the association between red and processed meat and disease risk was non-significant.

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Appendices

Appendix 1. Baseline characteristics of study population stratified by dietary quality¹ and consumption of poultry, n=9,848

	Unhealthy diet ¹		Healthy diet ¹	
	Low consumption of poultry ²	High consumption of poultry ²	Low consumption of poultry ²	High consumption of poultry ²
	n (%)	n (%)	n (%)	n (%)
Age, mean (sd)	42 (16)	40 (15)	48 (16)	46 (15)
Sex				
Men	1368 (54.2)	1387 (57.8)	893 (37.2)	1006 (39.8)
Women	1156 (45.8)	1013 (42.2)	1505 (62.8)	1520 (60.2)
Ethnicity				
Danish	2472 (97.9)	2336 (97.3)	2330 (97.2)	2447 (96.9)
Western	23 (0.9)	18 (0.8)	25 (1.0)	31 (1.2)
Non-western	29 (1.1)	46 (1.9)	43 (1.8)	48 (1.9)
Educational level				
Long	512 (20.3)	511 (21.3)	850 (35.4)	942 (37.3)
Medium	1135 (45.0)	1105 (46.0)	917 (38.2)	1008 (39.9)
Short	877 (34.7)	784 (32.7)	631 (26.3)	576 (22.8)
BMI				
Underweight	73 (2.9)	66 (2.8)	56 (2.3)	45 (1.8)
Normal weight	1390 (55.1)	1287 (53.6)	1358 (56.6)	1434 (56.8)
Overweight	781 (30.9)	765 (31.9)	721 (30.1)	785 (31.1)
Obese	280 (11.1)	282 (11.8)	263 (11.0)	262 (10.4)
Smoking				
Never	1069 (42.4)	1094 (45.6)	1229 (51.3)	1360 (53.8)
Former	521 (20.6)	511 (21.3)	725 (30.2)	736 (29.1)
Current	934 (37.0)	795 (33.1)	444 (18.5)	430 (17.0)
Physical activity				
None	335 (13.3)	265 (11.0)	152 (6.3)	141 (5.6)
Light	1052 (41.7)	947 (39.5)	888 (37.0)	920 (36.4)
Moderate/hard	1137 (45.0)	1188 (49.5)	1358 (56.6)	1465 (58.0)

¹ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

² Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

Abbreviations: n, number of participants; sd, standard deviation

Appendix 2. Baseline characteristics of study population stratified by dietary quality¹ and consumption of total meat, n=9,848

	Unhealthy diet ¹		Healthy diet ¹	
	Low consumption of total meat ²	High consumption of total meat ²	Low consumption of total meat ²	High consumption of total meat ²
	n (%)	n (%)	n (%)	n (%)
Age, mean (sd)	40 (17)	42 (15)	47 (16)	47 (15)
Sex				
Men	637 (31.9)	2118 (72.3)	709 (24.2)	1190 (59.7)
Women	1357 (68.1)	812 (27.7)	2221 (75.8)	804 (40.3)
Ethnicity				
Danish	1929 (96.7)	2879 (98.3)	2829 (96.6)	1948 (97.7)
Western	24 (1.2)	17 (0.6)	44 (1.5)	12 (0.6)
Non-western	41 (2.1)	34 (1.2)	57 (1.9)	34 (1.7)
Educational level				
Long	442 (22.2)	581 (19.8)	1070 (36.5)	722 (36.2)
Medium	802 (40.2)	1438 (49.1)	1088 (37.1)	837 (42.0)
Short	750 (37.6)	911 (31.1)	772 (26.3)	435 (21.8)
BMI				
Underweight	84 (4.2)	55 (1.9)	78 (2.7)	23 (1.2)
Normal weight	1221 (61.2)	1456 (49.7)	1785 (60.9)	1007 (50.5)
Overweight	502 (25.2)	1044 (35.6)	789 (26.9)	717 (36.0)
Obese	187 (9.4)	375 (12.8)	278 (9.5)	247 (12.4)
Smoking				
Never	898 (45.0)	1265 (43.2)	1553 (53.0)	1036 (52.0)
Former	377 (18.9)	655 (22.4)	825 (28.2)	636 (31.9)
Current	719 (36.1)	1010 (34.5)	552 (18.8)	322 (16.1)
Physical activity				
None	250 (12.5)	350 (11.9)	187 (6.4)	106 (5.3)
Light	881 (44.2)	1118 (38.2)	1090 (37.2)	718 (36.0)
Moderate/hard	863 (43.3)	1462 (49.9)	1653 (56.4)	1170 (58.7)

¹ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

² Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

Abbreviations: n, number of participants; sd, standard deviation

Appendix 3. Association between poultry consumption or total meat consumption and risk of ischemic heart disease, n=8,007

	No. of cases	IR¹	HR [95%CI]²
Poultry, low ³	128	1.7	1.00 Reference
Poultry, medium	205	1.5	1.07 [0.86;1.34]
Poultry, high	106	1.5	1.03 [0.80;1.34]
Poultry, per 100 g/day			0.92 [0.62;1.37]
Total meat, low ⁴	104	1.5	1.00 Reference
Total meat, medium	221	1.5	1.07 [0.84;1.37]
Total meat high	114	1.7	1.23 [0.89;1.70]
Total meat, per 100 g/day			1.18 [0.99;1.41]

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of poultry: < 1 g/day; Medium consumption of poultry: 1-34 g/day; High consumption of poultry: > 34 g/day

⁴ Low consumption of total meat: < 91 g/day; Medium consumption of total meat: 91-176 g/day; High consumption of total meat: > 176 g/day
Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 4. Association between poultry consumption or total meat consumption and risk of acute coronary syndrome, n=8,198

	No. of cases	IR¹	HR [95%CI]²
Poultry, low ³	127	0.9	1.00 Reference
Poultry, high	115	0.8	0.98 [0.76;1.26]
Poultry, per 100 g/day			1.03 [0.62;1.71]
Total meat, low ⁴	106	0.7	1.00 Reference
Total meat high	136	1.0	1.23 [0.91;1.67]
Total meat, per 100 g/day			1.18 [0.94;1.48]

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 5. Association between poultry consumption or total meat consumption and risk of colorectal cancer, n=6,282

	No. of cases	IR¹	HR [95%CI]²
Poultry, low ³	53	0.5	1.00 Reference
Poultry, high	74	0.8	1.62 [1.13;2.31]
Poultry, per 100 g/day			1.39 [0.69;2.77]
Total meat, low ⁴	61	0.6	1.00 Reference
Total meat high	66	0.7	1.38 [0.92;2.09]
Total meat, per 100 g/day			1.20 [0.86;1.67]

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, total energy intake

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 6. Association between poultry consumption or total meat consumption and risk of all-cause mortality, n=9,848

	No. of cases	IR¹	HR [95%CI]²
Poultry, low ³	225	2.3	1.00 Reference
Poultry, medium	277	1.4	0.98 [0.82;1.17]
Poultry, high	138	1.4	0.92 [0.74;1.14]
Poultry, per 100 g/day			0.91 [0.65;1.28]
Total meat, low ⁴	201	2	1.00 Reference
Total meat, medium	322	1.6	0.86 [0.71;1.04]
Total meat high	117	1.3	0.76 [0.58;1.01]
Total meat, per 100 g/day			0.91 [0.77;1.06]

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, and total energy intake

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 7. Association between poultry consumption and total meat consumption and risk of ischemic heart disease. Stratified by dietary quality⁵, n=8,007

	Unhealthy diet no. of cases	Medium diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Medium diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Medium diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for interactions
Poultry, low ³	35	72	21	1.8	1.9	1.3	1.00 Reference	1.00 Reference	1.00 Reference	
Poultry, medium	34	110	61	1.1	1.5	1.8	0.78 [0.48;1.26]	1.06 [0.78;1.43]	1.54 [0.93;2.54]	0.21
Poultry, high	25	60	21	1.3	1.7	1.2	0.94 [0.56;1.60]	1.12 [0.79;1.58]	0.97 [0.53;1.78]	
Poultry, per 100 g/day							0.81 [0.35;1.87]	0.96 [0.56;1.63]	0.91 [0.39;2.13]	0.97
Total meat, low ⁴	14	53	37	1.5	1.5	1.4	1.00 Reference	1.00 Reference	1.00 Reference	
Total meat, medium	43	128	50	1.3	1.6	1.5	1.02 [0.54;1.93]	1.04 [0.74;1.46]	1.14 [0.73;1.80]	0.84
Total meat, high	37	61	16	1.5	1.9	2.3	1.01 [0.49;2.07]	1.14 [0.73;1.79]	1.96 [0.96;4.00]	
Total meat, per 100 g/day							1.18 [0.86;1.61]	1.05 [0.82;1.35]	1.64 [1.07;2.51]	0.26

¹ Per 100,000 person-years² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.³ Low consumption of poultry: < 1 g/day; Medium consumption of poultry: 1-34 g/day; High consumption of poultry: > 34 g/day⁴ Low consumption of total meat: < 91 g/day; Medium consumption of total meat: 91-176 g/day; High consumption of total meat: > 176 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 8. Association between poultry consumption and total meat consumption and risk of acute coronary syndrome. Stratified by dietary quality⁵, n=8,198

	Unhealthy diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for interactions
Poultry, low ³	68	59	0.9	0.9	1.00 Reference	1.00 Reference	0.80
Poultry, high	57	58	0.8	0.8	0.96 [0.67;1.37]	1.04 [0.72;1.50]	
Poultry, per 100 g/day					1.21 [0.63;2.32]	0.82 [0.38;1.77]	0.47
Total meat, low ⁴	37	69	0.6	0.8	1.00 Reference	1.00 Reference	0.18
Total meat, high	88	48	1.0	0.9	1.45 [0.94;2.26]	1.04 [0.67;1.60]	
Total meat, per 100 g/day					1.25 [0.94;1.67]	1.03 [0.70;1.51]	0.31

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 9. Association between poultry consumption and total meat consumption and risk of colorectal cancer. Stratified by dietary quality⁵, n=6,282

	Unhealthy diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for interactions
Poultry, low ³	26	27	0.5	0.5	1.00 Reference	1.00 Reference	0.75
Poultry, high	35	39	0.8	0.7	1.72 [1.03;2.87]	1.52 [0.93;2.50]	
Poultry, per 100 g/day					1.50 [0.56;4.00]	1.29 [0.48;3.48]	0.89
Total meat, low ⁴	25	36	0.7	0.5	1.00 Reference	1.00 Reference	0.41
Total meat, high	36	30	0.7	0.8	1.20 [0.66;2.17]	1.49 [0.84;2.65]	
Total meat, per 100 g/day					1.19 [0.76;1.88]	1.17 [0.70;1.95]	0.66

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 10. Association between poultry consumption and total meat consumption and risk of all-cause mortality. Stratified by dietary quality⁵, n=9,848

	Unhealthy diet no. of cases	Medium diet no. of cases	Healthy diet no. of cases	Unhealthy diet IR ¹	Medium diet IR ¹	Healthy diet IR ¹	Unhealthy diet HR [95%CI] ²	Medium diet HR [95%CI] ²	Healthy diet HR [95%CI] ²	p-value for interactions
Poultry, low ³	63	125	37	2.2	2.5	1.9	1.00 Reference	1.00 Reference	1.00 Reference	
Poultry, medium	77	135	65	1.5	1.4	1.5	1.24 [0.88;1.75]	0.89 [0.69;1.14]	1.03 [0.68;1.54]	0.88
Poultry, high	32	71	35	1.1	1.4	1.6	0.87 [0.56;1.36]	0.95 [0.71;1.28]	0.96 [0.60;1.55]	
Poultry, per 100 g/day							0.93 [0.48;1.81]	0.77 [0.47;1.26]	1.41 [0.72;2.78]	0.21
Total meat, low ⁴	42	100	59	2.4	2.1	1.7	1.00 Reference	1.00 Reference	1.00 Reference	
Total meat, medium	82	172	68	1.6	1.6	1.6	0.85 [0.57;1.28]	0.84 [0.64;1.09]	0.94 [0.64;1.38]	0.66
Total meat, high	48	59	10	1.3	1.4	1.1	0.69 [0.41;1.15]	0.81 [0.55;1.19]	0.73 [0.34;1.56]	
Total meat, per 100 g/day							0.89 [0.67;1.19]	0.93 [0.74;1.17]	0.92 [0.60;1.40]	0.75

¹ Per 100,000 person-years² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake³ Low consumption of poultry: < 1 g/day; Medium consumption of poultry: 1-34 g/day; High consumption of poultry: > 34 g/day⁴ Low consumption of total meat: < 91 g/day; Medium consumption of total meat: 91-176 g/day; High consumption of total meat: > 176 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 1.1. Association between dietary quality and risk of ischemic heart disease. Stratified by poultry consumption or by total meat consumption, n=8,007

	Low meat no. of cases	Medium meat no. of cases	High meat no. of cases	Low meat IR ¹	Medium meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	Medium meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Poultry ³										
Dietary quality, low ⁴	35	34	25	1.8	1.1	1.3	1.49 [0.83;2.66]	0.71 [0.45;1.12]	1.36 [0.71;2.57]	
Dietary quality, medium	72	110	60	1.9	1.5	1.7	1.44 [0.87;2.37]	0.96 [0.69;1.32]	1.54 [0.92;2.59]	0.21
Dietary quality, high	21	61	21	1.3	1.8	1.2	1.00 Reference	1.00 Reference	1.00 Reference	
Total meat ⁵										
Dietary quality, low ⁴	14	43	37	1.5	1.3	1.5	1.23 [0.67;2.27]	1.11 [0.78;1.59]	1.13 [0.74;1.73]	
Dietary quality, medium	53	128	61	1.5	1.6	1.9	1.01 [0.53;1.92]	0.91 [0.59;1.40]	1.38 [0.74;2.56]	0.84
Dietary quality, high	37	50	16	1.4	1.5	2.3	1.00 Reference	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.³ Low consumption of poultry: < 1 g/day; Medium consumption of poultry: 1-34 g/day; High consumption of poultry: > 34 g/day⁴ Low consumption of total meat: < 91 g/day; Medium consumption of total meat: 91-176 g/day; High consumption of total meat: > 176 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 12. Association between dietary quality and risk of acute coronary syndrome. Stratified by poultry consumption or by total meat consumption, n=8,198

	Low meat no. of cases	High meat no. of cases	Low meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Poultry³							
Dietary quality, low ⁵	68	57	0.9	0.8	1.07 [0.73;1.56]	1.09 [0.73;1.6]	0.80
Dietary quality, high	59	58	0.9	0.8	1.00 Reference	1.00 Reference	
Total meat⁴							
Dietary quality, low ⁵	37	88	0.6	1.0	0.89 [0.59;1.36]	1.17 [0.81;1.69]	0.18
Dietary quality, high	69	48	0.8	0.9	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years

² Adjusted by sex, educational attainment (the year before baseline), ethnicity, smoking, physical activity, alcohol, BMI, history of diabetes (10 years before baseline), and total energy intake.

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 13. Association dietary quality and risk of colorectal cancer. Stratified by poultry consumption or by total meat consumption, n=6,282

	Low meat no. of cases	High meat no. of cases	Low meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Poultry³							
Dietary quality, low ⁵	26	35	0.5	0.8	1.04 [0.58;1.88]	1.17 [0.72;1.9]	0.75
Dietary quality, high	27	39	0.5	0.7	1.00 Reference	1.00 Reference	
Total meat⁴							
Dietary quality, low ⁵	25	36	0.7	0.7	1.26 [0.73;2.16]	0.88 [0.53;1.48]	0.41
Dietary quality, high	36	30	0.5	0.8	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years

² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake

³ Low consumption of poultry: < 16 g/day; High consumption of poultry: > 16 g/day

⁴ Low consumption of total meat: < 126 g/day; High consumption of total meat: > 126 g/day

⁵ Unhealthy diet: < 3.1 on the dietary quality score; Healthy diet: > 3.1 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

Appendix 14. Association between dietary quality and risk of all-cause mortality. Stratified by poultry consumption or by total meat consumption, n=9,848

	Low meat no. of cases	Medium meat no. of cases	High meat no. of cases	Low meat IR ¹	Medium meat IR ¹	High meat IR ¹	Low meat HR [95%CI] ²	Medium meat HR [95%CI] ²	High meat HR [95%CI] ²	p-value for interactions
Poultry ³										
Dietary quality, low ⁵	63	77	32	2.2	1.5	1.1	1.35 [0.87;2.09]	1.42 [0.99;2.03]	0.80 [0.47;1.37]	
Dietary quality, medium	125	135	71	2.5	1.4	1.4	1.23 [0.84;1.81]	0.99 [0.73;1.34]	0.91 [0.59;1.39]	0.88
Dietary quality, high	37	65	35	1.9	1.5	1.6	1.00 Reference	1.00 Reference	1.00 Reference	
Total meat ⁴										
Dietary quality, low ⁵	42	82	48	2.4	1.6	1.3	1.54 [1.00;2.35]	1.26 [0.89;1.78]	1.10 [0.54;2.27]	
Dietary quality, medium	100	172	59	2.1	1.6	1.4	1.14 [0.82;1.60]	1.02 [0.77;1.36]	1.08 [0.54;2.13]	0.66
Dietary quality, high	59	68	10	1.7	1.6	1.1	1.00 Reference	1.00 Reference	1.00 Reference	

¹ Per 100,000 person-years² Adjusted by sex, age, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake³ Low consumption of poultry: < 1 g/day; Medium consumption of poultry: 1-34 g/day; High consumption of poultry: > 34 g/day⁴ Low consumption of total meat: < 91 g/day; Medium consumption of total meat: 91-176 g/day; High consumption of total meat: > 176 g/day⁵ Unhealthy diet: < 2.4 on the dietary quality score; Medium diet: 2.4-3.7 on the dietary score; Healthy diet: > 3.7 on the dietary quality score

Abbreviations: n, number of participants; IR, incidence rates; HR, hazard ratios; CI, confidence interval

