

Modelling the impact of reductions in meat and dairy consumption on nutrient intakes and disease risk

Summary briefing



1. Introduction

In December 2022, the Climate Change Committee (CCC) recommended that the Scottish Government (SG) “take low-cost, low-regret actions to encourage a 20% shift away from all meat by 2030, rising to 35% by 2050, and a 20% shift from dairy products by 2030”.

To understand the impact of achieving these recommendations on diet and related health, Food Standards Scotland (FSS) commissioned research from the University of Edinburgh, using data on dietary intakes collected in adults, as part of the [Scottish Health Survey \(SHeS\) in 2021](#).

The researchers modelled a number of scenarios to reduce meat and dairy to assess the impact on energy and nutrient intakes, achievement of the [Scottish Dietary Goals \(SDG\)](#) and potential impacts on health.

To ensure the robustness of the research, FSS and the University of Edinburgh consulted with representatives of the [UK Scientific Advisory Committee on Nutrition \(SACN\)](#) throughout this project. SACN members also peer reviewed the final report, as did a nutrition expert from the University of Aberdeen.

For the modelling, the following definitions were used for meat and dairy:

All meat: beef, lamb, pork, other red meat, offal, poultry, game birds, processed red meat, processed poultry, burgers, sausages, and meat contained within composite dishes (e.g. spaghetti Bolognese) or manufactured products (e.g. sausage roll).

Red and red processed meat: beef, lamb, pork, other red meat, offal, processed red meat, burgers and sausages, in addition to red and red processed meat contained within composite dishes (e.g. spaghetti Bolognese) or manufactured products (e.g. sausage roll).

Dairy products: milk and milk products made from all animal milks, including cheeses, yogurts, creams, butter and dairy desserts, in addition to milk or milk products contained within composite dishes (e.g. macaroni cheese) or manufactured products (e.g. cakes).

Milk and milk products: milk and milk products made from all animal milks, including cheeses, yogurts, creams, butter and dairy desserts.

2. Key findings

- On any given day, 86% of adults in Scotland consume some type of meat and 99% consume some dairy. Meat and dairy are important sources of a number of nutrients, including iron, calcium, zinc, selenium, iodine and vitamin B₁₂
- Modelling completed by the University of Edinburgh showed that many population sub-groups are already at risk of low micronutrient intakes and these may be worsened by a reduction in meat and/or dairy intakes, particularly if these are not replaced with suitable alternatives
- However, the modelling also showed that it would be possible to mitigate the negative impact of a shift away from meat and dairy on micronutrient intakes, with careful consideration of replacements, such as vegetables, oily fish, eggs, pulses and legumes, and plant-based meat and dairy alternatives
- Further modelling was conducted to reduce total meat consumption, by reducing intakes of red and red processed meat among high consumers only (those consuming >70g/day). This is existing public health nutrition advice to consumers and this group are generally less at risk of micronutrient insufficiencies. At present, 1/3 of adults living in Scotland report consuming more than 70g red and red processed meat/day
- If all adults living in Scotland met the SDG for red and processed red meat (70g/day), in line with existing public health recommendations, it would achieve a 16% reduction in total meat intake, as defined by the CCC. This would affect 28% of adults (16+yr) in Scotland
- To achieve a 20% reduction in the population average total meat intake, as defined by the CCC, all adults (16+yr) living in Scotland currently consuming more than 60g/day red and red processed meat would need to reduce their intake to 60g/day. This would affect 32% of adults in Scotland
- To achieved a 35% reduction in population average total meat intake, as defined by the CCC, all adults (16+yr) living in Scotland currently consuming more than 31g/day red and red processed meat would need to reduce their intake to 31g/day. This would affect 54% of adults in Scotland
- Existing evidence demonstrates that high consumers of red and red processed meat are at higher risk of developing colo-rectal cancer. Modelling of other long term health impacts shows that if high consumers of red and red processed meat reduce intakes to no more than 70g/day, there would be a small reduction in average Body Mass Index and a small reduction in cases of cardiovascular disease over a ten-year period. The research also estimates a reduction of ~10,000 cases of Type 2 diabetes over a ten-year period

3. Aims

The overarching aim of this research was to identify if it is possible to reduce meat and dairy consumption without negative impacts on dietary intakes and health outcomes for adults living in Scotland. To achieve this aim, the research explored:

- Existing evidence on the nutritional benefits and risks of reducing meat and dairy
- Current intakes of meat, dairy and selected nutrients in Scotland, including by age, sex, Body Mass Index (BMI) and Scottish Index of Multiple Deprivation (SIMD)
- The contribution of meat, dairy and other foods to nutrient intakes in Scotland, including by age, sex, BMI and SIMD
- The characteristics of high consumers of red and red processed meat, along with when and how red and red processed meat is most frequently reported as consumed by people living in Scotland
- Modelling the impact of various scenarios reducing meat and dairy on energy and nutrient intake and achievement of the SDGs
- Modelling the impact of various scenarios of reducing meat and dairy on BMI and chronic diseases

4. Methodology

Data sources

Modelling of diet and health impacts of meat and dairy reductions were carried out on dietary intake data collected in 2021 from 3,447 adults (aged 16+yr) living in Scotland, who completed at least 1 recall using Intake24 as part of the [Scottish Health Survey \(SHeS\)](#). SHeS data is available on the [UK Data Archive](#).

Dairy disaggregation

Data on the total dairy content of foods had not previously been disaggregated from the SHeS data. As part of this project, the University of Edinburgh disaggregated dairy from all dairy-containing food products using the Food Standards Agency Standard Recipes Database, such as homemade recipes and manufactured products, to estimate the dairy including milk, cheese, yogurt, cream and butter in 100g of product.

With the disaggregated data, the research assessed:

- Contribution of dairy foods and drinks to total dairy intake, including discretionary foods e.g. confectionery, cakes, biscuits, pastries and savoury snacks and sugary drinks.

Modelling impacts of reducing meat and dairy

The research modelled the impact of the CCC targets for all meat and dairy and 23 reduction scenarios for red and red processed meat and dairy on intakes of energy, protein, iron, zinc, calcium, selenium, iodine and vitamin B12. These nutrients were selected because meat and dairy are important sources of these nutrients.

The first two scenarios were based on the CCC recommendations for meat and dairy reductions:

- 20% and 35% reductions in grams of total meat plus a 20% reduction in dairy applied to the whole adult population with no replacement

The CCC recommendations are to reduce consumption of all types of meat, however there are currently only dietary recommendations for reducing red and red processed meat. The existing SDG advises that people who eat more than 90g of red and red processed meat a day cut down to 70g or less. Additional modelling was therefore undertaken to investigate the possibility of meeting the CCC recommendation for all meat, via a reduction in red and red processed meat only in high consumers (those consuming >70g per day).

The following additional scenarios were assessed:

- The percentage reduction in total meat consumption achieved by reducing intakes of red and red processed meat to 70g per day in those currently above this level
- The reduction in red and red processed meat required to achieve a 20% reduction in total meat consumption
- The reduction in red and red processed meat required to achieve a 35% reduction in total meat consumption
- Combined effects of a reduction in red and red processed meat consumption in high consumers, substituting pulses and legumes, vegetables, egg, oily fish, plant-based meat alternatives or chicken, **and** a 20% reduction in total dairy, applied to the whole adult population substituting plant-based milk, plant-based yogurt and spreads (for butter)
- The impact of these simulations on the percent of adults living in Scotland who met the SDGs was also evaluated

Further analysis was also completed to assess consumption patterns of red and red processed meat from the 2021 SHeS and understand how intakes and demographic characteristics of individuals differ by red and red processed meat consumer tertiles. The research also explored how different meal occasions contributed to total intake; how consumption varied across different days of the week; identified key food group contributors to intake; and locations where it was being purchased and consumed.

Modelling impacts on BMI and chronic disease risk

The research modelled the impact of red and red processed meat and dairy reductions on BMI and chronic disease risk using [micro-Simulation of the Health Impacts of Food Transformations \(mSHIFT\) methodology](#).

Impacts on obesity, type 2 diabetes, cardiovascular disease and all-cause mortality were estimated for the overall adult population in Scotland and by age, sex, BMI and SIMD quintile.

Out of scope

The research did not consider issues around supply and demand, implications for sectors and climate change mitigation activity taking place in meat and dairy production. Additionally, socio-economic, cultural and financial challenges which individuals face in making healthy changes to their diets are not addressed by this research.

5. Results: current intakes

Meat Intakes

On any given day, most adults in Scotland (86%) consume some type of meat, with an average intake of 94g per day. This comprises 37g of white meat, 32g of processed meat and 26g of red meat.

In Scotland, the majority of meat eaten among consumers is poultry (37%), followed by pork (34%) and beef (25%), with small intakes from lamb (3%) and game (1%). There was no difference in these proportions by gender or BMI category, however some differences were observed by SIMD quintile, age group, and gender/age group:

- Men aged 25-34y were found to be the highest meat consumers compared to other age and sex groups

Men and individuals living in the most deprived areas were the most likely to be high consumers of red and red processed meat.

Contribution of food groups to meat consumption

Table 1 below outlines the top five types of food groups which contributed to meat intake in 2021. Homemade dishes containing chicken or beef, such as a fried chicken breast or spaghetti Bolognese, and ham sandwiches were some of the most common ways in which adults in Scotland consumed meat in 2021.

Table 1. Top five contributing food groups to meat intake (% frequency among consumers)

Food group	Food item	% frequency
Other chicken/turkey including homemade recipe dishes	Chicken breast, fried	25%
	Chicken curry home made	7%
	Chicken casserole/stew	7%
	Roast/grilled chicken breast (skin not eaten)	7%
	Roast chicken (skin not eaten)	6%
Other beef and veal including homemade recipe dishes	Spaghetti Bolognese, homemade (pasta and sauce)	18%
	Chilli con carne	11%
	Beef lasagne	9%
	Roast beef	6%
Sandwiches	Ham sandwich with white/malted bread	20%
	Ham sandwich with wholemeal/oatmeal bread	17%
	Cheese and ham sandwich with white/malted bread	7%
	Bacon sandwich with white/malted bread	6%
Other bacon and ham including homemade recipe dishes	Ham, not smoked	26%
	Bacon, back/middle, unsmoked, grilled (fat removed)	14%
	Ham, smoked	12%
	Bacon, back/middle, smoked, grilled (including fat)	8%
	Bacon, back/middle, unsmoked, grilled (including fat)	7%
Other sausages including homemade recipe dishes	Pork sausage, grilled	37%
	Square/Lorne sausage	15%
	Sausage, fried	14%
	Chorizo	9%
	Beef Sausage, grilled	7%

Characteristics of high consumers of red and red processed meat

Consumers were categorised into low (n=824; >0g to ≤34.5g/day), medium (n=784; >34.5g to 70g/day), and high (n=886; >70g/day) consumers of red and red processed meat. The average intakes of red and red processed meat among these groups were:

- 19g/day among low consumers
- 50g/day among medium consumers
- 117g/day among high consumers. On average, high consumers would therefore need to reduce their intake by 47g per day, equating to around 1.5 sausages or 2 slices of meat.

Men were more likely to be a high consumer of red and red processed meat (45%) than women (30%). Whilst there were no differences in average intakes, those in SIMD 1 (most deprived) were more likely to be a high consumer of red and red processed meat (44%) than those in SIMD 5 (least deprived) (31%). There was no difference by age group.

Dinners were found to account for the highest proportion of red and red processed meat consumption among high (55%) and medium (52%) consumers. Low consumers spread their intake more across lunch (40%) and dinner (48%). Overall, especially among high consumers, intake of red and red processed meat was highest on Sundays.

In relation to where red and red processed meat is purchased, the majority was found to come from supermarkets (85-88%), with 10-12% purchased from cafes, restaurants & takeaways.

Intakes of dairy products

As outlined within the methodology, work to fully disaggregate dairy within the dataset was undertaken as part of this project. Failing to account for dairy products included in foods such as cakes, biscuits and pastries leads to an underestimation of dairy intake. In particular, milk was underestimated by 7%, cheese by 50% and butter by 50%, whereas yogurt was overestimated by 15% and cream by 79%.

Even more so than meat, the vast majority of adults in Scotland (99%) consume some dairy. On average, daily intake of dairy among consumers was 241g/day with the majority of this coming from milk (67%), cheese (14%), and yogurt (9%) with small proportions coming from butter (7%) and cream (2%). Sandwiches and pizza were the highest contributing composite dishes to dairy consumption, contributing 4% and 3%, respectively. Discretionary foods are not a significant source of dairy (<10% of dairy by weight).

Nutrient intakes and contribution of meat and dairy

Reference Nutrient Intake (RNI) and Lower Reference Nutrient Intake (LRNI)

Used by the Scientific Advisory Committee on Nutrition (SACN) for use in the UK, the RNI is the amount of a nutrient that is enough to ensure that the needs of nearly all the group (97.5%) are being met. The LRNI is the amount of a nutrient that is adequate for 2.5% of the population.

SACN advises on nutrition and related health matters. It advises the Office for Health Improvement and Disparities (OHID) and other UK government organisations, including the devolved governments.

Average Requirement (AR) and Adequate Intake (AI)

Used by the European Food Safety Agency (EFSA), the AR refers to the amount of a nutrient that is adequate for half of the population. The AI refers to the level of intake seen in apparently healthy populations, where there is insufficient evidence to estimate the other metrics. Of the nutrients explored within our report, iodine, selenium, and vitamin B12 are limited to AI estimates, while energy, protein, calcium, iron, and zinc have AR estimates.

Impacts of meat and dairy reduction on both EFSA and UK recommendations for intake are explored within the main report. For this shorter paper, only impacts on UK RNI recommendations have been presented.

Analysis of nutrient intakes (excluding supplements) among adults in Scotland demonstrates that a wide range of food groups contribute to micronutrient intakes among adults in Scotland. Meat is an important source of selenium and average intake of selenium is below the RNI for all age and sex groups. Dairy, particularly milk, is an important source of iodine, calcium and vitamin B12. While average intake of vitamin B12 is well above the RNI for all age and sex groups, calcium and iodine are a concern for young people (16-18 years). Meat and dairy are important sources of zinc, and men of all ages have average intakes of zinc below the RNI.

Average intakes of energy and protein among adults were 1,630kcal/d and 67.2g/day, respectively. Table 2 provides an overview of intakes of the micronutrients of interest by age and sex, as compared to RNI:

- Across all age and gender groups, more than 40% of the population had selenium and zinc intakes below the RNI.
- Across all age and gender groups except men 35+y, more than 40% of the population had calcium and iron intakes below the RNI.
- Across all age and gender groups except men 75+y, more than 40% of the population had iodine intakes below the RNI.
- Only 0-12% of the population had vitamin B12 intakes below the RNI.

Table 2. Weighted percentage of participants in whom nutrient intake did not meet dietary requirements among adults (16+y) living in Scotland, by gender and age group (total unweighted base 3,042).

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Below UK Reference Nutrient Intakes (RNIs)								
Calcium (mg/day)	Women	60%	53%	45%	48%	49%	49%	49%
	Men	63%	51%	27%	39%	39%	35%	40%
Iron (mg/day)	Women	97%	93%	93%	75%	57%	58%	48%
	Men	57%	47%	32%	37%	38%	33%	35%
Iodine (µg/day)	Women	75%	73%	62%	61%	53%	49%	52%
	Men	62%	69%	48%	49%	47%	41%	33%
Selenium (µg/day)	Women	95%	92%	87%	88%	88%	92%	91%
	Men	90%	87%	86%	91%	91%	91%	91%
Zinc (mg/day)	Women	63%	61%	51%	51%	56%	56%	48%
	Men	69%	69%	58%	66%	75%	71%	78%
Vitamin B ₁₂ (µg/day)	Women	12%	11%	14%	12%	9%	6%	3%
	Men	5%	13%	6%	6%	6%	3%	0%
Based on the average of two 24-h recalls. Percentages that are above 40 have been identified within the summary of results.								

6. Results: modelling

Modelling impacts of reducing meat and dairy

As outlined within Section 5, most adults living in Scotland had low intakes of at least one micronutrient of interest at baseline. Under the most extreme scenario of a 35% reduction in all meat and 20% reduction in all dairy, without replacement, and relative to current intakes:

- The percentage of the population below the RNI for calcium increased by 8 percentage points (from 46% to 54% of the population).
- The percentage of the population below the RNI for iron increased by 3 percentage points (from 58% to 61% of the population).
- The percentage of the population below the RNI for iodine increased by 10 percentage points (from 56% to 66% of the population).
- The percentage of the population below the RNI for selenium increased by 3 percentage points (from 90% to 93% of the population).
- The percentage of the population below the RNI for zinc increased by 12 percentage points (from 62% to 74% of the population).
- The percentage of the population below the RNI for vitamin B12 increased by 4 percentage points (from 8% to 12% of the population).

Impact of reducing red and red processed meat among high consumers only, alongside reductions in dairy for everyone on nutrient intake

To mitigate against the risk of exacerbated micronutrient insufficiencies in the general adult population, the research explored the impact of reductions of red and red processed meat in high consumers only, alongside reductions in dairy for everyone who consumes dairy.

There are no clear health benefits from a reduction in white meat. However, there is a well-established link between red and red processed meat and increased risk of colo-rectal cancer, which forms the basis of current public health nutrition advice that people who eat more than 90g of red and red processed meat a day cut down to 70g or less. The research therefore explored how reducing red and red processed meat intake among high consumers, classified as those with red and red processed meat intake above 70g/day, would affect population average “all meat” intake as defined by the CCC.

There are currently no recommended intake levels for dairy. A 20% reduction in dairy was therefore applied to all dairy consumers, in line with CCC recommendations.

In relation to total meat, the modelling found that:

- If all adults living in Scotland met the SDG for red and processed red meat (70g/day), it would result in a 16% reduction in the population mean total meat intake. This would affect 28% of the population
- In order to achieve a 20% reduction in the population mean total meat intake, all adults living in Scotland currently consuming more than 60g/day red and red processed meat would need to reduce their intake to 60g/day. This would affect 32% of the population
- In order to achieve a 35% reduction in the population mean total meat intake, all adults living in Scotland currently consuming more than 31g/day red and red processed meat would need to reduce their intake to 31g/day. This would affect 54% of the population

When a reduction of red and red processed meat to no more than 70g is applied with a 20% reduction in dairy, there is a slight increase in the proportion of the population who fall below the level required for an average adult of:

- 9 percentage points for iodine; increasing from 56 to 65% of the population
- 8 percentage points for calcium; from 46 to 54% of the population. These are both largely due to the impact of the dairy reduction
- 9 percentage points for zinc; from 62 to 71% of the population
- 2 percentage points for iron; from 58 to 60% of the population
- 2 percentage points for vitamin B12; from 8 to 10% of the population
- 1 percentage points for selenium; from 90 to 91% of the population

Impact of reducing red and red processed meat among high consumers only, alongside reductions in dairy for everyone on achievement of the Scottish Dietary Goals

At baseline, 72% of adults met the SDG for red and red processed meat. As the simulation scenarios modelled reductions to 70g per day, which is the existing SDG, the percentage of adults which met this goal therefore increased to 100%.

There was no significant impact of any of the scenarios on the percent of adults meeting the SDG for trans fat: 96-99% of adults met the SDG at baseline and following all scenarios. Similarly, there was limited impact on meeting the SDG for fibre: only 6% of adults met the SDG at baseline and only 6-9% met the SDG following all scenarios. This is likely because average fibre intake is so far below the SDG of 18g/day that quite substantial increases in fibre-rich foods are needed to increase the percent meeting the goal.

Specific replacements had varying impacts:

- Replacing 16-35% of red and red processed meat with pulses and legumes or vegetables can slightly increase the percent of adults meeting the SDGs for fruits & vegetables, total fat, saturated fat, total carbohydrates, and salt
- Replacing 16-35% of red and red processed meat with egg or oily fish can slightly increase the percent of adults meeting the SDGs for saturated fat, total carbohydrates, and salt.

Impact on BMI and chronic disease risk

The research modelled the impact of the following scenarios, on risk of obesity, type 2 diabetes, cardiovascular disease (CVD) and all-cause mortality:

- The impact of all high consumers of red and red processed meat coming down to 70g/day
- The impact of all high consumers of red and red processed meat coming down to 70g/day plus a 20% reduction in all dairy

If all high consumers of red and red processed meat reduced their intake to 70g/day, this would result in, over a ten-year period, on average:

- 0.36 kg/m² lower BMI (~1% decrease)
- 10,036 Type 2 diabetes cases prevented (~5% of new cases)
- 2,897 CVD cases prevented (~1% of new cases)
- 337 prevented deaths

If all high consumers of red and red processed meat reduced their intake to 70g/day, and all consumers of dairy reduced their intake of all dairy by 20%, this would result in, over a ten-year period, on average:

- 1.00 kg/m² lower BMI (~4% decrease)
- 8,651 Type 2 diabetes cases prevented (~4% of new cases)
- 2,847 CVD cases prevented (~1% of new cases)
- 311 prevented deaths

7. Limitations

Key limitations to note when interpreting these analyses:

- There is uncertainty around the validity of self-reported meat and dairy consumption and it is likely that meat and dairy are underreported due to the accuracy of self-reported data. As a result of underreporting of intake, the proportion of the population not meeting intake recommendations is likely to be overestimated. Equally, a larger number of adults may need to reduce their red and red processed meat intakes to meet the current dietary recommendation, given the likely under-reporting of intakes
- Reported inadequacy of intake does not always equal a clinical micronutrient deficiency. However, the large number of people who may be at risk of insufficiency of intake could be considered as evidence of poor overall diet in Scotland
- Replacement foods contribute differentially to nutrient intakes. Substitution scenarios are hypothetical and there are no nutritionally equivalent swaps. As there are no specific dietary recommendations for dairy intakes, other than guidance to choose lower fat, sugar and salt options, various milk or milk containing products were selected for reduction
- Consumer behaviour is unlikely to change based on advice alone. Additionally, there is a risk that those with already low micronutrient intakes could reduce meat and dairy consumption (without suitable replacement), which would thereby worsen any micronutrient insufficiencies. Consumers at risk of insufficiencies may change their diet, but those who need to change their diet may not. It should be noted that consumers are unlikely to be able to make healthy changes without support and better access to healthier food options
- This analysis has been carried out in adults only and more evidence is needed to understand the impact of meat and dairy reductions in children, given their differing nutritional needs and greater reliance on dairy products. Food Standards Scotland and the University of Edinburgh expect to publish data on the dietary intake of children and young people, including meat and dairy consumption, later in 2024
- Health modelling data (mSHIFT) is based on robust available evidence, however, it remains a best estimate of likely chronic disease risk, rather than a forecast of what will happen.

8. Summary and conclusion

Overall the research demonstrated that replacement of meat and dairy with alternative foods and drinks such as vegetables, beans and pulses, oily fish, eggs and plant based meat/milk alternatives can ensure existing insufficiencies do not worsen. The modelling also indicated potential positive impacts on the proportion of adults meeting the Scottish Dietary Goals for red and red processed meat, fruits and vegetables, total fat, saturated fat, total carbohydrates and salt.

The research demonstrated that the 20% reduction in all meat can be achieved by cutting intakes of high consumers of red and red processed only, which would help ensure that insufficiencies in intake do not become more widespread in the population. Replacement of meat and dairy with alternative foods and drinks such as vegetables, beans and pulses, oily fish, and eggs can also help ensure existing insufficiencies do not worsen. However, whilst there is existing advice to reduce high consumption of red and red processed meat, there is currently no health basis for recommending any reduction in dairy intake, other than replacing with low fat, salt or sugar options.

Overall, this research provides further evidence of poor diet in Scotland and additional justification for work to improve dietary intakes in general. Most people should be able to get the micronutrients they need by consuming a healthy, balanced diet as depicted by the Eatwell Guide. However, the majority of the population in Scotland do not have a diet similar to the Eatwell Guide, and meat and dairy are therefore relatively more important in the diet as an important source of micronutrients.

Within our [2023 report on consumer attitudes towards the diet and food environment in Scotland](#), more than a third of respondents said they actively reduce meat consumption most or all of the time, whilst over a quarter actively reduce their dairy intake. However, in the context of other decision making criteria, such as cost and taste, concerns around sustainability are a much lower priority. It is well evidenced that those living in the most deprived areas tend to have the worst diets and therefore may have less scope to make changes to their diets for health or sustainability reasons due to other priorities, concerns around affordability and less access to a wider range of foods.

What surrounds us, shapes us; without changes to the retail and out of home food environment which support consumers with healthier options, it is unlikely consumers will be able to make the changes required to achieve diets closer to the Eatwell Guide. FSS continues to advise Scottish Government and support development of approaches to improving the food environment through actions within their Healthier Futures: Scotland's diet and healthy weight and Out of Home action plan.