Approaches to modelling impact of reduction in meat and dairy consumption on nutrient intakes and disease risk

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Abbreviations

AI	Adequate Intake
AR	Average Requirement
BMI	Body mass index
CCC	Climate Change Committee
CI	Confidence interval
CVD	Cardiovascular disease
DRV	Dietary reference value
EAR	Estimated Average Requirement
EFSA	European Food Safety Agency
EPIC	European Prospective Investigation into Cancer and Nutrition
FIC	Food Information to Consumers
FSS	Food Standards Scotland
LRNI	Lower Reference Nutrient Intake
NDNS	National Diet and Nutrition Survey
RNI	Reference Nutrient Intake
SACN	Scientific Advisory Committee on Nutrition
SDG	Scottish Dietary Goal
SHeS	Scottish Health Survey
SIMD	Scottish Index of Multiple Deprivation
UI	Uncertainty interval

1. Introduction

1.1. Background

Throughout this report, unless otherwise specified, **"meat"** refers to all of the following: beef, lamb, pork, other red meat, poultry, game birds, processed red meat, processed poultry, burgers, sausages, and offal.

"**Red and red processed meat**" refers to all of the following: beef, lamb, pork, other red meat, processed red meat, burgers, sausages, and offal.

"**Processed meat**" refers to processed red meat and processed poultry.

"**Dairy**" refers to milk, cheese, yoghurt, cream, and butter.

Since 2008, the Climate Change Committee (CCC)[1] has published a number of reports, each with cross-sectoral recommendations for how reductions in greenhouse gas emissions may be achieved by the UK. The 2022 recommendations to Scottish Government included the following, which has relevance to diets in Scotland:

"*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.*"

On 20 June 2023, the Scottish Government partially accepted this recommendation (Scottish Government 2023).

Food Standards Scotland (FSS)[2] wish to establish the nutritional impact of this reduction in meat and dairy consumption in the population living in Scotland, as well as population subgroups most at risk of negative nutritional impacts and any dietary mitigations to prevent these. To this end, FSS commissioned the University of Edinburgh to complete modelling work to underpin advice to Ministers, through analysis of data collected in 2021, in 3,447 adults (16+y) living in Scotland, who completed 1-2 days of diet recall as part of the Scottish Health Survey (SHeS).

1.2. Aims

The overarching goal of this report was to identify impacts of reductions in meat and dairy consumption; minimising adverse impacts on nutrient intakes and maximising positive impacts on overall diet and health outcomes for adults living in Scotland.

To achieve this goal, the following aims were proposed:

1. Systematically review prior studies on the benefits and risks of reducing meat and dairy.
2. Calculate current intakes of meat, dairy, and select nutrients, overall and among consumers of meat and dairy and by population subgroups, e.g., age, gender, body mass index (BMI), and Scottish Index of Multiple Deprivation (SIMD).
3. Calculate the contribution of meat, dairy, and other foods to nutrient intake, overall and among consumers of meat and dairy and by population subgroups.
4. Investigate consumption behaviours of red and red processed meat.

[1] The CCC is an independent, statutory body established under the Climate Change Act 2008. The purpose of the CCC is to advise the UK and devolved governments on emissions targets and to report to Parliament on progress made in reducing greenhouse gas emissions and preparing for and adapting to the impacts of climate change.

[2] FSS was established on 1 April 2015 as the new public sector food body for Scotland. FSS have a unique role in government, working independently of Ministers and industry, to provide advice which is impartial, and based on robust science and data. The FSS remit covers all aspects of the food chain which can impact on public health – aiming to protect consumers from food safety risks and promote healthy eating.

5. Model the impact of various scenarios on energy and nutrient intake and achievement of the Scottish Dietary Goals.

The cultural and financial challenges which individuals face in making healthy changes to their diets are not addressed by this report.

1.3. Rationale for selection of nutrients

This work focused on energy and seven nutrients: protein, calcium, iron, iodine, selenium, zinc, and vitamin B_{12}. These were selected because meat and dairy are important sources of these nutrients.

1.4. Explanation of Dietary Reference Values

Reductions in meat and dairy consumption will lead to lower intakes of the nutrients found in these foods, though some of these can be replaced by foods consumed in their place. The net change will range from a reduction to an increase in nutrient intake, depending on the amount of nutrients in the foods substituted for the meat and dairy foods.

The impact of these changes on nutrient intake can be assessed by comparison with the recommended intake of each nutrient. In the UK, in 1991, a comprehensive report, entitled, "Dietary Reference Values. A Guide" proposed four metrics for nutrient adequacy (Department of Health 1991):

1. Reference Nutrient Intake (RNI): the intake that is adequate for 97.5% of the population.
2. Estimated Average Requirement (EAR): the intake that is adequate for 50% of the population.
3. Lower Reference Nutrient Intake (LRNI): the intake that is adequate for 2.5% of the population.
4. Safe level: the intake seen in apparently healthy populations, where there is insufficient evidence to estimate the other metrics.

The Dietary Reference Values (DRVs) Report states that the evidence used to establish DRVs for each nutrient is often incomplete, leading to uncertainty in the values (Department of Health 1991).

Values are given for different age and gender groups to reflect the variation in nutrient needs according to differences in body size and physiological factors. Additional requirements for pregnancy and lactation may be substantial, e.g., for calcium in lactation and zinc in pregnancy and lactation.

More recently, the European Food Safety Agency (EFSA) has provided estimates of nutrient requirements, using similar metrics but different terminology (EFSA 2019):

1. Population Reference Intake (PRI): the intake that is adequate for virtually all people in a population.
2. Average Requirement (AR): the intake that is adequate for half of the population.
3. Lower Threshold Intake: the intake that would be inadequate for virtually all people.
4. Adequate Intake (AI): the intake seen in apparently healthy populations, where there is insufficient evidence to estimate the other metrics.[3]

[3] Of the nutrients explored within our report, iodine, selenium, and vitamin B_{12} are limited to AI estimates, while energy, protein, calcium, iron, and zinc have AR estimates.

Given that the EFSA values are based on more recent evidence, both EFSA and UK values were explored in our report. EFSA suggests that the prevalence of inadequate nutrient intake in a population can be assessed by looking at the proportion of the population with intake below the AR, if the distribution of nutrient intakes is normal and intakes are independent from requirements (EFSA 2017). However, they point out that this approach, known as the AR cut-point method, will **overestimate the risk of deficiency** if the dietary intake is underestimated; if the number of days of dietary assessment per individual is small; and/or the intake is correlated with individual requirements (EFSA 2017). As this was the case in our sample, **estimates of insufficiency based on the AR should be considered conservative**.

2. Evidence of nutritional benefits and risks from modelling studies

2.1. Modelling studies on the impact of reducing meat and dairy consumption on nutrient intake

Several modelling studies have been conducted to understand the impact of reducing meat and dairy consumption on nutrient intake, including in the UK (see **Appendix 1** for search method).

In the Scientific Advisory Committee on Nutrition (SACN) Iron and Health report, a modelling exercise was undertaken using data from the National Diet and Nutrition Survey (NDNS) 2000/2001 in which meat consumption of consumers in the upper range of the distribution was reduced to maximum values of 180, 120, 100, 90, 80, 70, 60, 50, and 0g/day (SACN 2010). When the maximum meat consumption was set at 90g/day, the impact of these changes on the proportion of individuals with intakes below the LRNI for iron and zinc was minimal. At a maximum intake of 70g/day, the proportion below the LRNI for iron was unchanged, but the proportion below the LRNI for zinc was increased to over 5%. However, this exercise would overestimate the impact of reducing meat consumption as the nutrient intake from foods replacing meat was not considered.

More recently, a study using NDNS 2016/2017 (participants aged 1.5-95 years) modelled 12 specific meat[4] substitution scenarios (Farsi et al. 2022):

1. 25% reduction in meat and gram-for-gram replacement[5] with a **composite** of meat alternatives[6]
2. 50% reduction in meat and gram-for-gram replacement with a **composite** of meat alternatives
3. 75% reduction in meat and gram-for-gram replacement with a **composite** of meat alternatives
4. 100% reduction in meat and gram-for-gram replacement with a **composite** of meat alternatives
5. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **vegetables**[7]
6. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **mycoprotein**
7. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **beans and peas**
8. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **tofu**
9. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **nuts**
10. 100% reduction in meat and gram-for-gram replacement with meat alternatives produced predominantly from **soya**

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[4] In this study by Farsi et al., “meat” included red meat, processed red meat, white meat, processed white meat, and seafood.

[5] In all scenarios, calories were held constant by increasing intake uniformly across all food and drinks reported after the substitution.

[6] The nutrient composition of meat alternatives was assumed to be a weighted score based on the UK market share for these products: vegetables 23%, mycoprotein 18%, beans 17%, soya 15%, nuts 14%, and tofu 13%.

[7] For scenarios #5-10, the nutrient composition of meat alternatives was assumed to be the mean nutrient value from the respective category of meat alternative.

11. 100% reduction in meat and gram-for-gram replacement with meat alternatives that have been **fortified with nutrients (iron and vitamin B_{12})**
12. 100% reduction in meat and gram-for-gram replacement with meat alternatives that have **not been fortified with nutrients**

The key findings from that NDNS modelling study were as follows (Farsi et al. 2022):

- 100% replacement of meat with a **composite** of meat alternatives resulted in
    - a decrease in protein of 14.8g/day,
    - a decrease in saturated fat of 4.0g/day,
    - an increase in fibre of 8.2g/day,
    - an increase in sodium of 228mg/day, and
    - no significant change in iron or vitamin B_{12}.
    - (Other micronutrients such as selenium, zinc and calcium were not modelled.)
- In the targeted meat alternative product substitution scenarios (scenarios #5-10 in the list above),
    - the decrease in protein ranged from 4.9g/day in the tofu scenario to 19.8g/day in the nut scenario,
    - the decrease in saturated fat ranged from 3.7g/day in the mycoprotein scenario to 4.8g/day in the nut scenario,
    - the increase in fibre ranged from 3.1g/day in the tofu scenario to 10.2g/day in the nut scenario,
    - the change in sodium ranged from a decrease of 124mg/day in the nut scenario to an increase of 496mg/day in the soya scenario,
    - vitamin B_{12} decreased by 2.0µg/day in the tofu scenario, 1.9µg/day in the nut scenario and 1.8µg/day in the soya scenario (though in all three of these scenarios mean intake remained above the RNI), with no significant change in the other scenarios, and
    - iron increased by 7.6mg/day in the tofu scenario, with no significant change in the other scenarios.
- Replacement with fortified products increased iron intake by 3.1mg/day and replacement with unfortified products had no significant impact on iron intake.
- Replacement with fortified products had no impact on vitamin B_{12} intake and replacement with unfortified products decreased vitamin B_{12} intake by 1.8µg/day (but mean intake remained above the RNI).
- The effects for all scenarios were similar across population subgroups (age and gender).

A modelling study in French adults in which red and red processed meat was replaced with pulses twice a week, reducing meat consumption by about 15%[8], found the percent of the population with inadequate iron intake did not change (71% to 70%) but the percent with inadequate zinc increased (78% to 87%) when **bioavailability** was taken into account (Gazan et al. 2021).

Bioavailability is the amount of a nutrient that is absorbed and utilised for normal body functions by an individual. How much of the nutrients in our diets that we absorb is influenced by several factors. For example, **phytate**, found in whole grains, legumes, seeds, and some nuts, can decrease the absorption of minerals such as non-haem iron, zinc, and calcium. **Tannins** found in tea and coffee can also decrease absorption of non-haem iron. In contrast, **vitamin C** and **meat** can increase absorption of non-haem iron.

[8] From 117g/day to 97g/day, mostly with a reduction in red meat.

A second study in France evaluated 96 different substitution scenarios for meat, milk, and dairy desserts (**Table 1**) (Salomé et al. 2021). Generally, they found:

- When substituting **meat**,
  - an increase in adequacy of fibre, folate, calcium, and vitamin E,
  - a decrease in adequacy of vitamin B_{12}, zinc, vitamin B_2, iron, riboflavin, and protein,
  - a decrease in saturated fat, and
  - an increase in sodium (except when substitutions were made using 'Cooked pulses' or 'Tofu, tempeh or soy protein').
- When substituting **dairy**,
  - an increase in adequacy of fibre and iron, and
  - a decrease in adequacy of calcium, vitamin B_{12}, riboflavin, iodine, and potassium.
- When substituting **dairy desserts**,
  - an increase in adequacy of fibre and iron, and
  - a decrease in adequacy of calcium, riboflavin, and iodine.

Table 1. Meat and dairy substitution scenarios in a modelling study of French diets (Salomé et al. 2021).

Animal-based product category	Animal-based product sub category	Plant-based substitute
Meat	1. Beef, veal, lamb, horse, and game meats 2. Pork meats and sausages 3. Poultry and rabbit	1. Pulses (n=13) 2. Tofu, tempeh, or soy (n=3) 3. Plant-based burgers (n=24) 4. Plant-based sausages (n=5) 5. Plant-based meatballs or slices (n=5) 6. Plant-based breaded foods (n=6) *Total number of items modelled as meat substitutes n=56*
Milk	N/A	1. Plain plant-based milk drinks (n=7) 2. Plain plant-based milk drinks, calcium-fortified (n=3) 3. Sweet plant-based milk drinks (n=4) 4. Sweet plant-based milk drinks, calcium-fortified (n=2) *Total number of items modelled as milk substitutes n=16*
Dairy desserts	N/A	1. Plain plant-based desserts (n=2) 2. Plain plant-based desserts, calcium-fortified (n=2) 3. Sweet plant-based desserts (n=10) 4. Sweet plant-based desserts, calcium-fortified (n=8) 5. Plant-based mousses (n=2) *Total number of items modelled as dairy dessert substitutes n=24*

Two studies in The Netherlands also evaluated the impact of replacing meat and dairy with plant-based alternatives (Temme et al. 2013; 2015). Among young Dutch women (19-30y), with 100% replacement of meat and dairy,[9] saturated fat intake decreased from 13.2% to 9.2% total energy, and iron intake increased from 9.5 to 12.0mg/day (most iron in the 100% replacement scenario came from bread, eggs, and soya desserts) (Temme et al. 2013). Among Dutch children (2-6y), 100% replacement of meat and dairy with plant-based foods resulted in improved intakes of saturated fat, fibre, and iron (Temme et al. 2015). However, intakes of calcium, zinc, thiamine, and vitamin B_{12} decreased (Temme et al. 2015).

[9] Meat products and cheese for sandwiches replaced with a variety of sandwich toppings; meat replaced with plant-based meat alternatives; unsweetened milk replaced with high-calcium soya milk; sweetened milk replaced with chocolate/strawberry soya milk; and yoghurts and desserts replaced with dessert soya.

2.2. Modelling studies on the impact of reducing meat and dairy consumption on chronic diseases and mortality

Several modelling studies have been conducted to understand the impact of reducing meat and dairy consumption on chronic diseases and mortality, including in the UK (see **Appendix 1** for search method). Most have focused on colorectal cancer finding reductions in the consumption of red and/or processed meat could result in significant reductions in the number of colorectal cancer cases in Denmark, Germany, and across Europe [from the European Prospective Investigation into Cancer and Nutrition (EPIC) study, which included 10 countries: the UK, The Netherlands, Sweden, Spain, Norway, Italy, Greece, Germany, France, and Denmark) (Zec et al. 2019; Lourenço et al. 2018; Schönbach, Thiele, and Lhachimi 2019).

Most recently, a study modelled the impact of six combined actions proposed by the CCC across four sectors (energy, housing, transport, and food) on mortality in England and Wales (Milner et al. 2023). The six actions, modelled simultaneously, included a 20% reduction in the consumption of all meat and dairy products by 2030, rising to a 35% reduction of all meat by 2050. The model assumed that meat and dairy products were replaced with equivalent calories of fruits, vegetables, and legumes. In combination, the six modelled actions under the Balanced Pathway resulted in 11.1 million cumulative life-years gained in England and Wales over 2021-2100. The Widespread Engagement Pathway actions resulted in 13.7 million cumulative life-years gained. Given that their model was based on changes in average (population-level) exposures and health risks, they were not able to evaluate the impact on specific population subgroups.

Key Messages: **Nutritional Benefits and Risks from Modelling Studies**

1. Reducing meat and dairy consumption is likely to have mixed effects on nutrient intake, with some nutrients improving (e.g., fibre and saturated fat) and some worsening (e.g., zinc, iodine, calcium, and riboflavin).
2. Substitution scenarios need to carefully consider the sodium content of plant-based meat alternatives and added sugar content of plant-based dairy alternatives in order to avoid increases in these nutrients.
3. Reducing meat consumption, particularly red meat and processed meat, is likely to reduce the number of cases of colorectal cancer.

3. Potential mechanisms for dietary change

3.1. Patterns of meat consumption in the UK

A previous analysis of meat consumption in the UK using NDNS data found that from 2008 to 2019, average daily meat consumption per capita decreased from 103.7g to 86.3g (~1.7% per annum) (Stewart et al. 2021). In an unpublished paper, we explored this trend further by identifying which behaviours contributed to declines in UK meat consumption.[10] Meat consumption can be reduced through three mechanisms:

1. Reducing portion size consumed, for example, eating half a chicken fillet
2. Reducing the number of eating occasions, for example, not eating meat for lunch
3. Reducing the number of consumption days, for example, meat-free Mondays

Using data from NDNS years 2008/2009 to 2018/2019, we investigated changes in:

1. Portion size of meat (g) per meat-containing occasion
2. Number of meat-containing occasions per day
3. Number of meat-eating days

Additionally, we conducted a decomposition analysis, a statistical technique used to disaggregate the total change in meat consumption into the three mechanisms noted above (e.g., portion size, eating occasions, and consumption days). We explored this for total meat, as well as red meat, processed meat, and white meat.

[10] Pre-print: Vonderschmidt A, Bellows AL, Jaacks LM, Alexander P, Green R, Stewart C. Contribution of meat-free days, meat-free meals, and portion sizes to declines in meat consumption in the UK. Published online January 25, 2024. Doi: 10.21203/rs.3.rs-3749185/v1. Available from: https://www.researchsquare.com/article/rs-3749185/v1

Over half of people in the UK (56% in the latest survey) consume meat 1-2 times/day (**Error! Reference source not found.**).

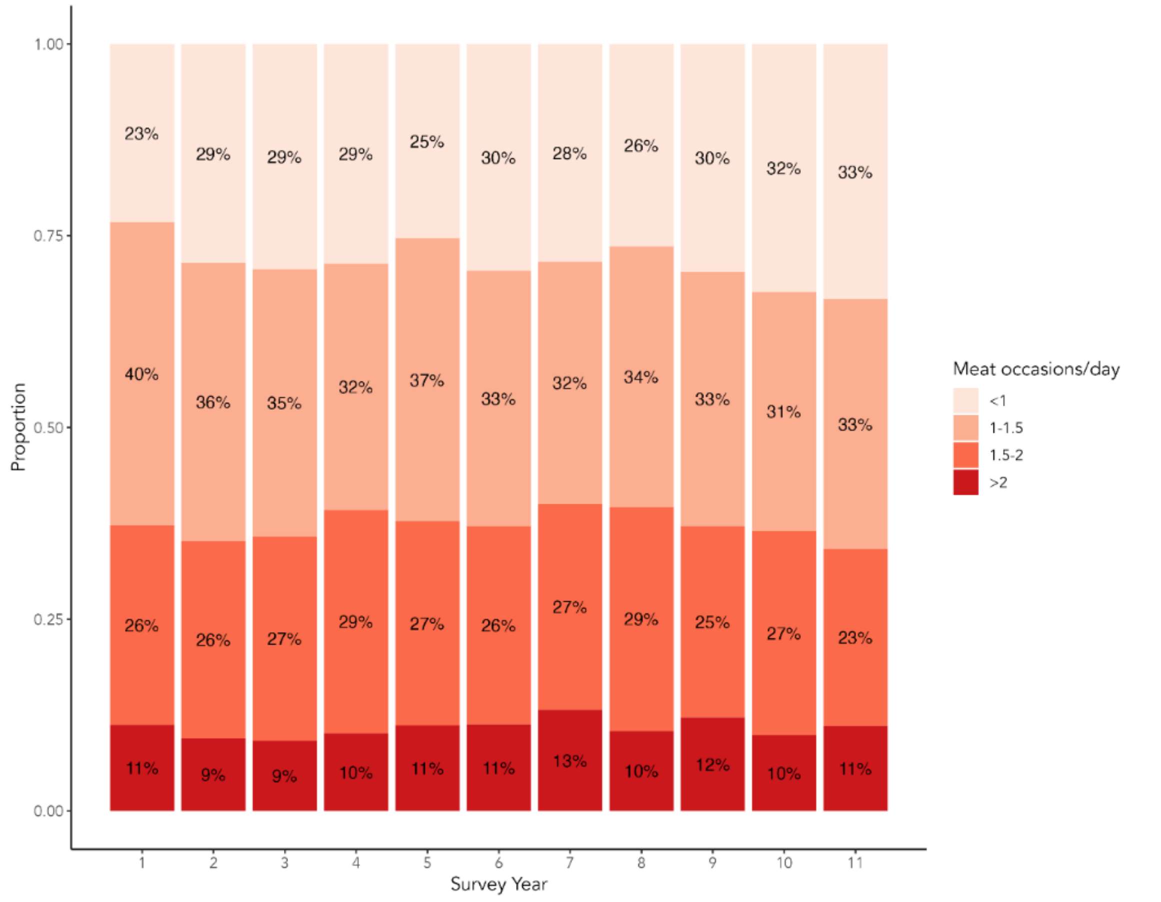


Figure 1. Percentage of children (1.5-17y) and adults (18+y) in the UK consuming meat during <1, 1-1.5, 1.5-2 or >2 occasions per day.

Ranges are provided instead of whole numbers because the average number of occasions over 4 days' food diaries was taken for each individual.

About half of people in the UK consumed meat on all of their food diary days (**Figure 2**).

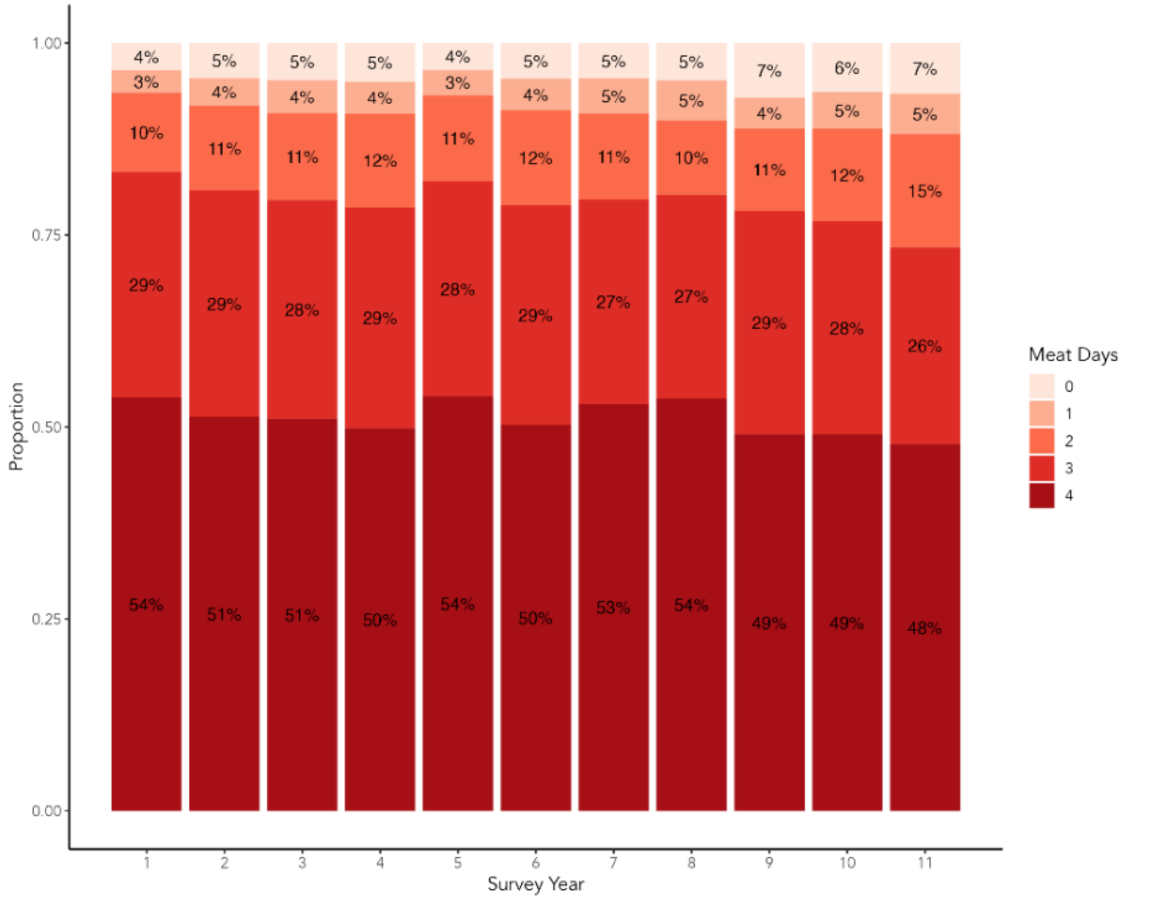


Figure 2. Percentage of children (1.5-17y) and adults (18+y) in the UK consuming meat on 0, 1, 2, 3, or 4 food diary days.

Ranges are provided instead of whole numbers because the average number of occasions over 1-4 days of food diaries was taken for each individual.

The average portion size of total meat decreased from 86g in 2008 to 76g in 2019 (-11%, *P*<0.001). Similar reductions in portion size were seen for processed meat [63g to 53g (-17%, *P*<0.001)] and red meat [90g to 70g (-22%, *P*<0.001)]. Whether the decrease in portion size was achieved at the individual level by a relatively large decrease in portion size of an item or a few items rather than a relatively small decrease across all / most items was not explored in this analysis. There was no statistically significant change in portion size of white meat [85g to 80g (-5%, *P*=0.186)].

The average number of meat-eating occasions per day decreased from 1.24 in 2008 to 1.13 in 2019 (-9%, *P*=0.009). Similar reductions were seen for processed meat [0.54 to 0.50 (-8%, *P*=0.008)] and red meat [0.44 to 0.33 (-24%, *P*<0.001)]. White meat-containing occasions per day increased from 0.40 to 0.45 (12%, *P*<0.001).

The average number of meat-eating days over the 4-day food diary period decreased from 3.27 in 2008 to 3.03 in 2019 (-7%, *P*<0.001). Similar trends were seen for processed meat [1.77 to 1.59 (-10%, *P*=0.002)] and red meat [1.56 to 1.23 (-21%, *P*<0.001)]. Days in which white meat was consumed increased from 1.42 to 1.56 (10%, *P*<0.001). Days in which no meat was consumed also increased from 0.73 to 0.97 (33%, *P*<0.001).

A decrease in portion size accounted for 57% of the decrease in total meat from 2008 to 2019, a decrease in meat-eating days accounted for 37%, and a decrease in meat-containing occasions per day for 6%.

3.2. Meat and dairy substitution patterns in the UK

There is currently little research on the substitution choices consumers make when reducing meat or dairy in the UK. Many papers have reported a decline in meat consumption over the past decades among multiple UK cohorts, particularly decreases in red meat and processed meat (Pot et al. 2015; Alae-Carew et al. 2022; Berger et al. 2019; Stewart et al. 2021; Madruga et al. 2022). Most of the trends in declining meat consumption were coupled with reported increases of white meat (Pot et al. 2015; Berger et al. 2019; Stewart et al. 2021). Over the same time period of reduced meat consumption, some papers have reported increased fish consumption (Pot et al. 2015; Berger et al. 2019), increased consumption of eggs (Berger et al. 2019; Madruga et al. 2022), and increased consumption of plant-based meat alternatives (Alae-Carew et al. 2022; Berger et al. 2019).

The percent of NDNS participants reporting consuming plant-based meat alternatives increased from 4.6% in 2008-2011 to 7.0% in 2017-2019 and the proportion consuming plant-based milk drinks increased from 2.3% to 7.4% (Alae-Carew et al. 2022). Women, low meat consumers, and those with higher income were more likely to consume plant-based alternatives. The increase in consumption of plant-based alternatives was accompanied by increases in beans, pulses, nuts, and seeds.

Two longitudinal UK cohorts found that high-fat dairy consumption over the past 30 years has decreased in the UK (Pot et al. 2015; Ng et al. 2012). This decreased high-fat dairy consumption was offset by an increase in consumption of reduced-fat milk and fruit juice as well as an increase in yoghurt/drinking yoghurt. Additionally, as mentioned above, trends in NDNS show increases in consumption of plant-based dairy alternatives (Alae-Carew et al. 2022).

A randomised controlled trial including 113 participants from Oxford aimed to reduce meat consumption by providing free meat substitutes for 4 weeks and information on the health and environmental benefits of eating less meat, recipes, and success stories (Bianchi et al. 2022). They found that meat consumption significantly decreased in the intervention, even after the provision of free meat substitutes had ended (**Figure 3**). Participants in the intervention group lost, on average, 0.6kg by 8 weeks. Total fat and saturated fat intake significantly declined in the intervention group and intake of protein, fibre, sugar, sodium, vitamin A, iron, calcium, and potassium did not significantly change.[11]

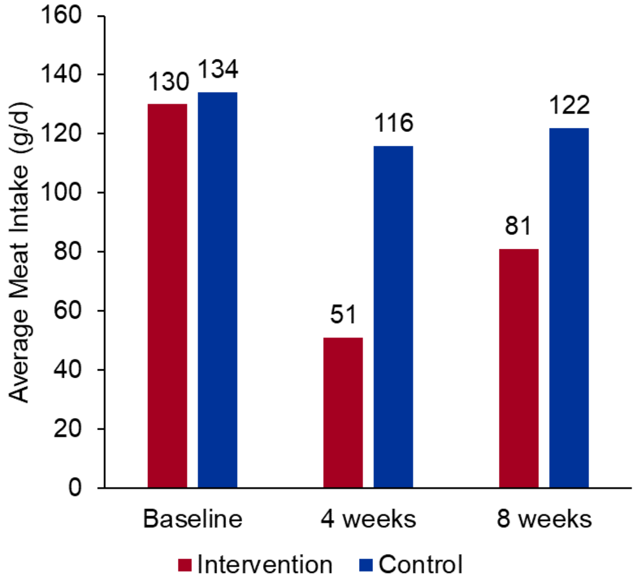


Figure 3. Average meat consumption at baseline, 4 weeks, and 8 weeks among intervention (n=57) and control (n=56) participants of a randomised controlled trial aimed at reducing meat consumption in Oxford, UK (data are from Bianchi et al. 2022).

3.3. Nutrient content of plant-based dairy and meat alternatives available in Scotland

The nutrient content of plant-based dairy and meat alternatives[12] available in Scotland was collected from nutrition information publicly available online and in store (see **Appendix 2** for detailed methodology and results). Our search found that the nutrient content varies widely, both between and within product categories. For example, for oat milk drinks, the most commonly consumed plant-based dairy alternative in SHeS 2021, the sugar content ranged from 0g/100ml to 6.8g/100ml with an average sugar content of 2.6g/100ml across the 19 oat milk drinks identified.

Of the 55 plant-based dairy alternatives identified, 25 were fortified with calcium and the fortification level was relatively consistent, with a majority having calcium levels of 120mg/100ml (15% of the EU Food Information to Consumers [FIC] nutrient reference value of 800mg). The nutrient reference value is the minimum amount in a food or drink required to be able to make a claim according to the Department of Health and Social Care's "Technical guidance on nutrition labelling" (Department of Health 2017). This is a voluntary declaration of vitamins and minerals, for which the vitamin or mineral must be present in a significant amount.

[11] Zinc, selenium, iodine, and vitamin B_{12} were not reported.
[12] Sometimes referred to as plant-based milk drinks or non-dairy alternative drinks.

The following guidance is given regarding what constitutes a significant amount:

- 15% of the nutrient reference values[13] supplied by 100g or 100ml in the case of products other than beverages,
- 7.5% of the nutrient reference values supplied by 100ml in the case of beverages, or
- 15% of the nutrient reference values per portion if the package contains only a single portion.

Similarly, for vitamin B_{12}, of the 55 plant-based dairy alternatives identified, 25 were fortified with vitamin B_{12} and the fortification level was relatively consistent with a majority having vitamin B_{12} levels of 0.38µg/100ml (15% of the EU FIC nutrient reference value of 2.5µg).

Only 8 of the 55 plant-based dairy alternatives identified were fortified with iodine. As far as we could tell from the nutrient information provided, no plant-based dairy alternatives were fortified with iron, selenium, or zinc.

Across all 160 plant-based meat alternative products identified, salt content ranged from 0g/100g to 3.8g/100g. The plant-based meat alternative product categories 'bacon' and 'meat slices' had the highest salt content, on average 2.6g/100g for each category. The lowest salt content was in the ‘tofu’ product category, on average 0.44g/100g.

The saturated fat content of plant-based meat alternative products varied substantially, particularly in the 'burger', 'sausage', 'mince', 'meatballs', and 'meat slices' product categories. For example, in the 'burger' product category, saturated fat content ranged from 0.4g/100g to 18g/100g.

Across the 160 plant-based meat alternative products, the sugar content ranged from 0g/100g to 18g/100g with an average of 1.5g/100g. Comparatively, the sugar content of the 55 plant-based dairy alternatives identified ranged from 0g/100ml to 7g/100ml with an average of 2.2g/100ml.

Tofu was the only plant-based meat alternative product category fortified with calcium. The plant-based meat alternative product categories 'bacon' and 'chicken' were most likely to be fortified with iron, zinc, and vitamin B_{12}, but even in these categories, fewer than half of products were fortified.

3.4. Dietary intake of meat reducers in the UK

While research on what people who are reducing their consumption of meat and/or dairy eat instead (if anything) is limited, there has been quite a lot of research on what flexitarians, pescatarians, vegetarians, and vegans (collectively referred to as ‘non-meat eaters’) eat in the UK as compared to individuals not following such diets.

EPIC-Oxford is a prospective cohort that recruited ~65,000 men and women aged 35+y—half of whom were non-meat eaters—across the UK from 1993-2001, with a follow-up in 2010 completed by ~30,000 participants. Of the 16,175 meat eaters at baseline, 604 (3.7%) stopped consuming meat and became a pescatarian (449, 74.3%), vegetarian (145, 24.0%), or vegan (10, 1.7%) at follow-up. Conversely, of the 14,216 non-meat eaters at baseline, 2,777 (19.5%) became a meat eater at follow-up (Tong et al. 2020).

[13] As per EU FIC point 1 of Part A of Annex XIII: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:304:0018:0063:EN:PDF

In the same cohort, non-meat eaters consumed ***higher*** amounts of soy, legumes, pulses, nuts and seeds, whole grains, vegetables and fruits, and ***lower*** amounts of refined grains, fried foods, alcohol, and sugar-sweetened beverages compared to meat-eaters (Papier et al. 2019). These differences meant that non-meat eaters adhered more closely to the UK's Eatwell recommendations (Public Health England 2018), resulting in an overall healthier diet compared to meat eaters.

Of note, vegetarians and vegans in the EPIC-Oxford cohort did not completely replace meat with non-meat protein sources, but increased consumption of a large variety of plant-based foods (Papier et al. 2019). This resulted in vegetarians and vegans consuming lower amounts of high-protein sources compared to meat eaters. As a proportion of total energy, high-protein foods (meat, fish, eggs, milk, cheese, yoghurt, soy, legumes, pulses, nuts and seeds) comprised 33% of calories among meat eaters, 25% among vegetarians, and 20% among vegans.

A similar analysis comparing protein-source food and other food groups was conducted using data from the UK Biobank cohort, which recruited men and women aged 40-69y (Bradbury, Tong, and Key 2017). The results of the analysis were nearly identical to those described above in the EPIC-Oxford cohort. In the UK Biobank, vegetarians and vegans consumed ***higher*** amounts of fruit, vegetables, whole meal pasta and brown rice, cereals and fruit/vegetable juice, and ***lower*** amounts of fried and roasted potatoes and sugar-sweetened beverages compared to meat eaters. High-protein foods (meat, fish, eggs, milk, cheese, yoghurt, legumes, nuts, and plant-based meat alternatives) comprised 25% of calories among meat eaters, 20% among vegetarians, and 15% among vegans.

Key Messages: **How Meat and Dairy Consumption Might Be Reduced in the UK**

1. A decrease in portion size has accounted for most of the decline in meat consumption in the UK observed over the past ~20 years, particularly for red meat and processed meat.
2. Little is known regarding what meat-reducers in the UK replace meat with – if anything. Trend analyses suggest that red meat and processed meat have been replaced with white meat, and possibly with fish, eggs, and plant-based meat alternatives.
3. There is substantial variability in the nutrient content of plant-based dairy and meat alternatives currently available in Scotland as fortification is currently voluntary. Most of these products are not fortified with any of the key micronutrients (e.g., calcium, iron, iodine, selenium, zinc, and vitamin B_{12}). This makes direct substitutions of dairy and meat with these plant-based alternatives challenging for consumers from a nutritional perspective.
4. People who identify as flexitarians, pescatarians, vegetarians, and vegans in the UK tend to have healthier diets characterised by higher consumption of legumes and pulses, nuts and seeds, whole grains, and fruits and vegetables.

4. Current intakes of meat, dairy, and select nutrients among adults living in Scotland

4.1. Reliability of data to estimate meat and dairy consumption

24-h recalls are a tool used to collect information on all of the foods and drinks an individual consumed on the previous day.

The **doubly labelled water method** involves consumption of water that has been labelled by scientists so that it can be traced in urine, saliva, or blood. Based on how rapidly the labelled water declines in urine, saliva, or blood over 1-2 weeks, scientists can determine how much energy has been utilised by the individual. This can be compared to reported energy intake to understand misreporting.

The accuracy of self-reported dietary intake is a major challenge for estimating intake of all foods and nutrients. The pattern of error can vary between different people and different types of foods. However, generally, self-reported dietary intake, including the **24-h recalls** used to assess dietary intake in Scotland, have a tendency to underestimate intake.

The **doubly labelled water method** is one of the few tools available to objectively assess dietary intake, in particular, energy intake. This method provides some insight into the overall accuracy of dietary intake data. The most recent doubly labelled water sub-study of NDNS, which involved 399 participants, found that the 4-day non-weighed food diary gave energy intake, on average, 29% lower than doubly labelled water (13% in children aged 4-10y; 31% in 11-15y olds; 33% in 16-49y olds and 50-64y olds; and 28% in 65+y, with little difference by gender) (Lennox et al. 2014).

A second study, which involved 74 adult participants, similarly found that self-reported energy intake from two 24-h recalls was 20-22% lower than doubly labelled water (Foster et al. 2019). In this small study, the degree of underestimation was not statistically significantly different between BMI categories (21%, 20%, and 29% in BMI <25 kg/m^2, 25-30 kg/m^2, and 30+ kg/m^2, respectively). However, there was a statistically significant difference across age categories: those aged 40-49y and 50-59y underestimated energy intake by 33% and 27%, respectively, while those aged 60-65y underestimated energy intake by 8%.

Together, these two doubly labelled water studies suggest that self-reported dietary intake is likely to be underestimated in the UK. Evidence to support this also comes from SHeS 2021 which reported an average self-reported daily caloric intake of 1,786 for men and 1,495 for women (Scottish Government 2022), notably lower than the recommended number of calories for an average man and woman of 2,500 and 2,000 kcal, respectively.

It is hard to know whether different foods will be underestimated to the same extent as energy intake. While some potential biomarkers of meat consumption, such as urinary methyl histidine excretion, have been proposed (Cross, Major, and Sinha 2011), they can only separate high and low consumers but cannot be used to validate individual intake estimates. A study in Aberdeenshire involving 59 participants living in a controlled study facility for 12 days covertly assessed dietary intake and compared it to what participants self-reported consuming (Garden et al. 2018). They found that milk and milk-based drinks and creams were underestimated by, on average, 28%, and meat was underestimated by, on average, 15%. More research is needed to understand if these findings are comparable to what would be observed in the 'real world,' i.e., outside a residential laboratory facility.

A further caveat which should be borne in mind when interpreting diet records of 4 days or fewer, such as NDNS or SHeS, is that estimates of the proportion of the population with intakes above or below cut-points can be inflated because the observed distribution includes some within- as well as between-person variation. This effect is greatest for foods or nutrients for which the day-to-day variation within individuals is highest.

Key Messages: **Underreporting of Dietary Intake**

1. There is uncertainty around the validity of self-reported meat and dairy consumption and it is likely that meat and dairy are underreported.
2. Underreporting of energy intake is ~15-30%. If underreporting is similar for meat and dairy, the amounts of meat and dairy consumed per day will also be underestimated.
3. Underreporting is likely to be higher among younger people than older people.
4. As a result of underreporting of intake, the proportion of the population not meeting intake recommendations is likely to be overestimated.

4.2. Approach to understanding current intakes of meat, dairy, and select nutrients

In order to understand the likely nutritional and health benefits and risks of reducing meat and dairy consumption, we evaluated current intakes of meat, dairy, energy, and select nutrients for which meat and dairy are likely to be important sources (protein, calcium, iron, iodine, selenium, zinc, and vitamin B_{12}).

We synthesised information from two sources:

1. An analysis of the latest SHeS data, which we conducted especially for this report. The SHeS data were collected in 2021 from a representative sample of adults (16+y) and downloaded from the UK Data Archive.

2. Extraction of summary statistics from NDNS tables Years 9 to 11 combined (2016/2017 to 2018/2019) (Public Health England 2020).

NDNS was included because it includes children and young people <16y and a few blood measures of nutritional status. However, Scotland-specific estimates cannot be derived from NDNS due to the small sample size. Additionally, the latest NDNS data are pre-pandemic. Thus, a combination of both information sources provides a more complete picture.

Herein we provide further details on the SHeS analysis as this was conducted especially for this report. Further details on the NDNS analysis are available elsewhere (Public Health England and Food Standards Agency 2018).

4.2.1. Further details on Scottish Health Survey sample

SHeS is a representative survey designed to capture a detailed picture of the health of the Scottish population. All adults (16+y) in SHeS 2021 were invited to complete up to two online 24-h recalls. In order to maximise use of the data, and because a single 24-h recall is sufficient for estimating average population intake of most foods and nutrients (National Cancer Institute, n.d.), all adults who completed at least one 24-h recall were included in our analysis.

Unless otherwise specified, all statistics presented in this report are weighted.[14] Stata software (version 17) was used. Linear regressions were used to test for differences in meat and dairy consumption by population subgroups. Logistic regressions were used to test for differences in being a consumer versus non-consumer of meat and dairy by population subgroups. Ordinal logistic regressions were used to test for differences in low-fat dairy consumption by subgroups, with low-fat dairy consumption split into three categories (0%, 1-99%, and 100%). $P<0.01$ was considered statistically significant.

Of the 6,157 individuals in SHeS, 4,557 were aged 16+y, of which 3,447 (unweighted 76%) completed at least one 24-h recall and comprised our final sample. The majority (85%) of this sample completed two recalls, with the remaining individuals completing one.

Characteristics of the survey sample are presented in **Table 2.**. Participants were aged 16-95y (mean 48.8y, SD 18.7y), 52% were female, 73% were white Scottish, and 16 were pregnant (0.6%).

[14] The Intake24 sub-sample survey weights were used.

Table 2. Characteristics of 2021 Scottish Health Survey sample who completed at least one 24-h recall, n=3,447.

	Unweighted Base	**Weighted %[1]**
Gender		
Women	2,034	51.7%
Men	1,413	48.3%
Age group		
16-24y	177	11.5%
25-34y	393	16.7%
35-44y	496	15.2%
45-54y	595	16.7%
55-64y	768	16.9%
65-74y	723	13.1%
75+y	295	10.0%
Ethnicity		
White: Scottish	2,490	73.2%
White: Other British	651	15.8%
White: Other	186	5.6%
Asian	62	3.3%
Other minority ethnic	55	2.1%
Refused	2	0.04%
Don't know	1	0.02%
SIMD quintile		
1 (Most deprived)	425	18.5%
2	596	19.9%
3	708	18.9%
4	899	21.2%
5 (Least deprived)	819	21.4%
BMI category[2]		
<25 kg/m^2	1,019	30.1%
25-29 kg/m^2	1,467	42.2%
≥30 kg/m^2	961	27.7%

[1] Weighted to be representative of adults (16+y) living in Scotland.
[2] BMI was missing for 291 of participants. Missing BMI data were imputed using multiple imputation and the following predictors: age, race, and SIMD quintile.

4.2.2. Definitions of meat categories

Estimates of meat consumption were based on **disaggregated meat values** (Fitt et al. 2010).[15] We estimated five meat categories:

1. **Total meat**: beef, lamb, pork, other red meat, offal, poultry, game birds, processed red meat, processed poultry, burgers, and sausages
2. **Red meat (unprocessed)**: beef, lamb, pork, other red meat, and offal
3. **White meat (unprocessed)**: poultry and game birds
4. **Processed meat**: processed red meat, processed poultry, burgers, and sausages
5. **Red and red processed meat**: beef, lamb, pork, other red meat, processed red meat, burgers, sausages, and offal

We also estimated the intake of each animal type[16]:

1. Beef
2. Lamb
3. Pork
4. Poultry
5. Game

For composite dishes such as beef Bolognese or chicken curry, **disaggregated meat values** are the amount of meat (in grams) in the dish. For example, someone may report eating 345g chicken curry for dinner on the previous day. That curry is estimated to contain 107g poultry. This value (107g), along with the values for all other meat-containing items reported that day, is used to determine the individual's meat consumption.

Unfortunately, it **was not possible in this analysis to disaggregate the nutrients** in composite dishes and attribute them to specific components of the dish. For example, while we can attribute 9% of protein intake to sandwiches, we cannot determine what percentage of this protein is from the meat in the sandwich versus other ingredients.

4.2.3. Definitions of dairy categories

Estimates of dairy consumption were also based on **disaggregated dairy values** derived for this report.[17] We estimated five dairy categories:

1. **Total dairy**: milk, cheese, yoghurt, cream, and butter
2. **Milk:** skimmed, semi-skimmed, and whole varieties
3. **Cheese**: cheddar cheese, cottage cheese, and other cheese; skimmed, semi-skimmed, and whole varieties
4. **Yoghurt**: skimmed, semi-skimmed, and whole varieties
5. **Cream**: semi-skimmed and whole varieties
6. **Butter**

Whey protein powder and Ensure / SlimFast liquid were not classified as dairy.

[15] Meat is disaggregated into the following mutually exclusive categories in the original SHeS 2021 dataset: beef, lamb, pork, processed red meat, other red meat, burgers, sausages, offal, poultry, processed poultry, and game birds. If a dish contains >1 meat type, each type of meat is disaggregated into one of these mutually exclusive categories. For example, a dish containing pork sausage and chicken would be disaggregated into 'sausages' and 'poultry'.

[16] This required manually identifying and re-categorising items as beef, lamb, pork, poultry, or game from the following categories in the original SHeS 2021 dataset: processed red meat, other red meat, burgers, sausages, and offal. For example, under 'burgers', 'Beef burger, grilled (no bun)' was classified as 'beef' whereas 'Lamb burger (no bun)' was classified as 'lamb'. See **Appendix 3** for details.

[17] Paper under review. Code and data files available on GitHub: https://github.com/Cristina-Stewart/SHeS_Dairy-disaggregation.

4.2.4. Definitions of food categories and food groups

We explored three levels of food groups:

1. Food category
2. Main food group
3. Sub food group

In SHeS 2021, food items were categorised into main food groups (e.g., 'chicken and turkey dishes') and sub food groups (e.g., 'manufactured chicken products including ready meals' and 'other chicken/turkey including homemade dishes'). This is the same categorisation used in NDNS. We further categorised main food groups into higher-level food categories (e.g., 'meat and meat products' and 'cereals and cereal products'), as defined in the NDNS. A complete list of the food groups analysed is available on the NDNS website (NDNS 2019) with the exception of 'sandwiches', which was an additional food group introduced with Intake24 in SHeS 2021.

All food categories and groups were analysed and reported as defined in the NDNS and SHeS (NDNS 2019) though we made some modifications to the food category 'milk and milk products' notably the inclusion of milky coffees (e.g., lattes, cappuccinos) and butter, and the removal of dairy-free items (**Appendix 3**).

4.3. Meat consumption

4.3.1. Meat consumption in the Scottish Health Survey

Eighty-six percent of respondents (unweighted base 2,911) were meat consumers (i.e., they reported eating >0g of any meat across their dietary recalls): 56% consumed processed meat, 53% consumed white meat, and 47% consumed red meat. As dietary intake was only assessed on one or two days, it is possible meat-eating was missed for some individuals, and an even greater percentage consume some type of meat. Women were less likely to be consumers of all types of meat (**Figure 4**). There were no significant differences in odds of being a meat consumer by age group or SIMD.

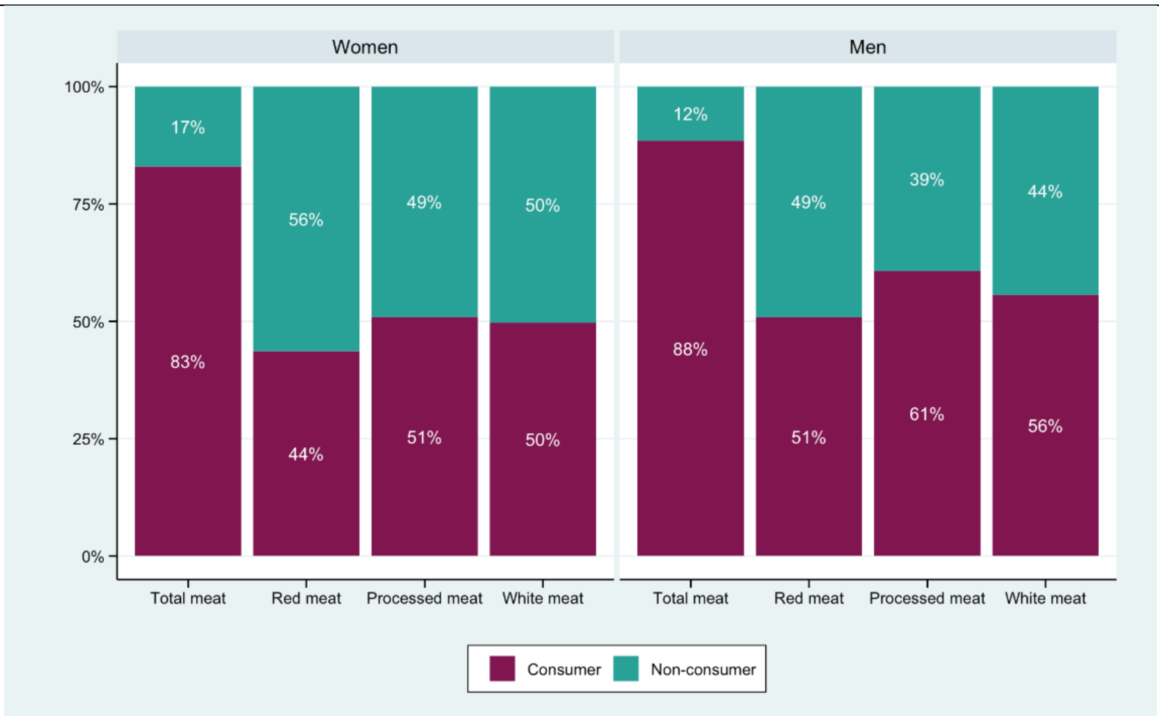


Figure 4. Percentage consumers of meat by gender among adults (16+y) in Scotland (total unweighted base 3,447).

Among meat consumers, average meat consumption was 94g/day (95% CI 90-97g/day), comprised of 37g/day white meat (34-39g/day), 32g/day processed meat (29-34g/day), and 26g/day red meat (24-28g/day).[18] Tables of mean intakes (per capita and per consumer) and percent food group contributions to meat consumption among meat consumers, overall and by population subgroup, are provided in **Appendix 4**.

[18] The sum of the rounded means of meat subtypes is 95g/day due to rounding to the nearest whole gram.

Differences by population subgroups, among meat consumers, were as follows (**Figure 5**):

- By gender:
    - Men consumed, on average, 28g/day (*P*<0.001) more **total meat** than women.
    - Men ate more **processed meat** (11g/day, *P*<0.001), **white meat** (9g/day, *P*<0.001), and **red meat** (on average, 8g/day, *P*<0.001) than women.

- By age group:
    - Those aged 16-24y consumed, on average, 24g/day (*P*=0.003) and 23g/day (*P*=0.002), more **total meat** than those aged 75+y and 65-74y, respectively.
    - Individuals aged 16-24y consumed, on average, 15g/day more **white meat** than those aged 65-74y (*P*=0.004).
    - Those aged 16-24y consumed the most **processed meat**, on average, 14g/day (*P*=0.004) more than those aged 65-74y.
    - There was no difference in **red meat consumption** across age groups.

- By gender and age group:
    - Women aged 16-24y consumed **less total meat** than all male age groups under 55y; consuming on average 37g/day (*P*=0.002), 36g/day (*P*=0.004), 27g/day (*P*=0.005), and 22g/day (*P*=0.009) **less** than men aged 25-34y,16-24y, 35-44y, and 45-54y, respectively.
    - Women aged 16-24y consumed 16g/day (*P*=0.001) and 14g/day (*P*=0.001) **less red meat** than men aged 65-74y and men aged 45-54y, respectively.
    - There was no difference in **white and processed meat consumption** across age-gender groups.

- By BMI category:
    - Individuals with a BMI ≥30 kg/m^2 consumed, on average, 9g/day (*P*<0.001) more **processed meat** than those with a BMI <25 kg/m^2.
    - There were no differences in intake of **total meat, red meat,** or **white meat** by BMI category.

- By SIMD quintile:
    - There was no significant difference in total meat consumption or intake of any meat subtype by SIMD quintile.

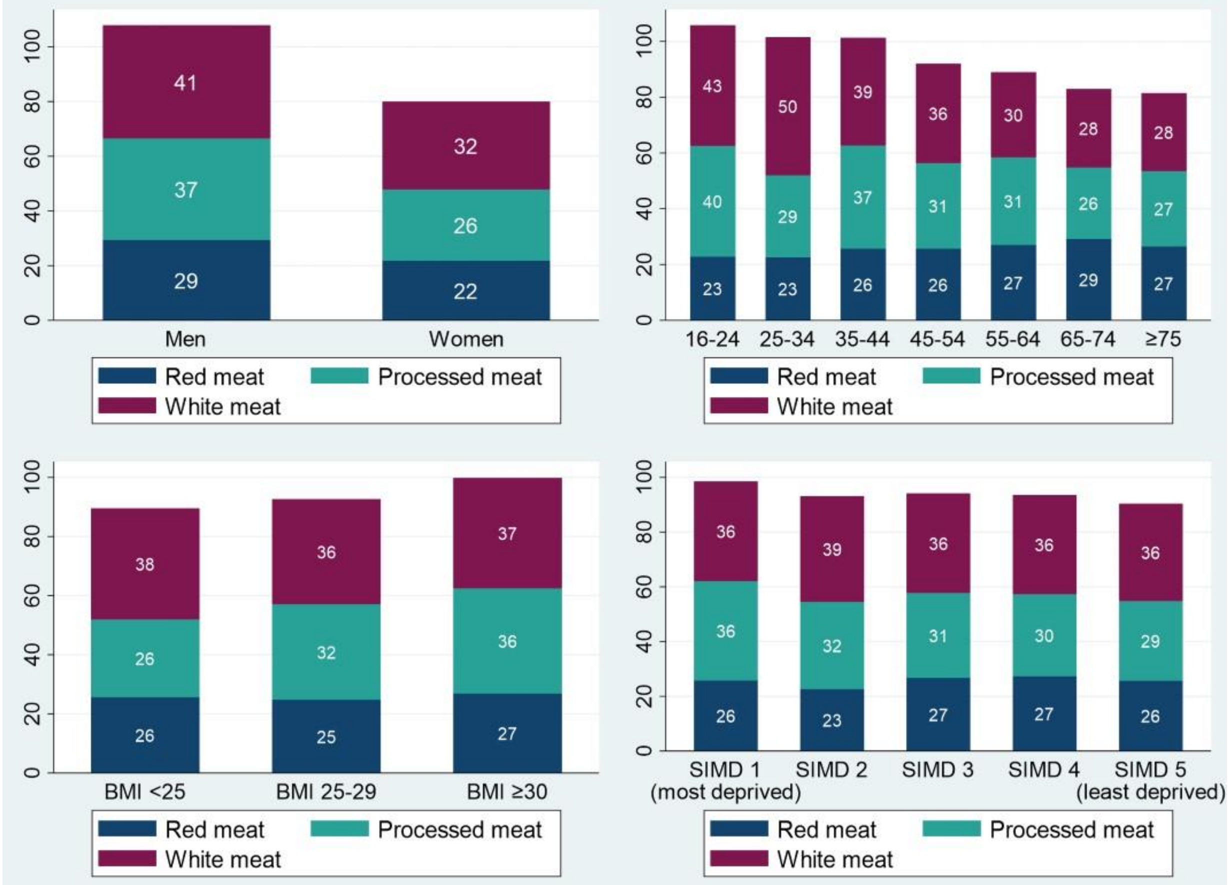


Figure 5. Average consumption (g/day) of red meat, processed meat, and white meat among adult meat consumers (16+y) in Scotland, by gender, age group (y), BMI (kg/m^2) category, and SIMD quintile (total unweighted base 2,911).

4.3.2. Contribution of beef, pork, lamb, poultry, and game to meat consumption in the Scottish Health Survey

The majority of the meat eaten among consumers was 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, the following differences were observed by SIMD quintile, age group, and gender/age group (**Figure 6**):

- The contribution of **game** to meat consumption was, on average, 1 percentage point higher (P=0.001) among those in SIMD 4 than those in SIMD 1 (most deprived).
- The contribution of **lamb** to meat consumption was, on average, 4 percentage points higher among those aged 75+y (P=0.009) and 65-74y (P<0.001), and 3 percentage points higher among those aged 55-64y (P=0.001), compared to individuals aged 16-24y.
- The contribution of **pork** to meat consumption was, on average, 12 percentage points higher among men aged 55-64y, than women aged 16-24y (P=0.008).

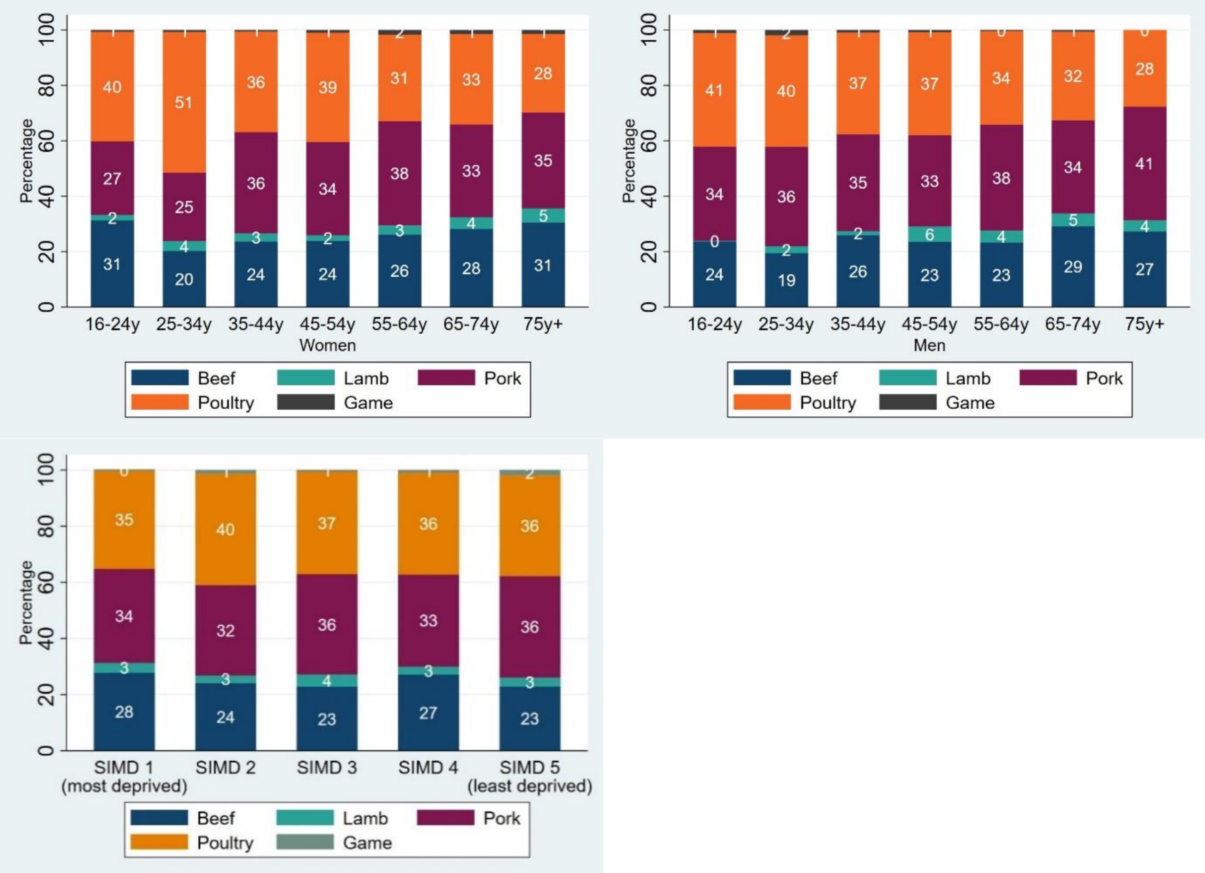


Figure 6. Percent contribution of different animal types to average daily meat consumption among adult meat consumers (16+y) in Scotland, by age (y) and gender groups and SIMD quintile (total unweighted base 2,911).

4.3.3. *Contribution of food groups to meat consumption in the Scottish Health Survey*

The top contributing **main food groups** to total meat consumption (g) among consumers were chicken and turkey dishes (herein: chicken dishes) (28%), followed by beef and veal dishes (herein: beef dishes) (16%), sandwiches (13%), bacon and ham (8%), and sausages (6%) (**Appendix 4**). With the exception of bacon and ham (among those aged 16-24y and 25-34y), and sausages (among those aged 16-24y and those in SIMD 4), these remained top contributors across all population subgroups. Other main food groups contributing >5% to total meat consumption in specific population subgroups were:

- Burgers and kebabs: highest among individuals aged 16-24y (11%), specifically women aged 16-24y (15%) and those in SIMD 1 (most deprived; 7%).
- Meat pies and pastries: highest among women aged 16-24y (8%) and those in SIMD 1 (most deprived; 8%).
- Coated chicken: highest among women aged 16-24y (10%).
- Pasta, rice and other cereals: highest among men aged 25-34y (7%).

More specifically, within the **sub food group** 'other chicken/turkey including homemade recipe dishes', chicken breast, fried, was the most commonly reported food item (**Error! Reference source not found.**, **Appendix 4**). Within the sub food group, 'Other beef and veal including homemade recipe dishes', spaghetti Bolognese and chilli con carne were the most commonly reported food items. Within the sub food group, 'sandwiches', and 'other sausages including homemade recipe dishes', ham sandwiches and grilled pork sausages were most common, respectively.

Table 3. Most commonly reported meat-containing food items within the top five contributing sub food groups to meat consumption among meat consumers (total unweighted base 2,911).

Sub food group*	Food item	Frequency	
		n	**Weighted %**
Other chicken/turkey including homemade recipe dishes	Chicken breast, fried	274	25%
	Chicken curry home made	90	7%
	Chicken casserole/stew	92	7%
	Roast/grilled chicken breast (skin not eaten)	99	7%
	Roast chicken (skin not eaten)	89	6%
Other beef and veal including homemade recipe dishes	Spaghetti Bolognese, homemade (pasta and sauce)	141	18%
	Chilli con carne	104	11%
	Beef lasagne	69	9%
	Roast beef	74	6%
Sandwiches	Ham sandwich with white/malted bread	170	20%
	Ham sandwich with wholemeal/oatmeal bread	151	17%
	Cheese and ham sandwich with white/malted bread	66	7%
	Bacon sandwich with white/malted bread	50	6%
Other bacon and ham including homemade recipe dishes	Ham, not smoked	241	26%
	Bacon, back/middle, unsmoked, grilled (fat removed)	124	14%
	Ham, smoked	103	12%
	Bacon, back/middle, smoked, grilled (including fat)	58	8%
	Bacon, back/middle, unsmoked, grilled (including fat)	56	7%
Other sausages including homemade recipe dishes	Pork sausage, grilled	171	37%
	Square/Lorne sausage	71	15%
	Sausage, fried	67	14%
	Chorizo	39	9%
	Beef Sausage, grilled	32	7%

* A detailed list and definitions of all sub food groups can be found on the NDNS website (NDNS 2019).

4.3.4. Red and red processed meat consumption behaviours in the Scottish Health Survey

"**Red and red processed meat**" refers to all of the following: beef, lamb, pork, other red meat, processed red meat, burgers, sausages, and offal. Processed white meat (contributing 2% of all processed meat consumed), was not included.

The **Scottish Dietary Goals** include limiting average intake of red and red processed meat to 70g per person per day.

Seventy-two percent of respondents (unweighted base 2,494) consumed some quantity 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.[19]

Of consumers who completed two recalls (n=2,269), 50% consumed red and red processed meat on both days (16% of low, 52% of medium, and 76% of high consumers). Mean intake of red and red processed meat was 66g/day among all consumers; 19g/day among low; 50g/day among medium; and 117g/day, among high consumers. The majority of red and red processed meat was processed (56%), and most processed meat was pork (87%) (**Appendix 6**).

Men were more likely to be a high consumer of red and red processed meat (45%) than women (30%) (*P*<0.001). Among consumers, 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%) (*P*=0.001). There was no difference by age group.

[19] When creating three equal sized groups, the cut-off for high consumers was 72g/day. We adjusted this upper threshold to ensure alignment with the recommended limit of 70g/day, affecting 43 respondents.

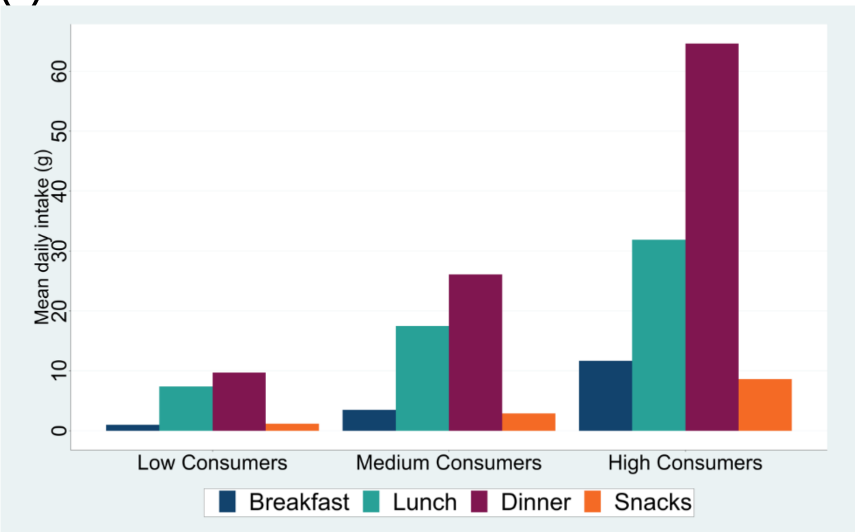
Dinners accounted for the highest proportion of red and red processed meat consumption among high (55%) and medium (52%) consumers (**Figure 7**).[20] Low consumers distributed their intake more across lunch (40%) and dinner (48%).

The majority of red and red processed meat consumed was purchased from supermarkets (85-88% across consumer tertiles), with 10-12% purchased from cafes, restaurants & takeaways (**Figure 7**).

Overall, especially among high consumers, intake of red and red processed meat was highest on Sundays (**Figure 7**).

[20] Our methodology for estimating mean intakes of red and red processed meat by meal occasion, purchase location, and day of the week is available in **Appendix 5**.

(A)



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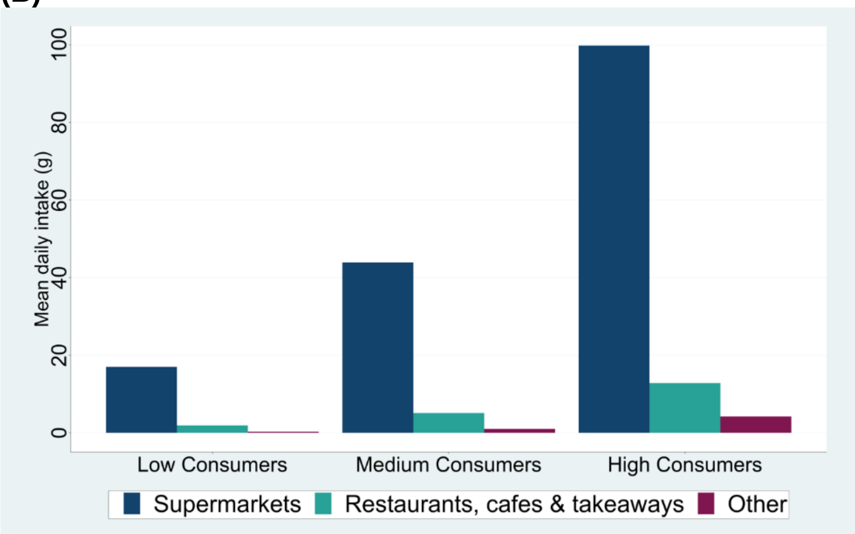

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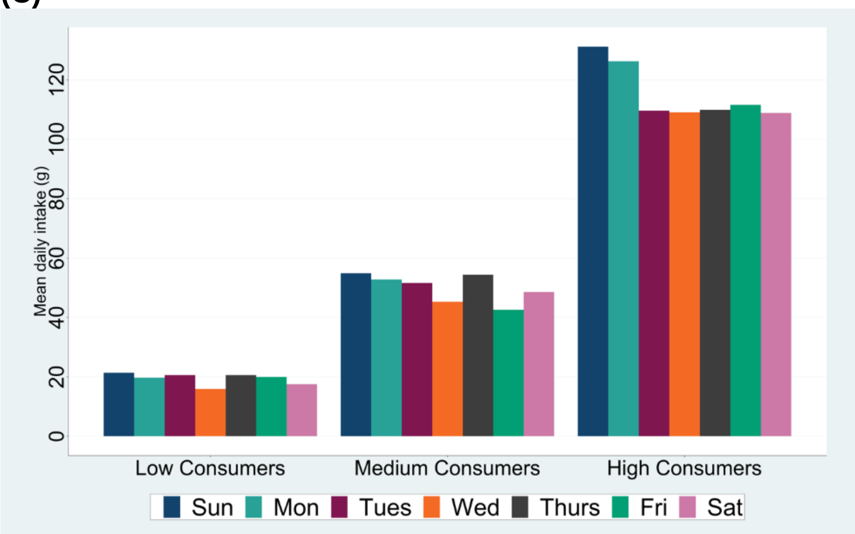

Figure 7. Mean intakes (g/day) of red and red processed meat by (A) meal occasion, (B) purchase location, and (C) day of the week among adult red and red processed meat consumers (16+y) in Scotland, by consumer tertiles (total unweighted base 2,494).

Beef dishes and sandwiches (notably spaghetti Bolognese and ham sandwiches, **Appendix 6**) were the largest contributors to intake among high (26% and 15%, respectively) and medium (28% and 18%, respectively) consumers. Bacon and ham, followed by beef dishes were the largest contributors among low consumers (19% and 17%, respectively) (**Figure 8**).

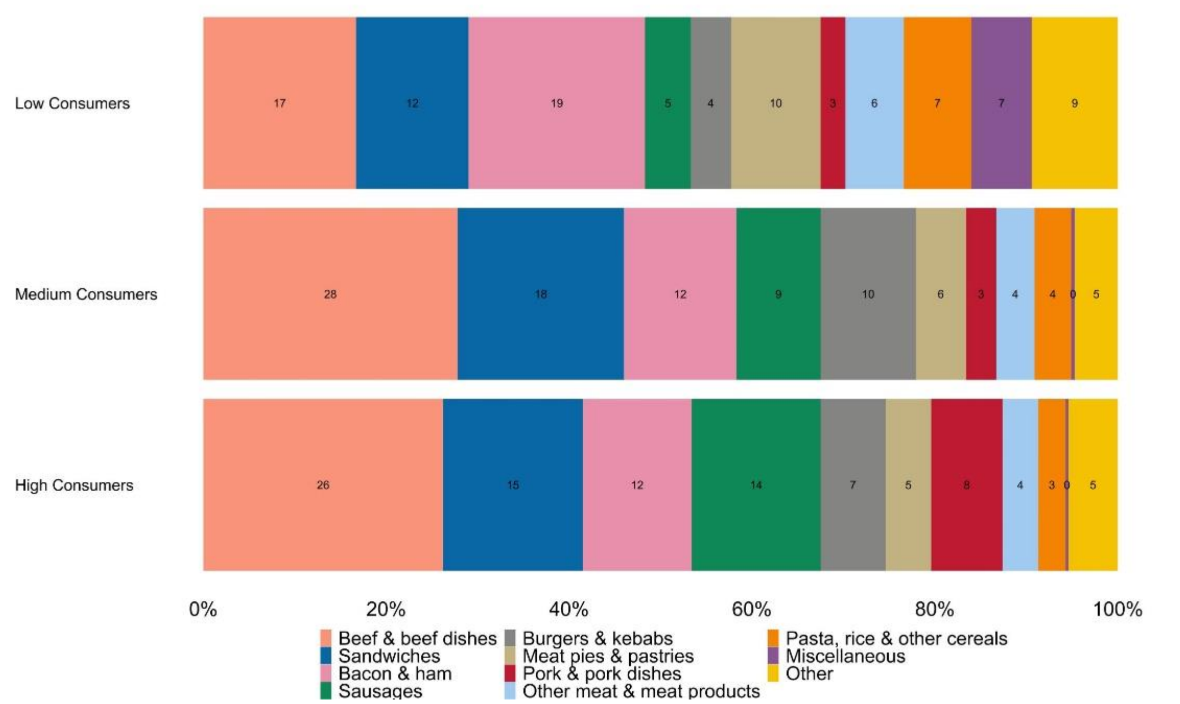

Figure 8. Percent contribution of main food groups to red and red processed meat consumption among adult red and red processed meat consumers (16+y) in Scotland, by consumer tertiles (total unweighted base 2,494).

Food groups contributing <5% to all tertiles are grouped into 'other'. Percent contribution of 'miscellaneous' items to medium and high consumers was 0.4% and 0.3%, respectively. 'Miscellaneous' includes soups, savoury sauces, pickles, gravies, and condiments.

Key Messages: **Meat Consumption**

1. On any given day, most adults (16+y) in Scotland – 86% – consume some type of meat, whether it be red meat, white meat, or processed meat. As dietary intake was only assessed on one or two days, it is possible meat-eating was missed for some individuals, and an even greater percent consume some type of meat.
2. On average, adult meat consumers in Scotland consume 94g/day total meat, comprised of 37g/day white meat, 32g/day processed meat, and 26g/day red meat.
3. One-quarter of meat consumed is beef.
4. Men aged 25-34y are the highest meat consumers.
5. Homemade dishes containing chicken or beef, such as a chicken breast, fried, or spaghetti Bolognese, and ham sandwiches are some of the most common ways in which adults in Scotland consume meat.
6. Men and individuals living in the most deprived areas are most likely to be high consumers of red and red processed meat.
7. Consumption of red and red processed meat is highest on Sundays and during dinners.
8. Only 10-12% of red and red processed meat was purchased at cafes, restaurants, pubs and takeaways.

4.4. Dairy consumption

4.4.1. Dairy consumption in the Scottish Health Survey

Ninety-nine percent of survey respondents (unweighted base 3,422) consumed some kind of dairy. There were no significant differences in odds of being a dairy consumer by gender, age group, BMI category, or age-gender group. Individuals in SIMD 3 were more likely to be a dairy consumer than those in SIMD 1 (most deprived) (*P*=0.003).

Average dairy consumption among consumers was 241g/day (95% CI 231-250/d), comprised of 185g/day milk (176-194g/day), 23g/day yoghurt (20-25g/day), 22g/day cheese (20-23g/day), 8g/day butter (7-8g/day), and 4g/day cream (3-4g/day). Tables of mean intakes (per capita and per consumer) and % food group contributions to dairy consumption among consumers, overall and by population subgroup, are provided in **Appendix 7**.

The following differences were observed for population subgroups among consumers:

- By gender:
  - Men consumed 1g/day more **butter** than women (*P*=0.001).

- By age group:
  - Those aged 75+y consumed the most **total dairy,** 69g/day more than individuals aged 16-24y (*P*=0.006).
  - Those aged 75+y consumed 13g/day more **yoghurt** than those aged 16-24y (*P*=0.008).
  - Those aged 16-24y were the lowest consumers of **butter**, consuming 4g/day less than those aged 75+y (*P*<0.001) and 3g/day less than those aged 65-74y, 55-64y, 45-54y (all *P*<0.001), and 35-44y (*P*=0.001).

- By age and gender group:
  - Women aged 16-24y consumed the least amount of **total dairy**, consuming 126g/day less than men aged 75+y (*P*<0.001), 97g/day less than men aged 65-74y (*P*=0.008), 90g/day less than women aged 65-74y (*P*=0.001), 83g/day less than men aged 55-64y (*P*=0.002), and 81g/day less than women aged 75+y (*P*=0.007).
  - Women aged 16-24y consumed 115g/day less **milk** than men aged 75+y (*P*=0.001), 74g/day less than men aged 55-64y (*P*=0.007), and 73g/day less than women aged 65-74y (*P*=0.007).
  - Women aged 16-24y consumed 17g/day less **yoghurt** than women aged 65-74y (*P*=0.001), 17g/day less than women aged 75+y (*P*=0.005), and 15g/day less than women aged 55-64y (*P*=0.002).
  - Women aged 16-24y consumed 5g/day less **butter** than men aged 75+y (*P*<0.001), 4g/day less than men aged 45-54y (*P*=0.001), and 3g/day less than men aged 55-64y (*P*=0.002).

- By BMI category:
  - Those with a BMI<25 kg/m^2 consumed the highest quantities of **yoghurt**, 10g/day more than those with a BMI>30 kg/m^2 (*P*<0.001).

- By SIMD quintile:
    - Those in SIMD 5 (least deprived) consumed, on average, 48g/day more **total dairy** than individuals in SIMD 1 (most deprived) (*P*=0.002).
    - Those in SIMD 5 (least deprived) consumed, on average 7g/day more **cheese** than individuals in SIMD 1 (most deprived) (*P*=0.002).
    - Individuals in SIMD 1 (most deprived) consumed less **yoghurt** than all other SIMD quintiles, notably 16g/day and 14 g/day less than those in SIMD 4 (*P*<0.001) and 5 (least deprived) (*P*=0.001), respectively.

The majority of the dairy consumed by weight was milk (67%) followed by cheese (14%) and yoghurt (9%), with smaller contributions from butter (7%) and cream (2%).

These proportions differed across all population subgroups (**Figure 9**):

- By gender:
    - The contribution of **yoghurt** to dairy consumption was, on average, 3 percentage points higher among women, than men (*P*<0.001).
    - The contribution of **butter** to dairy consumption, was on average, 2 percentage points higher among men, than women (*P*=0.003).

- By age group:
    - The contribution of **milk** to dairy consumption, was on average, 11 percentage points higher among individuals aged 75+y, than those aged 16-24y (*P*=0.007)
    - The contribution of **cheese** to dairy consumption, was on average, 12 percentage points higher and 10 percentage points higher among individuals aged 16-24y, than those aged 75+y (*P*<0.001) and 64-75y (*P*=0.001), respectively.

- By age and gender group:
    - The contribution of **milk** to dairy consumption, was on average 15 percentage points higher among men aged 75+y than women aged 16-24y(*P*=0.002).
    - The contribution of **cheese** to dairy consumption, was higher among women aged 16-24y, compared to both men and women aged 65-74y and 75+y, ranging from 10 percentage points higher than men aged 65-74y (*P*=0.001) to 13 percentage points higher than men aged 75+y (*P*<0.001).
    - The contribution of **yoghurt** to dairy consumption, was 6 percentage points higher and 5 percentage points higher among women aged 65-74y (*P*=0.005) and women aged 55-64y (*P*=0.008), respectively, than women aged 16-24y.

- By BMI category:
    - The contribution of **milk** to dairy consumption, was on average, 6 percentage points higher among those with a BMI>30 kg/m^2 than those with a BMI<25 kg/m^2 (*P*=0.005).
    - The contribution of **yoghurt** to dairy consumption, was on average, 3 percentage points higher among those with a BMI<25 kg/m^2 than those with a BMI>30 kg/m^2 (*P*=0.002).

- By SIMD quintile:
    - The contribution of **milk** to dairy consumption was highest among those in SIMD 1 (most deprived); 7 percentage points higher than those in both SIMD 4 (*P*<0.001) and SIMD 5 (least deprived) (*P*=0.003), and 6% higher than those in SIMD 3 (*P*=0.003).
    - The contribution of **yoghurt** to dairy consumption was lowest among those in SIMD 1 (most deprived); 6 percentage points lower than those in SIMD 4 (*P*<0.001), and

5 percentage points lower than those in SIMD 3 (P<0.001) and SIMD 5 (least deprived) (P=0.001).

Among consumers, 62% of the dairy consumed was low fat (skimmed or semi-skimmed); 80% of milk, 37% of yoghurt, 17% of cheese, and 28% of cream.

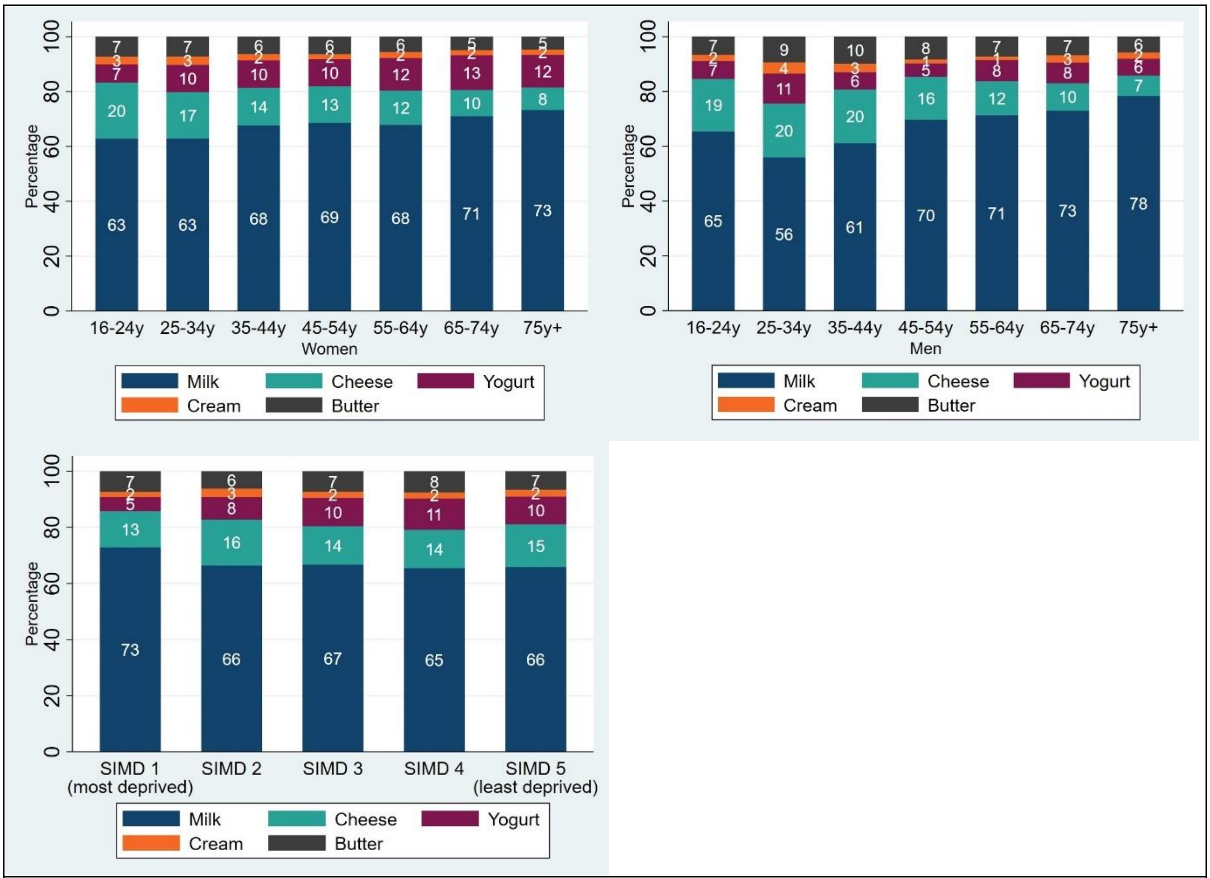

Figure 9. Percent contribution of dairy subtypes to average daily dairy consumption among adult consumers (16+y) in Scotland, by age and gender groups and SIMD (total unweighted base 3,422).

4.4.2. Contribution of food groups to dairy consumption in the Scottish Health Survey

Among dairy consumers, the top contributing **sub food groups** to dairy consumption (g) were: semi-skimmed milk (29%), other milk[21] (10%), whole milk (9%), yoghurt (9%), and skimmed milk (5%). These remained top contributors among all population subgroups with the exception of (**Appendix 7**):

- Skimmed milk was not a top contributor (>5%) for those aged 16-24y, 25-34y, 35-44y, and 75+y, those with a BMI <25 kg/m^2, and those in SIMD 1 (most deprived), SIMD 2, and SIMD 3
- Yoghurt was not a top contributor for those in SIMD 1 (most deprived)

[21] Includes goat milk, evaporated milk, condensed milk, dried milk and lactose-free milks, coffee creamers/mates, and milkshakes.

Overall, sandwiches and pizza were the highest contributing composite dishes to dairy consumption, contributing 4% and 3%, respectively. The contribution of sandwiches was ≥5% among three subgroups: men aged 35-44y and 45-54y (both 6%), and men aged 65-74y (5%). Pizza contributed ≥5% among men (5%) younger age groups (16-24y and 25-34y (both 6%)), those in SIMD 2 (5%), as well as men aged 16-24y (11%), 25-34y (8%) and 35-44y (7%).

Overall, 70% of sandwiches contained dairy (n=971), among these the most common sandwiches were plain ham sandwiches (containing butter) and cheese sandwiches. Almost all pizzas contained dairy (99%, n=347), among these, the most frequently reported pizzas were 'meat pizza (e.g., Hawaiian, pepperoni, meat feast)' and 'cheese and tomato (e.g., Margherita)' not from a restaurant/takeaway and not stuffed crust.

Key Messages: **Dairy Consumption**

1. The vast majority of survey respondents (99%) consumed dairy products.
2. Average daily intake of dairy among consumers was 241g/day.
3. The majority of the dairy consumed was milk (67%), cheese (14%), and yoghurt (9%) with small proportions coming from butter (7%) and cream (2%).
4. The most important composite dairy dishes were sandwiches and pizza, yet their contribution was small (<5% each).
5. Men aged 75+y consumed the most total dairy, milk, and butter compared to women aged 16-24y.
6. Individuals in SIMD 5 (least deprived) consumed more total dairy, cheese, and yoghurt than those in SIMD 1 (most deprived).

4.5. Nutrient intake

The following sections present nutrient intake from food and drink only (i.e., not including supplements). As the vast majority of survey respondents consumed some quantities of meat and/or dairy (99%), with only 9 survey respondents consuming neither, we did not explore intakes separately among this "non-consumer" group. Tables of mean nutrient intakes per capita and percent food group contributions to nutrient intakes, overall and by population subgroup, are provided in **Appendix 8**.

4.5.1. Nutrient intake per capita and by population subgroups in the Scottish Health Survey

Average intakes of energy and protein were 1,630kcal/d and 67.2g/day, respectively. Comparing average per capita intake of nutrients to their respective RNI values based on age and gender showed that (**Error! Reference source not found.**):

- Average intake of calcium was above the RNI for all age and gender groups, except for men and women aged 16-18y.
- Average intake of iron and iodine was above the RNI for all age and gender groups, except for men and women aged 16-18y, and women aged 19-50y.
- Average intake of selenium was below the RNI for all age and gender groups.
- Average intake of zinc was above the RNI for women of all ages, but below the RNI for men of all ages.
- Average intake of vitamin B_{12} was above the RNI for all age and gender groups.

Recall that the **RNI** is the nutrient intake adequate for **97.5%** of the population. **AR** is the nutrient intake adequate for **50%** of the population. **LRNI** is the nutrient intake adequate for **2.5%** of the population. Because nutrient intake is estimated based on only two 24-h recalls and overall dietary intake is under-estimated in SHeS, the **percentage of the population below the RNI, AR, and LRNI is likely to be over-estimated**.

Table 4. Weighted mean daily nutrient intakes by gender and age group* as compared to UK Lower Reference Nutrient Intakes (LRNIs), EFSA Average Requirement (AR) or Adequate Intake (AI), and UK Reference Nutrient Intakes (RNIs) among adults (16+y) living in Scotland (total unweighted base 3,447).†

Nutrient		Men			Women		
		16-18y	19-50y	51+y	16-18y	19-50y	51+y
Calcium (mg/day)	Mean intake	**745**	849	859	**746**	767	754
	LRNI	480	400	400	450	400	400
	AR	960	750	750	960	750	750
	RNI	1000	700	700	800	700	700
Iron (mg/day)	Mean intake	**10.7**	10.4	10.3	**8.0**	**8.7**	8.8
	LRNI	6.1	4.7	4.7	8.0	8.0	4.7
	AR	8	6	6	7	7	7
	RNI	11.3	8.7	8.7	14.8	14.8	8.7
Iodine (µg/day)	Mean intake	**133**	150	170	**102**	**123**	147
	LRNI	70	70	70	70	70	70
	AI	130	150	150	130	150	150
	RNI	140	140	140	140	140	140
Selenium (µg/day)	Mean intake	**42**	**46**	**46**	**32**	**37**	**38**
	LRNI	40	40	40	40	40	40
	AI	70	70	70	70	70	70
	RNI	70	75	75	60	60	60
Zinc (mg/day)	Mean intake	**7.9**	**8.5**	**8.2**	7.0	7.1	7.1
	LRNI	5.5	5.5	5.5	4.0	4.0	4.0
	AR	11.8	11.0	11.0	9.9	8.9	8.9
	RNI	9.5	9.5	9.5	7.0	7.0	7.0
Vitamin B_{12} (µg/day)	Mean intake	4.0	4.9	5.2	3.4	3.8	4.3
	LRNI	1.0	1.0	1.0	1.0	1.0	1.0
	AI	4.0	4.0	4.0	4.0	4.0	4.0
	RNI	1.5	1.5	1.5	1.5	1.5	1.5

* These age groups are presented to match the age groups given for RNIs in the UK. The age groups for the RNIs in the UK differ from those used for the EFSA AR/AI. Here we show the AR/AI for 15-17y for the RNI age group 16-18y, and the AR/AI for 25+y for the RNI age groups 19-50y and 51+y. See **Appendix 8** for the mean intake by AR/AI age groups.

† Average intakes that are below the RNI are **bolded** and shaded in blue. Intakes are from food and drink only (i.e., not including supplements).

In participants with two 24-h recalls (n=3,042), we further looked at the percent below the LRNI, AR/AI, and RNI (**Error! Reference source not found.**).

- Below the LRNI:
    - Across all age and gender groups, more than 20% of the population had selenium intake below the LRNI.
    - 22-26% of men 16-34y had iron, iodine, and zinc intakes below the LRNI.
    - 60% of women 16-24y and 48% of women 25-34y had iron intakes below the LRNI.
    - 22-25% of women 25-44y had iodine intakes below the LRNI.

- Below the AR/AI:
    - Across all age and gender groups, more than 40% of the population had iodine, selenium, and zinc intakes below the AR/AI.
    - Across all age and gender groups except men 35-44y, more than 40% of the population had calcium intakes below the AR.
    - Across all age and gender groups except men 65+y, more than 40% of the population had vitamin B_{12} intakes below the AI.
        - Of note, the AI for vitamin B_{12} is higher than the RNI: 4.0µg/day versus 1.5µg/day.
    - The percentage of participants below the AR for iron was only more than 40% for women 16-24y.
        - Of note, the AR for iron for women 16-50y is half the RNI: 7mg/day versus 14.8mg/day.

- Below the 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 B_{12} intakes below the RNI.

Table 5. 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 Lower Reference Nutrition Intakes (LRNI)								
Calcium (mg/day)	Women	13%	14%	11%	15%	13%	10%	12%
	Men	16%	10%	9%	13%	10%	6%	7%
Iron (mg/day)	Women	**60%**	**48%**	**42%**	**27%**	7%	9%	2%
	Men	**26%**	6%	5%	8%	6%	5%	6%
Iodine (µg/day)	Women	14%	**25%**	**22%**	18%	13%	10%	9%
	Men	**22%**	**23%**	10%	16%	11%	6%	3%
Selenium (µg/day)	Women	**68%**	**66%**	**56%**	**63%**	**62%**	**63%**	**63%**
	Men	**54%**	**52%**	**41%**	**48%**	**45%**	**48%**	**53%**
Zinc (mg/day)	Women	12%	10%	12%	14%	10%	12%	12%
	Men	**24%**	**21%**	17%	19%	**21%**	18%	20%
Vitamin B_{12} (µg/day)	Women	7%	5%	6%	6%	4%	2%	0%
	Men	0%	7%	4%	2%	5%	2%	0%
Below EFSA Average Requirements (AR) / Adequate Intakes (AI)								
Calcium (mg/day)	Women	**73%**	**58%**	**51%**	**54%**	**56%**	**53%**	**54%**
	Men	**69%**	**55%**	35%	**44%**	**44%**	**41%**	**46%**
Iron (mg/day)	Women	**45%**	37%	31%	33%	30%	37%	28%
	Men	30%	14%	12%	13%	13%	11%	10%
Iodine (µg/day)	Women	**77%**	**80%**	**67%**	**68%**	**58%**	**53%**	**57%**
	Men	**63%**	**74%**	**54%**	**54%**	**51%**	**49%**	**41%**
Selenium (µg/day)	Women	**99%**	**97%**	**92%**	**94%**	**92%**	**96%**	**95%**
	Men	**85%**	**86%**	**86%**	**87%**	**86%**	**87%**	**90%**
Zinc (mg/day)	Women	**80%**	**79%**	**74%**	**78%**	**78%**	**78%**	**74%**
	Men	**81%**	**81%**	**75%**	**81%**	**82%**	**84%**	**94%**
Vitamin B_{12} (µg/day)	Women	**65%**	**65%**	**59%**	**64%**	**53%**	**49%**	**46%**
	Men	**61%**	**56%**	**46%**	**48%**	**45%**	37%	29%
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 20% for the LRNI and 40% for the AR/AI and RNI are **bolded** and shaded in blue.

4.5.2. Contribution of food groups to nutrient intake, per capita, in the Scottish Health Survey

Collectively, meat products and milk products accounted for 26% of energy intake and 42% of protein intake (**Figure 10**).

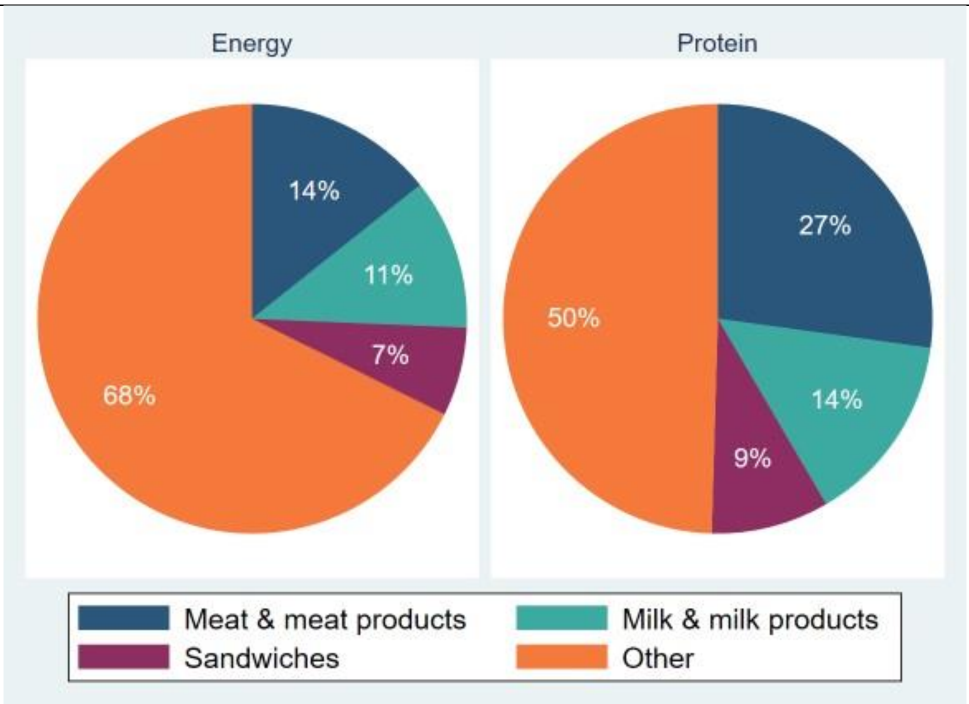

Figure 10. Percent contribution of food categories to average daily energy (kcal) and protein (g) intake among adults (16+y) living in Scotland (total unweighted base 3,447).

'Other' included all food categories other than 'meat & meat products', 'milk & milk products' and 'sandwiches'. Food categories are mutually exclusive. Unrounded total percent for 'meat & meat products' and 'milk & milk products' 26% for energy intake and 42% for protein intake.

Contributions from meat and meat products varied from 7% for calcium to 26% for selenium. Contributions from milk and milk products varied from 2% for iron to 38% for iodine (**Figure 11**).

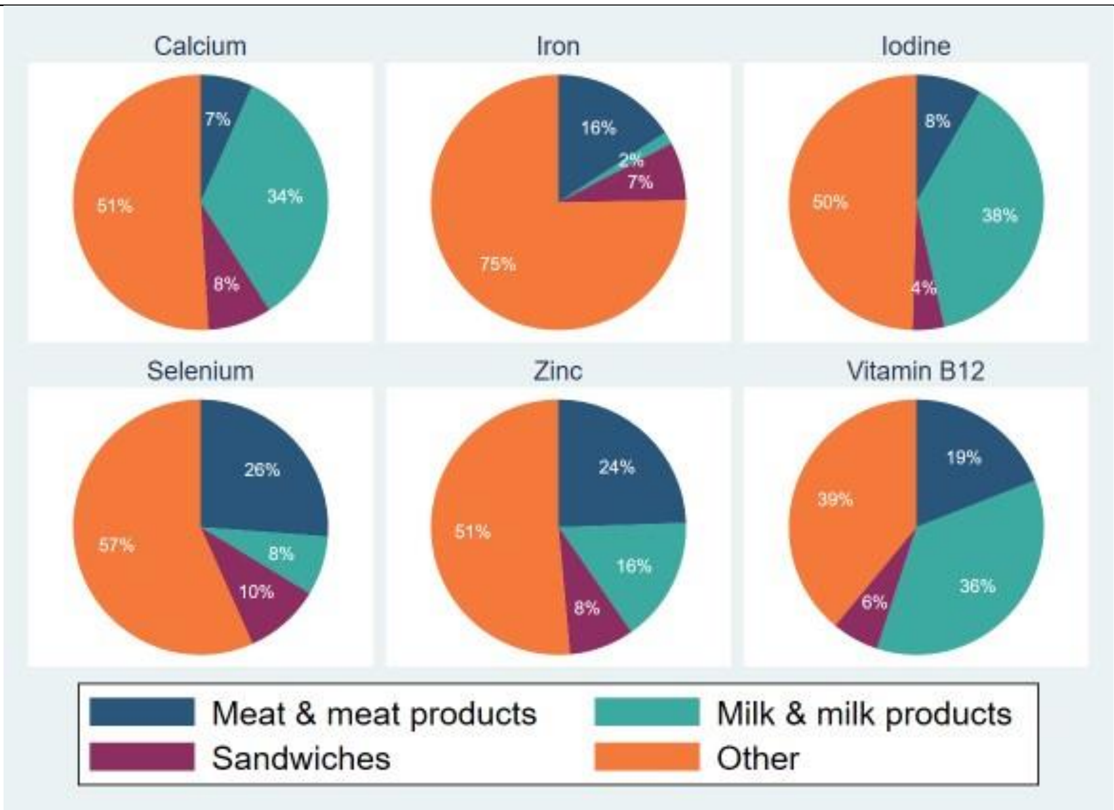

Figure 11. Percent contribution of food categories to average daily calcium, iron, iodine, selenium, zinc and vitamin B_{12} intake among adults (16+y) living in Scotland (total unweighted base 3,447).

'Other' included all food categories other than 'meat & meat products', 'milk & milk products' and 'sandwiches'. Food categories are mutually exclusive.

In the following section, wherein food categories are broken down into smaller food groups, all food groups are mutually exclusive. For example, ‘white bread’ does not include bread in sandwiches but rather bread consumed as toast, for example.

Energy
Overall, only four main food groups contributed ≥5% to total energy intake: pasta, rice and other cereals[22] (8%), sandwiches (7%), white bread (5%), and biscuits (5%) (**Appendix 8**). These food groups remained top contributors among the majority of the population subgroups. Biscuits were a top contributor (≥5% to total intake) among several population subgroups, the highest among men aged 75+y (8%). Chicken dishes were also a top contributor (≥5% to total intake) among several population subgroups, the highest among men aged 16-24y (9%).

Protein
The top four main food groups contributing to protein intake were chicken dishes (11%), sandwiches (9%), pasta, rice and other cereals (7%) and beef dishes (6%) (**Appendix 8**), collectively contributing to almost one-third of protein intake. These food groups remained among the top contributors across all population subgroups. Further, semi-skimmed milk was a top contributor for those aged 65-74y (5%) and 75+y (6%), specifically women aged 65-74y (6%) and 75+y (7%). Cheese was a top contributor among women aged 16-24y (6%). White bread was a top contributor for those in SIMD 1 (most deprived; 6%) and aged 35-44y (6%), specifically women aged 35-44y (7%).

Calcium
Semi-skimmed milk (11%), sandwiches (8%), white bread (7%), cheese (7%) and pasta, rice and other cereals (6%) were the largest contributors to calcium intake (**Appendix 8**). Results were consistent across population subgroups. Individuals aged 16-24y and 75+y and SIMD 1 (most deprived) got a large proportion of their calcium from whole milk (7%, 6% and 7%, respectively) as well as semi-skimmed milk (11%, 17% and 10%, respectively). Yoghurt, fromage frais and dairy desserts was a top contributor among older women (6% among women aged 55-64y and 7% among women aged 65-75y and 75+y).

Iron
The largest contributor to iron consumption among all respondents was high-fibre breakfast cereals (9%), followed by sandwiches (7%), vegetables (7%), pasta, rice and other cereals (6%) and white bread (6%) (**Appendix 8**). These remained top contributors across population subgroups. However, contributions from pasta, rice and other cereals were lower among older age groups (2% among those aged 65-74y and 75+y). Chicken dishes were also a top contributor among several population subgroups, notably highest among men aged 16-24y (11%). Further, older age groups (both men and women) got a proportion of their iron from wholemeal bread (6% among those aged 55-64y, and 7% among those aged 65-74y and 75+y).

Iodine
Semi-skimmed milk was the largest contributor to iodine intake overall (14%), followed by eggs and egg dishes (7%), and other milk and cream (6%) (**Appendix 8**). This was the case for the majority of population subgroups. Whole milk was the largest contributor for women aged 16-24y (10%), while men aged 25-34y had equal contributions from pasta, rice and other cereals, and semi-skimmed milk (both 7%). Whole milk was the second largest contributor for those aged 16-24y (9%) and those in SIMD 1 (most deprived; 10%).

Selenium
Chicken dishes (11%), sandwiches (10%), pasta, rice and other cereals (9%) and eggs and egg dishes (9%), were the largest contributors to selenium intake among all respondents

[22] In this section, food groups that contain meat and/or dairy are bolded.

(**Appendix 8**). These food groups remained among the top contributors across population subgroups. However, the contribution from pasta, rice and other cereals was lower among older age groups (5% among individuals aged 65-74y and 3% among individuals aged 75+y). Other large contributors among subgroups were other white fish, shellfish and fish dishes (largest among men aged 75+y; 8%), beef dishes (largest among men aged 16-24y; 7%) and wholemeal bread (largest among individuals aged 75+y; 6%).

Zinc
The majority of the zinc obtained by survey respondents came from sandwiches (8%), beef dishes (8%) and pasta, rice and other cereals (8%) (**Appendix 8**). This was the case for the majority of the population subgroups. Chicken dishes were also a large contributor to zinc among men aged 16-24y (10%), and both men and women aged 25-34y (7% and 8%, respectively), while burgers and kebabs were a large contributor among those aged 16-24y (7%). Older age groups had higher contributions from high fibre breakfast cereals and wholemeal bread (all contributing 6% among those aged 65-74y and 75+y).

Vitamin B_{12}
The top contributors to vitamin B_{12} intake were semi-skimmed milk (14%), eggs and egg dishes (9%) and beef dishes (7%) (**Appendix 8**). This was broadly similar across population subgroups with some variations. Cheese and whole milk were the top contributors for women aged 16-24y (both 9%), while whole milk was also a top contributor among men 75+y (10%) and those in SIMD 1 (most deprived; 10%). Oily fish was a top contributor among older age groups (65-74y, 6%; and 75+y, 8%), and those in SIMD 5 (least deprived; 6%).

4.5.3. Nutrient intake in children and young people, and nutritional status in all age groups in the National Diet and Nutrition Survey

Data from NDNS for children and young people (recall that SHeS only has dietary intake for 16+y) shows that mean protein intake exceeds the RNI in all age and gender groups, by a margin ranging from 28% in adolescent boys 11-18y to 98% in boys 4-10y (**Table 6**).

Table 6. Average intake of protein (g/day) by gender and age group as compared to Reference Nutrition Intake (RNI) among children and young people in the UK.*

	Boys		Girls	
	4-10y	**11-18y**	**4-10y**	**11-18y**
Mean intake	55.9	70.6	49.9	58.0
RNI†	28.3	55.2	28.3	45.0
Unweighted base	372	337	353	346

* Data are from the National Diet and Nutrition Survey Years 9 to 11 combined (2016/17-2018/19) obtained from 4 days' non-weighed food diaries.
† If RNI values are given for several age bands, the higher is presented.

For micronutrients, the picture is more complex (**Table 7**). Girls and boys 11-18y were least likely to meet dietary requirements for calcium, iron, iodine, and zinc.[23]

Table 7. Percentage of participants by gender and age group in whom nutrient intake did not meet dietary requirements* among children and young people in the UK.†

	Boys		Girls	
Nutrient	**4-10y**	**11-18y**	**4-10y**	**11-18y**
Calcium	1%	14%	1%	16%
Iron	1%	11%	2%	**49%**
Iodine	6%	19%	8%	**28%**
Selenium	1%	**24%**	2%	**41%**
Zinc	8%	20%	15%	16%
Unweighted base	372	337	353	346

* Percentage below the Lower Reference Nutrition Intakes.
† Data are from the National Diet and Nutrition Survey Years 9 to 11 combined (2016/17-2018/19). Percentages that are above 20% are **bolded** and shaded in blue.

[23] Vitamin B_{12} not reported in NDNS Years 9-11 combined.

NDNS data show that children 4-10y in particular get a substantial proportion of their calcium and iodine from milk and milk products (**Error! Reference source not found.**).

Table 8. Percentage contribution of meat and meat products and milk and milk products to intake of nutrients of interest among children and young people in the UK.*

	Meat and Meat Products		Milk and Milk Products	
Nutrient	**4-10y**	**11-18y**	**4-10y**	**11-18y**
Protein	29%	37%	20%	13%
Calcium	6%	9%	**44%**	34%
Iron	14%	19%	3%	3%
Iodine	7%	11%	**51%**	40%
Selenium	27%	34%	11%	7%
Zinc	26%	33%	21%	15%
Unweighted base	725	683	725	683

* Data are from the National Diet and Nutrition Survey Years 9 to 11 combined (2016/17-2018/19). Percentages that are above 40% are bolded and shaded in blue.

An independent measure of micronutrient insufficiency is provided by blood or urine biomarkers. In NDNS, there is evidence of iron insufficiency in girls and women 19-64y, and of iodine insufficiency in boys and men 19-64y, and in girls and women of all ages (**Table 9**). In contrast, vitamin B_{12} insufficiency is less common, particularly in younger age groups.

Table 9. Percentage of participants by gender and age group who had biomarkers indicative of deficiency for nutrients of interest among children and adults in the UK.*

	Boys				Girls			
Nutrient	**4-10y**	**11-18y**	**19-64y**	**65+y**	**4-10y**	**11-18y**	**19-64y**	**65+y**
Iron (plasma ferritin <15µg/L)†	5%	6%	1%	0%	13%	17%	15%	3%
Urinary iodine <50 µg/L‡	8%	11%	15%	7%	15%	14%	19%	13%
Serum vitamin B_{12} <50 pmol/L	0%	1%	3%	5%	0%	2%	5%	4%
Unweighted base (ferritin and vitamin B_{12})	78	127	302	95	59	98	427	126
Unweighted base (iodine)	297	269	479	157	228	255	688	197

* Data are from the National Diet and Nutrition Survey Years 9 to 11 combined (2016/17-2018/19).
† <12 µg/L in 4y olds.
‡ The World Health Organisation recommends no more than 20% should be below 50µg/L.

4.5.4. High-risk groups

Other than the elevated risks of insufficiency of micronutrients mentioned above, particularly in adolescents and younger women, groups at risk of micronutrient insufficiency as a result of a reduction in meat and dairy consumption may be pregnant and lactating women. The RNI for protein increases by 6g/day in pregnancy and 11 and 8g/day in early and late lactation, respectively. The RNI for iron increases by 6.1g/day in women of childbearing age. There is no increase in the RNI for calcium, iron, iodine, selenium, zinc, or vitamin B_{12} during pregnancy. During lactation, the RNI for calcium, selenium, zinc, and vitamin B_{12} increases (Department of Health 1991) so some caution in reducing intake of meat and dairy foods or advice on nutrient-rich replacements at these times may be appropriate.

Other groups identified by SACN to be at increased risk of iron deficiency anaemia identified in its "Iron and Health" report were older adults in institutions (SACN 2010), households on low income and minority ethnic groups, though the dietary and haematological data for these groups were limited and in some cases are now over 20 years old. A more recent analysis of haematological data from adults 40-69y in the UK Biobank found that women from Asian backgrounds had lower haemoglobin and were more likely to be anaemic than their white counterparts (Tong et al. 2019). In the same population, the vegetarians were at greater risk of anaemia than regular meat-eaters, with the difference ranging from 1% of white British men to 5.9% of pre-menopausal Asian women.

Key Messages: **Nutrient Intake**

1. Across nearly all age and gender groups, more than 40% of the population have calcium, iron, iodine, zinc, and selenium intakes below the RNI.
2. While only 0-12% of the population had vitamin B_{12} intakes below the RNI, the RNI for vitamin B_{12} (1.5µg/day) is much lower than the more recent AI (4.0µg/day) and according to the AR cut-point method, more than 40% of the population also have insufficient intakes of vitamin B_{12}.
3. A wide range of food groups contribute to micronutrient intakes among adults (16+y) in Scotland.
4. Meat is an important source of selenium and average intake of selenium is below the RNI for all age and gender groups.
5. Dairy, particularly milk, is an important source of iodine, calcium, and vitamin B_{12}. While average intake of vitamin B_{12} is well above the RNI for all age and gender groups, it is below the AI, and calcium and iodine are a concern, especially for young people.
6. Meat and dairy are important sources of zinc, and men of all ages have average intakes of zinc below the RNI.
7. Boys and girls 11-18y are at higher risk of insufficiency for many nutrients compared to adults.
8. Women of reproductive age and pregnant and lactating women are potentially at risk of iron, selenium, calcium, and vitamin B_{12} insufficiency.

Thus, foods rich in selenium, calcium, iodine, and zinc (see **Section 5**, below) should be emphasised if meat and dairy are to be reduced.

5. Simulation Scenarios

Reminder that **"all meat"** refers to the following: beef, lamb, pork, other red meat, poultry, game birds, processed red meat, processed poultry, burgers, sausages, and offal.

"**Red and red processed meat**" refers to the following: beef, lamb, pork, other red meat, processed red meat, burgers, sausages, and offal.

Using the SHeS 2021 data, we first simulated the CCC recommendations of a 20% reduction in all meat and dairy, and a 35% reduction in all meat and 20% reduction in all dairy. We did not replace either meat or dairy in these scenarios as the CCC recommendations do not currently state what, if anything, meat and dairy should be replaced with.

While the CCC recommendation specifies "all meat," a Scottish Dietary Goal for reducing red and red processed meat consumption to 70g/day has already been established on the basis of the SACN "Iron and Health" report. Moreover, as described in **Section 3.1**, red and red processed meat consumption of people in the UK has been slowly reducing over the past ~15 years. We therefore explored how reducing red and red processed meat consumption among high consumers would affect population average "all meat" intake as defined by the CCC. We found the following:

- Reducing everyone to 70g/day red and red processed meat resulted in a **16% reduction** in population mean "all meat" intake.[24]
    - This reduction would apply to 28% of the population.
- Reducing everyone to 60g/day red and red processed meat resulted in a **20% reduction** in population mean "all meat" intake.
    - This reduction would apply to 32% of the population.
- Reducing everyone to 31g/day red and red processed meat resulted in a **35% reduction** in population mean "all meat" intake.
    - This reduction would apply to 54% of the population.

With regards to dairy, there is no recommended intake level.

We therefore developed simulation scenarios based on reducing high consumers of red and red processed meat to 70g/day (the current Scottish Dietary Goal), 60g/day (which would achieve the CCC recommended 20% reduction in all meat), and 31g/day (which would achieve the CCC recommended 35% reduction in all meat), combined with a 20% reduction in dairy in all dairy consumers.

We modelled replacement of red and red processed meat with foods rich in nutrients of concern (**Table 10**).

Finally, given evidence that as consumption of red meat has declined in the UK, consumption of white meat has increased (see **Section 3.1**), we simulated the impact of replacing red and red processed meat with chicken.

[24] In all scenarios where red and red processed meat was reduced to a maximum level (70, 60, or 31g/day), those below the maximum level did not have their consumption levels increased to the maximum level.

Table 10. Nutrient-rich foods for guidance on substitutions for red and red processed meat (British Nutrition Foundation 2021b; 2021a).

Nutrient	Non-meat foods for potential substitution
Iron	Beans, pulses, nuts and seeds, fish (such as canned sardines and mussels), quinoa, wholemeal bread, and dried fruit.
Zinc	Some shellfish (such as crab, cockles, and mussels), nuts and seeds (such as pumpkin seeds and pine nuts), wholegrain breakfast cereals, and wholegrain and seeded breads.
Calcium	Some green leafy vegetables (such as kale), calcium fortified plant-based dairy alternatives, canned fish (where soft bones are eaten), and breads (white, brown, and wholegrain).
Selenium	Some nuts and seeds (such as Brazil nuts, cashews, and sunflower seeds), eggs, and fish and shellfish.
Iodine	Some fish (such as cod, mackerel, and haddock), some shellfish (such as crab and mussels), eggs, and some fortified plant-based dairy alternatives.

All dairy products were reduced by 20%. However, only milk, yoghurt, and butter were replaced (not cheese or cream). Milk was replaced with plant-based milk drinks,[25] yoghurt with plant-based yogurt,[26] and butter with plant-based solid fats.[27] We did not replace cheese or cream as plant-based replacements for these products are not widely available in Scotland.

All replacements were gram-for-gram replacements, which means that calories were not held constant. This was thought to be a more realistic behaviour change than calorie-for-calorie replacement.

Nutrient values for replacement foods for meat were taken from the UK Nutrient Databank. For each replacement food, a single composite nutrient value was derived, weighted based on frequency of reported intake of foods in this food group in SHeS (2021). For example, for the replacement "pulses and legumes," 32% of the nutrients were based on the nutrients in baked beans, 26% lentil soup, 12% houmous, 3% reduced fat houmous, 2% lentil dahl, 2% falafel, 2% canned chickpeas, 2% lentils, 2% canned kidney beans, 2% lentil curry with tomatoes, 1% reduced sugar baked beans, 1% vegetable curry with chickpeas, 1% soya beans, 1% cannellini beans, and 1% chickpeas. See **Appendix 9** for details. Using the nutrients from as-consumed products such as baked beans was thought to be a more realistic behaviour change than only replacing with the nutrients in pulses and legumes alone.

We simulated 23 scenarios (**Table 11**). Simulations could only be conducted for adults (16+y) living in Scotland at this time as dietary intake data on younger people living in Scotland are not currently available. An overview of the modelling methodology is provided in **Appendix 9**.

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[25] Specifically, a weighted (based on frequency of reported intake in SHeS 2021) composite of oat milk (49%), almond milk / hazelnut milk (21%), unsweetened soya milk (14%), sweetened soya milk (10%), fresh coconut milk (3%), light soya milk (2%), and rice milk (1%).
[26] Specifically, 'Soya yoghurt, plain'.
[27] Specifically, 'Vitalite Dairy free spread/margarine' (34%), 'Hard spread/margarine (e.g., Stork, Willow)' (29%), 'Pure dairy-free soya spread/margarine' (26%), and 'Flora pro activ buttery spread' (11%).

Table 11. Summary of simulation scenarios for reducing meat and dairy among adults (16+y) living in Scotland. Changes between sequential scenarios are bolded.

No.	Change in meat and dairy	Replacement
CCC20	20% reduction in grams of all meat	None
	20% reduction in grams of dairy	None
CCC35	**35%** reduction in grams of all meat	None
	20% reduction in grams of dairy	None
1	Reducing high consumers of **red and red processed meat** to **70g/day** (16% reduction in all meat)	None
	20% reduction in grams of dairy	None
2	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	None
	20% reduction in grams of dairy	None
3	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	None
	20% reduction in grams of dairy	None
4	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	**Pulses and legumes**
	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
5	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Pulses and legumes
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
6	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Pulses and legumes
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
7	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	**Vegetables**
	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
8	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Vegetables

	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
9	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Vegetables
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
10	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	**Egg**
	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
11	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Egg
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
12	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Egg
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
13	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	**Oily fish**
	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
14	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Oily fish
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
15	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Oily fish
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
16	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	**Plant-based meat alternatives**

	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
17	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Plant-based meat alternatives
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
18	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Plant-based meat alternatives
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
19	Reducing high consumers of red and red processed meat to 70g/day (16% reduction in all meat)	Roast/grilled chicken breast (skin not eaten)
	20% reduction in grams of dairy	**Plant-based milk drinks, plant-based yoghurt, plant-based solid fats**
20	Reducing high consumers of red and red processed meat to **60g/day** (20% reduction in all meat)	Roast/grilled chicken breast (skin not eaten)
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats
21	Reducing high consumers of red and red processed meat to **31g/day** (35% reduction in all meat)	Roast/grilled chicken breast (skin not eaten)
	20% reduction in grams of dairy	Plant-based milk drinks, plant-based yoghurt, plant-based solid fats

Key Messages: **Simulation Scenarios**

1. If all adults (16+y) living in Scotland met the Scottish Dietary Goal for red and processed red meat (70g/day), it would result in a **16% reduction** in the population average "all meat" intake as defined by the CCC. This would affect 28% of the population.
2. In order to achieve a **20% reduction** in the population average "all meat" intake, all adults (16+y) 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.
3. In order to achieve a **35% reduction** in the population mean total meat consumption, all adults (16+y) 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.
4. In addition to the CCC recommendations, we simulated the above reductions in red and red processed meat among high consumers, along with a 20% reduction in dairy, and no replacement or replacement of the dairy with plant-based milk drinks, plant-based yogurt, and plant-based solid fats, and the replacement of meat with one of the following: pulses and legumes, vegetables, egg, oily fish, plant-based meat alternatives, or chicken. This resulted in 23 simulation scenarios.

6. Simulation Results: Nutrient Intake

6.1. Climate Change Committee recommendations scenarios

Under the CCC recommendations of a 20% reduction in all meat and dairy, and a 35% reduction in all meat and 20% reduction in all dairy, with no replacement:

- Consistent with current intakes:
  - Average intakes of calcium for women and men of all ages remained well above the LRNI (**Table 12** for women and **Table 13** for men).
  - Average intakes of iron for women and men of all ages except women 16-24y remained above the LRNI and AR.
  - Average intakes of iodine for women and men of all ages remained below the AI but above the LRNI (exception: men 35-44y and 75+y where intakes were also above the AI).
  - Average intakes of selenium for women and men of all ages remained below both the LRNI, AI, and RNI.
  - Average intakes of zinc for women and men of all ages remained below the AR and RNI but above the LRNI.
  - Average intakes of vitamin B_{12} for women and men of all ages remained well above the LRNI and RNI.
- However, a worsening of average intake relative to the AR and RNI occurred for calcium for most women.
- Average intakes of all nutrients decreased slightly from CCC20 to CCC35.

The proportions below the LRNI, AR/AI, and RNI increased slightly from CCC20 (**Table 14**) to CCC35 (**Table 15**). Relative to current intakes, overall:

- The percentage of the population below the RNI for calcium increased by 8 percentage points in both scenarios (from 46% to 54% of the population).
- The percentage of the population below the RNI for iron increased by 2 percentage points in the CCC20 scenario (from 58% to 60% of the population) and by 3 percentage points in the CCC35 scenario (from 58% to 61% of the population).
- The percentage of the population below the RNI for iodine increased by 9 percentage points in the CCC20 scenario (from 56% to 65% of the population) and by 10 percentage points in the CCC35 scenario (from 56% to 66% of the population).
- The percentage of the population below the RNI for selenium increased by 2 percentage points in the CCC20 scenario (from 90% to 92% of the population) and by 3 percentage points in the CCC35 scenario (from 90% to 93% of the population).
- The percentage of the population below the RNI for zinc increased by 9 percentage points in the CCC20 scenario (from 62% to 71% of the population) and by 12 percentage points in the CCC35 scenario (from 62% to 74% of the population).
- The percentage of the population below the RNI for vitamin B_{12} increased by 3 percentage points in the CCC20 scenario (from 8% to 11% of the population) and by 4 percentage points in the CCC35 scenario (from 8% to 12% of the population).

Tables with the population mean nutrient intake and percentages of the population meeting the Scottish Dietary Goals, overall and by population subgroup, are provided for the CCC20 and CCC35 scenarios in **Appendix 10**.

Table 12. Weighted mean daily nutrient intakes as compared to UK Lower Reference Nutrient Intakes (LRNIs), EFSA Average Requirement (AR) / Adequate Intake (AI), and UK Reference Nutrient Intakes (RNIs) among adult **women** (16+y) living in Scotland under scenarios in which intake of all meat is reduced by 20% and dairy is reduced by 20% (CCC20) and in which intake of all meat is reduced by 35% and dairy is reduced by 20% (CCC35), with no replacement of meat or dairy in either scenario.*

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Calcium (mg/day)	CCC20	**638**	**681**	731	**676**	**657**	**684**	**673**
	CCC35	**636**	**679**	729	**675**	**655**	**683**	**671**
	LRNI	450	400	400	400	400	400	400
	AR	960	750	750	750	750	750	750
	RNI	800	700	700	700	700	700	700
Iron (mg/day)	CCC20	**7.4**	**8.5**	**9.0**	**8.9**	**8.6**	**8.4**	9.2
	CCC35	**7.3**	**8.3**	**8.8**	**8.8**	**8.5**	**8.3**	9.1
	LRNI	8.0	8.0	8.0	8.0	4.7	4.7	4.7
	AR	7	7	7	7	7	7	7
	RNI	14.8	14.8	14.8	14.8	8.7	8.7	8.7
Iodine (µg/day)	CCC20	**95**	**99**	**118**	**120**	**125**	142	**133**
	CCC35	**94**	**98**	**117**	**119**	**125**	142	**132**
	LRNI	70	70	70	70	70	70	70
	AI	130	150	150	150	150	150	150
	RNI	140	140	140	140	140	140	140
Selenium (µg/day)	CCC20	**31**	**33**	**37**	**36**	**36**	**35**	**36**
	CCC35	**30**	**31**	**35**	**34**	**35**	**34**	**35**
	LRNI	40	40	40	40	40	40	40
	AI	70	70	70	70	70	70	70
	RNI	60	60	60	60	60	60	60
Zinc (mg/day)	CCC20	**6.4**	**6.2**	**6.9**	**6.4**	**6.3**	**6.6**	**6.6**
	CCC35	**6.2**	**6.0**	**6.6**	**6.2**	**6.1**	**6.3**	**6.4**
	LRNI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	AR	9.9	8.9	8.9	8.9	8.9	8.9	8.9
	RNI	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Vitamin B_{12} (µg/day)	CCC20	2.9	3.3	3.5	3.4	3.7	4.0	4.1
	CCC35	2.8	3.2	3.4	3.3	3.6	3.9	4.0
	LRNI	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	AI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	RNI	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* The AR/AI for 15-17y is shown for the age group 16-24y. Average intakes that are below the RNI are **bolded** and shaded in blue.

Table 13. Weighted mean daily nutrient intakes as compared to UK Lower Reference Nutrient Intakes (LRNIs), EFSA Average Requirement (AR) / Adequate Intake (AI), and UK Reference Nutrient Intakes (RNIs) among adult **men** (16+y) living in Scotland under scenarios in which intake of all meat is reduced by 20% and dairy is reduced by 20% (CCC20) and in which intake of all meat is reduced by 35% and dairy is reduced by 20% (CCC35), with no replacement of meat or dairy in either scenario.*

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Calcium (mg/day)	CCC20	**699**	706	844	780	778	765	730
	CCC35	**696**	703	841	777	776	763	728
	LRNI	480	400	400	400	400	400	400
	AR	960	750	750	750	750	750	750
	RNI	1000	700	700	700	700	700	700
Iron (mg/day)	CCC20	**10.2**	9.5	10.9	9.9	10.4	9.9	9.8
	CCC35	**10.1**	9.4	10.7	9.8	10.3	9.7	9.6
	LRNI	6.1	4.7	4.7	4.7	4.7	4.7	4.7
	AR	8	6	6	6	6	6	6
	RNI	11.3	8.7	8.7	8.7	8.7	8.7	8.7
Iodine (µg/day)	CCC20	**125**	**118**	153	141	148	150	173
	CCC35	**123**	**116**	151	140	147	149	172
	LRNI	70	70	70	70	70	70	70
	AI	130	150	150	150	150	150	150
	RNI	140	140	140	140	140	140	140
Selenium (µg/day)	CCC20	**42**	**41**	**47**	**43**	**43**	**42**	**44**
	CCC35	**39**	**39**	**45**	**41**	**42**	**40**	**43**
	LRNI	40	40	40	40	40	40	40
	AI	70	70	70	70	70	70	70
	RNI	70	75	75	75	75	75	75
Zinc (mg/day)	CCC20	**7.7**	**7.2**	**8.2**	**7.6**	**7.5**	**7.4**	**7.1**
	CCC35	**7.3**	**6.9**	**7.8**	**7.3**	**7.2**	**7.1**	**6.8**
	LRNI	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	AR	11.8	11.0	11.0	11.0	11.0	11.0	11.0
	RNI	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Vitamin B_{12} (µg/day)	CCC20	4.0	4.1	4.4	4.1	4.3	4.7	5.4
	CCC35	3.9	3.9	4.3	4.0	4.1	4.5	5.2
	LRNI	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	AI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	RNI	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* The AR/AI for 15-17y is shown for the age group 16-24y. Average intakes that are below the RNI are **bolded** and shaded in blue.

Table 14. Weighted percentage of participants in whom nutrient intake did not meet dietary requirements among adults (16+y) living in Scotland under scenarios in which intake of all meat is reduced by 20% and dairy is reduced by 20% (CCC20), with no replacement of meat or dairy, by age group (y).*

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Below UK Lower Reference Nutrition Intakes (LRNI)								
Calcium (mg/day)	Women	**21%**	20%	15%	19%	18%	15%	20%
	Men	**29%**	14%	11%	16%	14%	9%	11%
Iron (mg/day)	Women	**61%**	**51%**	**44%**	**28%**	8%	10%	4%
	Men	**26%**	8%	5%	9%	7%	6%	7%
Iodine (µg/day)	Women	**29%**	**31%**	**27%**	**23%**	18%	12%	10%
	Men	**29%**	**28%**	12%	20%	15%	8%	6%
Selenium (µg/day)	Women	**73%**	**74%**	**63%**	**70%**	**66%**	**67%**	**66%**
	Men	**57%**	**56%**	**46%**	**52%**	**51%**	**56%**	**58%**
Zinc (mg/day)	Women	16%	13%	15%	17%	14%	15%	15%
	Men	**31%**	**31%**	**23%**	**24%**	**26%**	**24%**	**27%**
Vitamin B_{12} (µg/day)	Women	8%	7%	8%	6%	7%	2%	0%
	Men	5%	7%	4%	2%	5%	2%	0%
Below EFSA Average Requirements (AR) / Adequate Intakes (AI)								
Calcium (mg/day)	Women	**77%**	**66%**	**60%**	**67%**	**67%**	**62%**	**66%**
	Men	**76%**	**60%**	**43%**	**51%**	**52%**	**54%**	**60%**
Iron (mg/day)	Women	**51%**	39%	33%	34%	34%	38%	30%
	Men	30%	16%	12%	14%	15%	12%	11%
Iodine (µg/day)	Women	**85%**	**85%**	**73%**	**78%**	**72%**	**61%**	**69%**
	Men	**73%**	**77%**	**64%**	**61%**	**59%**	**63%**	**59%**
Selenium (µg/day)	Women	**99%**	**97%**	**93%**	**95%**	**93%**	**97%**	**95%**
	Men	**92%**	**88%**	**86%**	**90%**	**89%**	**89%**	**90%**
Zinc (mg/day)	Women	**84%**	**87%**	**82%**	**86%**	**86%**	**83%**	**83%**
	Men	**82%**	**86%**	**86%**	**86%**	**88%**	**89%**	**96%**
Vitamin B_{12} (µg/day)	Women	**76%**	**78%**	**65%**	**73%**	**61%**	**61%**	**58%**
	Men	**64%**	**62%**	**55%**	**58%**	**53%**	**48%**	40%
Below UK Reference Nutrient Intakes (RNIs)								
Calcium (mg/day)	Women	**70%**	**61%**	**53%**	**59%**	**60%**	**57%**	**57%**
	Men	**67%**	**56%**	36%	**48%**	**47%**	**44%**	**49%**
Iron (mg/day)	Women	**97%**	**93%**	**94%**	**76%**	**60%**	**59%**	**53%**
	Men	**57%**	**51%**	35%	39%	**41%**	36%	38%
Iodine (µg/day)	Women	**82%**	**80%**	**69%**	**73%**	**63%**	**57%**	**64%**
	Men	**67%**	**76%**	**58%**	**57%**	**56%**	**56%**	**49%**
Selenium (µg/day)	Women	**99%**	**95%**	**88%**	**90%**	**89%**	**94%**	**93%**
	Men	**97%**	**89%**	**89%**	**93%**	**93%**	**94%**	**92%**
Zinc (mg/day)	Women	**68%**	**71%**	**62%**	**63%**	**67%**	**65%**	**59%**
	Men	**77%**	**80%**	**68%**	**77%**	**79%**	**82%**	**89%**
Vitamin B_{12} (µg/day)	Women	15%	18%	16%	16%	12%	8%	4%
	Men	12%	16%	8%	10%	8%	5%	1%

* Percentages that are above 20% for the LRNI and 40% for the AR/AI and RNI are **bolded** and shaded in blue.

Table 15. Weighted percentage of participants in whom nutrient intake did not meet dietary requirements among adults (16+y) living in Scotland under scenarios in which intake of all meat is reduced by 35% and dairy is reduced by 20% (CCC35), with no replacement of meat or dairy, by age group (y).*

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Below UK Lower Reference Nutrition Intakes (LRNI)								
Calcium (mg/day)	Women	**21%**	**21%**	15%	19%	18%	15%	20%
	Men	**29%**	16%	11%	16%	14%	9%	11%
Iron (mg/day)	Women	**62%**	**53%**	**45%**	**28%**	8%	10%	4%
	Men	**26%**	10%	6%	9%	8%	6%	7%
Iodine (µg/day)	Women	**31%**	**32%**	**27%**	**23%**	19%	13%	10%
	Men	**30%**	**28%**	13%	20%	16%	8%	6%
Selenium (µg/day)	Women	**81%**	**77%**	**66%**	**72%**	**69%**	**69%**	**68%**
	Men	**59%**	**57%**	**51%**	**55%**	**55%**	**61%**	**59%**
Zinc (mg/day)	Women	17%	16%	16%	17%	15%	18%	18%
	Men	**32%**	**36%**	**24%**	**28%**	**29%**	**28%**	**29%**
Vitamin B_{12} (µg/day)	Women	8%	7%	9%	7%	7%	2%	1%
	Men	5%	7%	5%	3%	5%	3%	0%
Below EFSA Average Requirements (AR) / Adequate Intakes (AI)								
Calcium (mg/day)	Women	**77%**	**67%**	**60%**	**67%**	**67%**	**63%**	**67%**
	Men	**76%**	**60%**	**43%**	**52%**	**53%**	**55%**	**60%**
Iron (mg/day)	Women	**53%**	**42%**	33%	35%	37%	39%	30%
	Men	30%	17%	14%	15%	15%	13%	12%
Iodine (µg/day)	Women	**85%**	**85%**	**73%**	**79%**	**72%**	**61%**	**69%**
	Men	**73%**	**77%**	**65%**	**63%**	**60%**	**64%**	**59%**
Selenium (µg/day)	Women	**99%**	**97%**	**94%**	**95%**	**93%**	**97%**	**96%**
	Men	**97%**	**91%**	**87%**	**93%**	**91%**	**90%**	**92%**
Zinc (mg/day)	Women	**86%**	**88%**	**83%**	**90%**	**88%**	**86%**	**86%**
	Men	**87%**	**90%**	**90%**	**93%**	**89%**	**92%**	**97%**
Vitamin B_{12} (µg/day)	Women	**81%**	**78%**	**66%**	**75%**	**62%**	**62%**	**60%**
	Men	**67%**	**66%**	**58%**	**59%**	**55%**	**51%**	**42%**
Below UK Reference Nutrient Intakes (RNIs)								
Calcium (mg/day)	Women	**70%**	**61%**	**53%**	**59%**	**60%**	**57%**	**57%**
	Men	**67%**	**56%**	36%	**48%**	**47%**	**44%**	**49%**
Iron (mg/day)	Women	**97%**	**93%**	**94%**	**77%**	**60%**	**60%**	**55%**
	Men	**58%**	**51%**	35%	**44%**	**42%**	36%	39%
Iodine (µg/day)	Women	**82%**	**81%**	**69%**	**73%**	**64%**	**58%**	**64%**
	Men	**67%**	**76%**	**59%**	**57%**	**57%**	**56%**	**49%**
Selenium (µg/day)	Women	**99%**	**96%**	**90%**	**91%**	**90%**	**94%**	**93%**
	Men	**97%**	**95%**	**92%**	**93%**	**94%**	**94%**	**92%**
Zinc (mg/day)	Women	**72%**	**73%**	**65%**	**66%**	**71%**	**69%**	**60%**
	Men	**80%**	**82%**	**75%**	**80%**	**82%**	**83%**	**91%**
Vitamin B_{12} (µg/day)	Women	15%	20%	16%	16%	14%	9%	4%
	Men	12%	20%	11%	10%	9%	7%	2%

* Percentages that are above 20% for the LRNI and 40% for the AR/AI and RNI are **bolded** and shaded in blue.

6.2. Red and red processed meat and dairy scenarios

Under the most useful scenario to demonstrate both the achievement of the public health goal for red and red processed meat, which is the worst-case scenario of no replacement (everyone meeting the Scottish Dietary Goal for red and red processed meat of limiting intake to 70g/day and 20% reduction in dairy, with no replacement for either – Scenario 1 in **Table 11**):

- Both women and men remained well above the RNI for vitamin B_{12} (**Table 16** for women and **Table 17** for men).
- Average intake for both women and men, of all ages, was below the RNI for selenium and zinc.
- Average intake for both women and men 16-34y was below the RNI for calcium and iodine, and further for all women older than 34y (for calcium and iodine except women 65-74y for iodine) and men 45-54 (for iodine only).
- Average intake for both women and men 16-24y was below the RNI for iron and further for women 24-74y.

With regards to the percentage of the population below dietary requirements (**Table 18**), relative to current intakes, if there is no replacement of red and red processed meat or dairy, the change in the proportion of the population falling below the RNI will be:

- 8 percentage points higher for calcium; from 46 to 54% of the population
- 2 percentage points higher for iron; from 58 to 60% of the population
- 9 percentage points higher for iodine; increasing from 56 to 65% of the population
- 1 percentage points higher for selenium; from 90 to 91% of the population
- 9 percentage points higher for zinc; from 62 to 71% of the population
- 2 percentage points higher for vitamin B_{12}; from 8 to 10% of the population

Table 16. Weighted mean daily nutrient intakes as compared to UK Lower Reference Nutrient Intakes (LRNIs), EFSA Average Requirement (AR) / Adequate Intake (AI), and UK Reference Nutrient Intakes (RNIs) among adult **women** (16+y) living in Scotland under a scenario in which intake of red and red processed meat is reduced to 70g/day and dairy is reduced by 20%, with no replacement, by age group (y).*

		16-24	25-34	35-44	45-54	55-64	65-74	75+
Calcium (mg/day)	Mean	**639**	**682**	**730**	**677**	**657**	**684**	**674**
	LRNI	450	400	400	400	400	400	400
	AR	860	750	750	750	750	750	750
	RNI	800	700	700	700	700	700	700
Iron (mg/day)	Mean	**7.5**	**8.5**	**8.9**	**9.0**	**8.6**	**8.4**	9.3
	LRNI	8.0	8.0	8.0	8.0	4.7	4.7	4.7
	AR	7	7	7	7	7	7	7
	RNI	14.8	14.8	14.8	14.8	8.7	8.7	8.7
Iodine (µg/day)	Mean	**95**	**99**	**118**	**120**	**126**	142	**133**
	LRNI	70	70	70	70	70	70	70
	AI	150	150	150	150	150	150	150
	RNI	140	140	140	140	140	140	140
Selenium (µg/day)	Mean	**32**	**34**	**37**	**36**	**37**	**36**	**37**
	LRNI	40	40	40	40	40	40	40
	AI	70	70	70	70	70	70	70
	RNI	60	60	60	60	60	60	60
Zinc (mg/day)	Mean	**6.5**	**6.4**	**6.8**	**6.5**	**6.3**	**6.6**	**6.8**
	LRNI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	AR	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	RNI	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Vitamin B_{12} (µg/day)	Mean	2.9	3.3	3.5	3.5	3.7	4.0	4.1
	LRNI	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	AI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	RNI	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* Average intakes that are below the RNI are **bolded** and shaded in blue.

Table 17. Weighted mean daily nutrient intakes as compared to UK Lower Reference Nutrient Intakes (LRNIs), EFSA Average Requirement (AR) / Adequate Intake (AI), and UK Reference Nutrient Intakes (RNIs) among adult **men** (16+y) living in Scotland under a scenario in which intake of red and red processed meat is reduced to 70g/day and dairy is reduced by 20%, with no replacement, by age group (y).*

		16-24	25-34	35-44	45-54	55-64	65-74	75+
Calcium (mg/day)	Mean	**699**	706	843	778	777	764	730
	LRNI	480	400	400	400	400	400	400
	AR	860	750	750	750	750	750	750
	RNI	1000	700	700	700	700	700	700
Iron (mg/day)	Mean	**10.2**	9.5	10.9	9.9	10.4	9.9	9.8
	LRNI	6.1	4.7	4.7	4.7	4.7	4.7	4.7
	AR	6	6	6	6	6	6	6
	RNI	11.3	8.7	8.7	8.7	8.7	8.7	8.7
Iodine (µg/day)	Mean	**125**	**118**	153	**141**	148	150	173
	LRNI	70	70	70	70	70	70	70
	AI	150	150	150	150	150	150	150
	RNI	140	140	140	140	140	140	140
Selenium (µg/day)	Mean	**42**	**42**	**48**	**43**	**44**	**42**	**45**
	LRNI	40	40	40	40	40	40	40
	AI	70	70	70	70	70	70	70
	RNI	70	75	75	75	75	75	75
Zinc (mg/day)	Mean	**7.6**	**7.1**	**8.2**	**7.5**	**7.4**	**7.3**	**7.1**
	LRNI	5.5	5.5	5.5	5.5	5.5	5.5	5.5
	AR	11.8	11.0	11.0	11.0	11.0	11.0	11.0
	RNI	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Vitamin B_{12} (µg/day)	Mean	3.9	4.1	4.4	4.0	4.2	4.7	5.3
	LRNI	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	AI	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	RNI	1.5	1.5	1.5	1.5	1.5	1.5	1.5

* Average intakes that are below the RNI are **bolded** and shaded in blue.

Table 18. Weighted percentage of participants in whom nutrient intake did not meet dietary requirements among adults (16+y) living in Scotland under a scenario in which intake of red and red processed meat is reduced to 70g/day and dairy is reduced by 20%, with no replacement, by age group (y).*

	Age (y)	16-24	25-34	35-44	45-54	55-64	65-74	75+
Below UK Lower Reference Nutrition Intakes (LRNI)								
Calcium (mg/day)	Women	**21%**	19%	15%	19%	17%	15%	20%
	Men	**29%**	14%	12%	16%	14%	9%	11%
Iron (mg/day)	Women	**60%**	**49%**	**44%**	**28%**	8%	9%	4%
	Men	**26%**	8%	6%	9%	7%	5%	6%
Iodine (µg/day)	Women	**28%**	**31%**	**26%**	**23%**	19%	12%	10%
	Men	**30%**	**28%**	13%	20%	16%	8%	6%
Selenium (µg/day)	Women	**73%**	**69%**	**60%**	**66%**	**66%**	**65%**	**64%**
	Men	**60%**	**54%**	**46%**	**52%**	**52%**	**54%**	**58%**
Zinc (mg/day)	Women	13%	12%	14%	16%	13%	14%	12%
	Men	**24%**	**28%**	**23%**	**24%**	**24%**	**23%**	**24%**
Vitamin B_{12} (µg/day)	Women	8%	6%	8%	7%	5%	2%	0%
	Men	5%	7%	4%	2%	5%	2%	0%
Below EFSA Average Requirements (AR) / Adequate Intakes (AI)								
Calcium (mg/day)	Women	**77%**	**67%**	**59%**	**67%**	**67%**	**63%**	**66%**
	Men	**76%**	**60%**	**43%**	**52%**	**52%**	**55%**	**60%**
Iron (mg/day)	Women	**45%**	40%	32%	34%	32%	38%	29%
	Men	30%	15%	12%	14%	14%	12%	11%
Iodine (µg/day)	Women	**85%**	**83%**	**73%**	**78%**	**71%**	**61%**	**68%**
	Men	**75%**	**77%**	**63%**	**61%**	**59%**	**63%**	**58%**
Selenium (µg/day)	Women	**99%**	**97%**	**94%**	**94%**	**93%**	**96%**	**95%**
	Men	**92%**	**88%**	**86%**	**88%**	**89%**	**89%**	**91%**
Zinc (mg/day)	Women	**85%**	**86%**	**80%**	**85%**	**87%**	**82%**	**80%**
	Men	**88%**	**89%**	**88%**	**92%**	**89%**	**90%**	**96%**
Vitamin B_{12} (µg/day)	Women	**75%**	**77%**	**66%**	**72%**	**60%**	**60%**	**58%**
	Men	**68%**	**65%**	**57%**	**59%**	**56%**	**48%**	**41%**
Below UK Reference Nutrient Intakes (RNIs)								
Calcium (mg/day)	Women	**70%**	**61%**	**53%**	**59%**	**59%**	**57%**	**57%**
	Men	**67%**	**56%**	37%	**48%**	**47%**	**45%**	**50%**
Iron (mg/day)	Women	**97%**	**94%**	**94%**	**76%**	**60%**	**60%**	**48%**
	Men	**58%**	**52%**	37%	**41%**	**42%**	35%	40%
Iodine (µg/day)	Women	**82%**	**80%**	**69%**	**72%**	**63%**	**57%**	**64%**
	Men	**67%**	**74%**	**59%**	**56%**	**56%**	**56%**	**48%**
Selenium (µg/day)	Women	**95%**	**93%**	**89%**	**89%**	**89%**	**93%**	**91%**
	Men	**92%**	**90%**	**89%**	**91%**	**93%**	**93%**	**92%**
Zinc (mg/day)	Women	**66%**	**68%**	**62%**	**59%**	**66%**	**64%**	**56%**
	Men	**82%**	**82%**	**66%**	**76%**	**83%**	**82%**	**90%**
Vitamin B_{12} (µg/day)	Women	13%	16%	15%	16%	12%	8%	4%
	Men	6%	19%	7%	8%	7%	6%	1%

* Percentages that are above 20% for the LRNI and 40% for the AR/AI and RNI are **bolded** and shaded in blue.

Tables with the population mean nutrient intake, overall and by population subgroup, are provided for 21 red and red processed meat and dairy scenarios (Scenarios 1 to 21 in **Table 11**) in **Appendix 11** (absolute values), **Appendix 12** (change as compared to current intakes), and **Appendix 13** (percent change as compared to current intakes).

Details of how the 21 red and red processed meat and dairy scenarios affected each nutrient and variation across population subgroups are described in the sections that follow. Across all scenarios and all nutrients evaluated, the direction of change (increase versus decrease) for nutrient intake was consistent for men and women, across age groups, across BMI groups, and across SIMD quintiles. However, the magnitude of change was bigger for men. This was largely driven by differences in baseline meat and dairy consumption.

Energy intake decreased across all scenarios (**Figure 12**). The average decrease ranged from **111kcal/d** (~7% of baseline energy intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to **3kcal/d** (<1% of baseline energy intake) when red and red processed meat was replaced with oily fish.

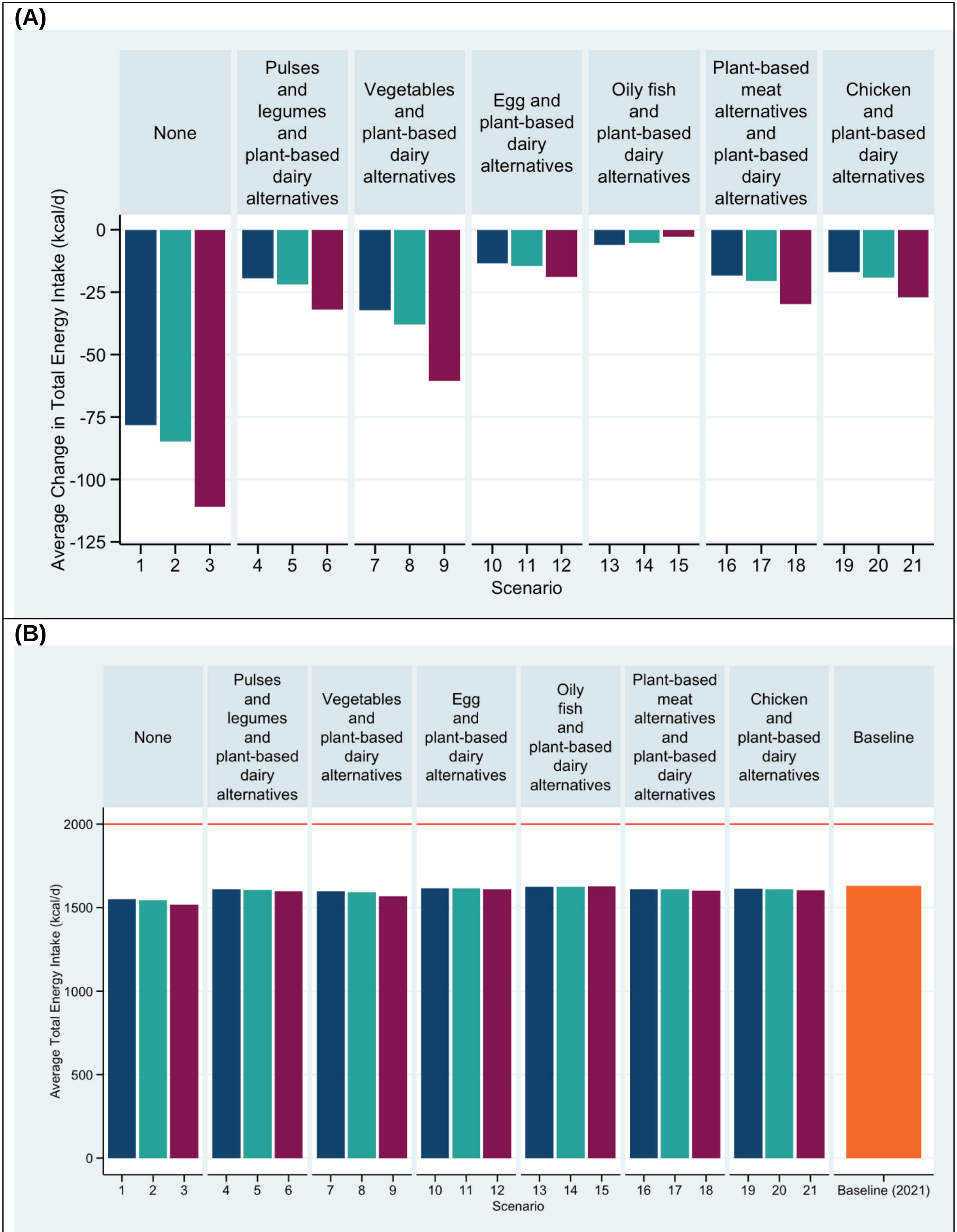


Figure 12. Average change (A) and average (B) energy intake (kcal/d) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The red line in (B) represents the EAR for adult women.

Protein intake decreased across all scenarios except when red and red processed meat was replaced with chicken (**Figure 13, panel A**), but average intake remained above the highest RNI of any gender/age group (**panel B**). The average change ranged from a **decrease of 9g/day** (~7% of baseline protein intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 1g/day** (~1% of baseline protein intake) when red and red processed meat was replaced with chicken.

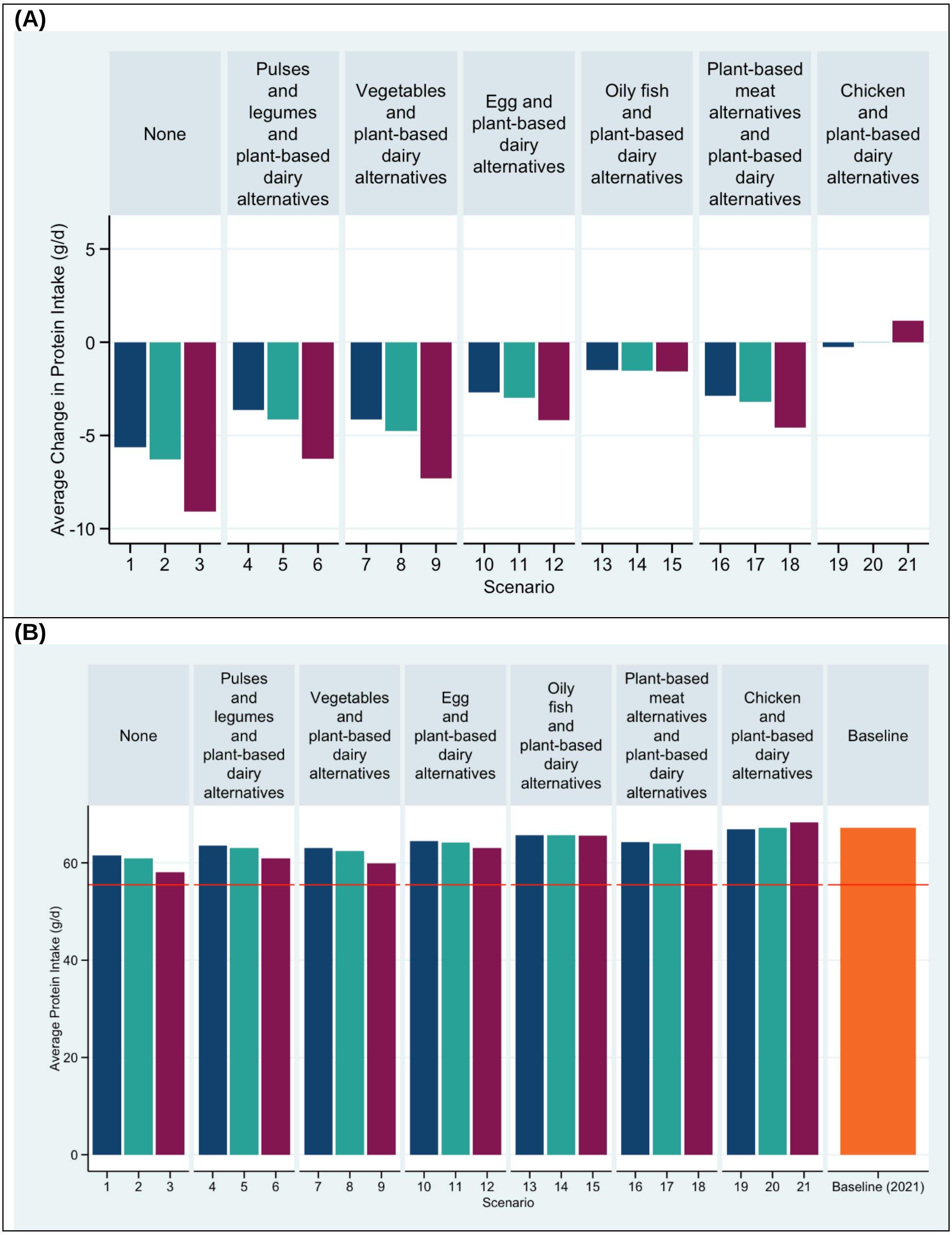
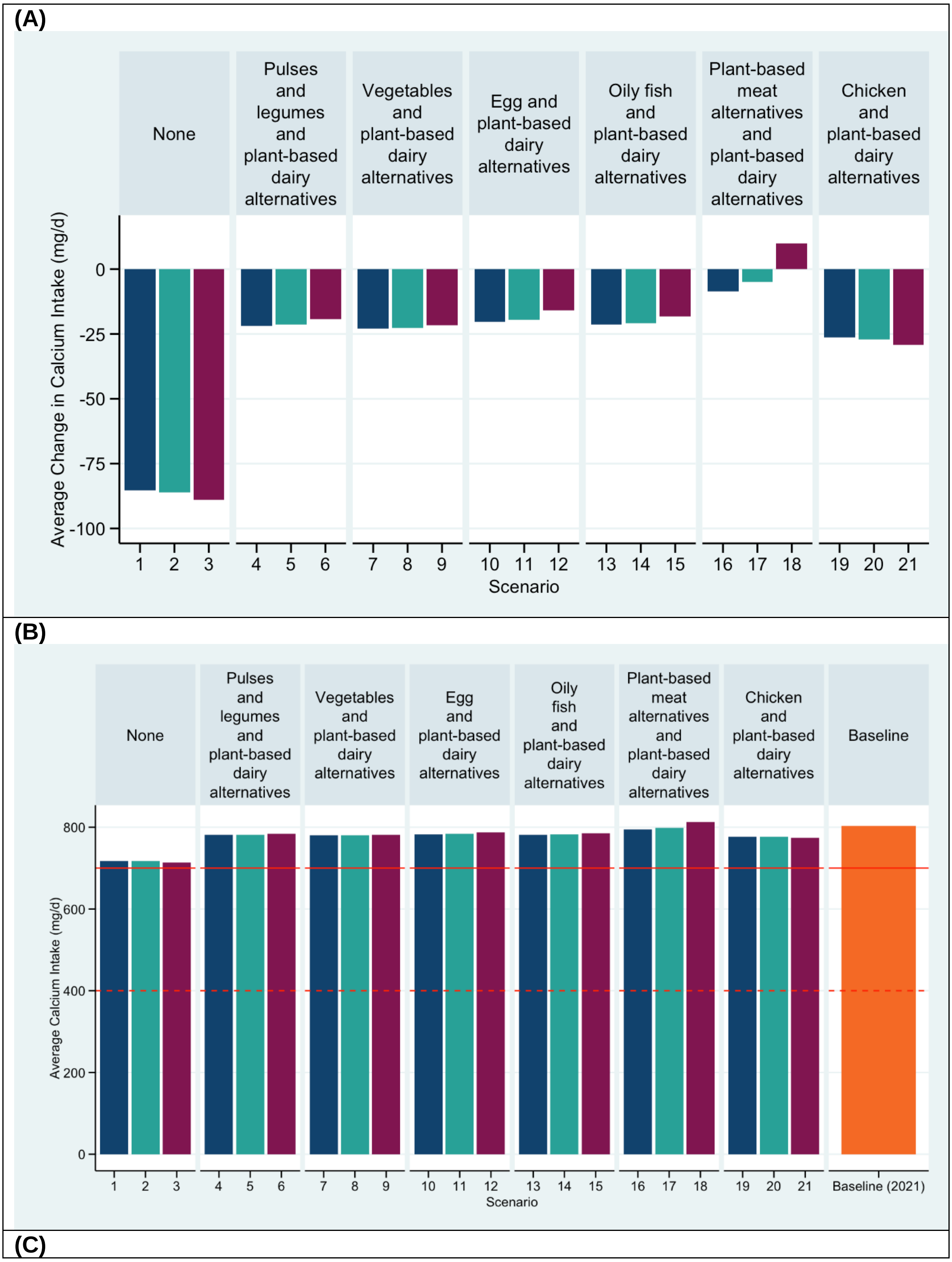


Figure 13. Average change (A) and average (B) protein intake (g/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The red line in (B) represents the highest RNI of any gender/age group (men 19-49y).

Calcium intake decreased across nearly all scenarios (**Figure 14, panel A**). The average change ranged from a **decrease of 89mg/day** (~10% of baseline calcium intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 10mg/day** (~2% of baseline calcium intake) when meat and dairy were replaced with plant-based meat and dairy alternatives. Average calcium intake was above the LRNI and RNI for men and women 19y and older across all replacement scenarios (**panel B**). However, in men and women 16-24y, average calcium intake was below the RNI for 16–18-year-olds across all scenarios (**panel C**).

The percentage of the population below the RNI for calcium ranged from 55% when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to 44% when red and red processed meat and dairy were replaced with plant-based meat and dairy alternatives (currently 46% of the population are below the RNI for calcium) (**Figure *15***).


(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Calcium Intake (mg/d)
0
-25
-50
-75
-100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Calcium Intake (mg/d)
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Baseline (2021)
Scenario
(C)

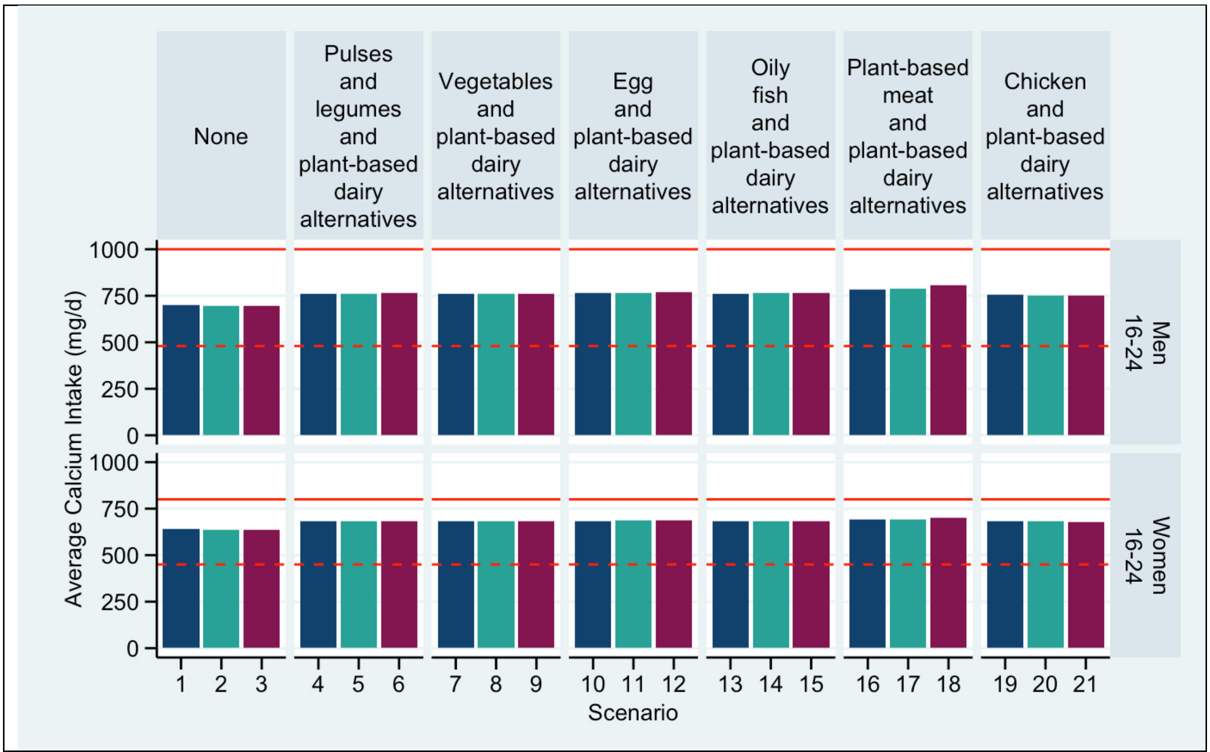
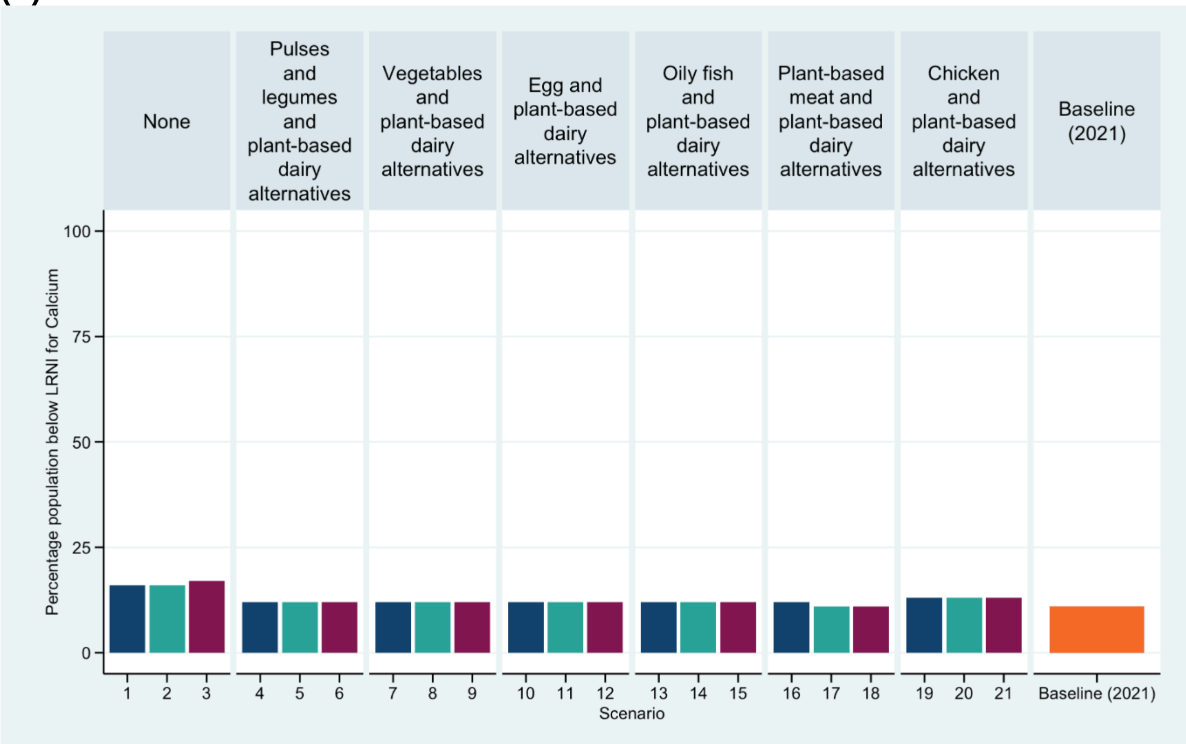


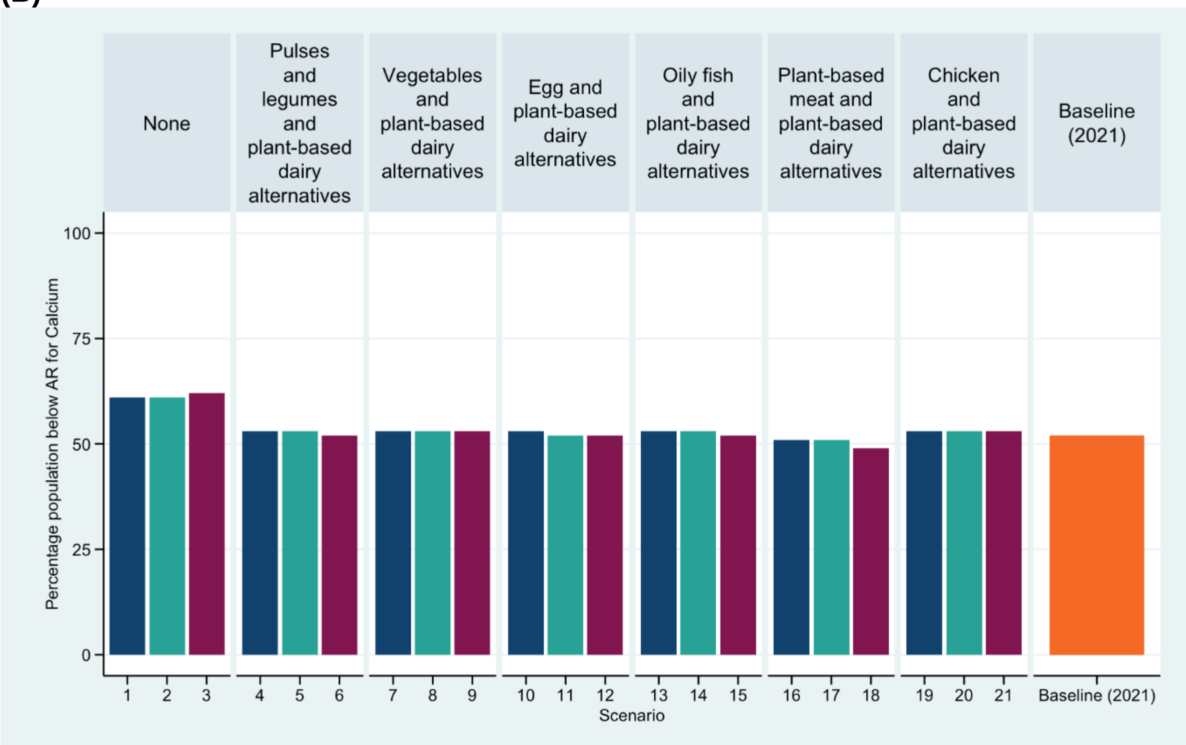
Figure 14. Average change (A) and average calcium intake (mg/day) overall (B) and among those aged 16-24y (C) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) represents the RNI for men and women 19y and older; the dotted red line represents the LRNI for men and women 19y and older. The solid red line in (C) represents the RNI for women and men 16-18y; the dotted red line represents the LRNI for women and men 16-18y.

(A)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Calcium
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(B)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Calcium
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

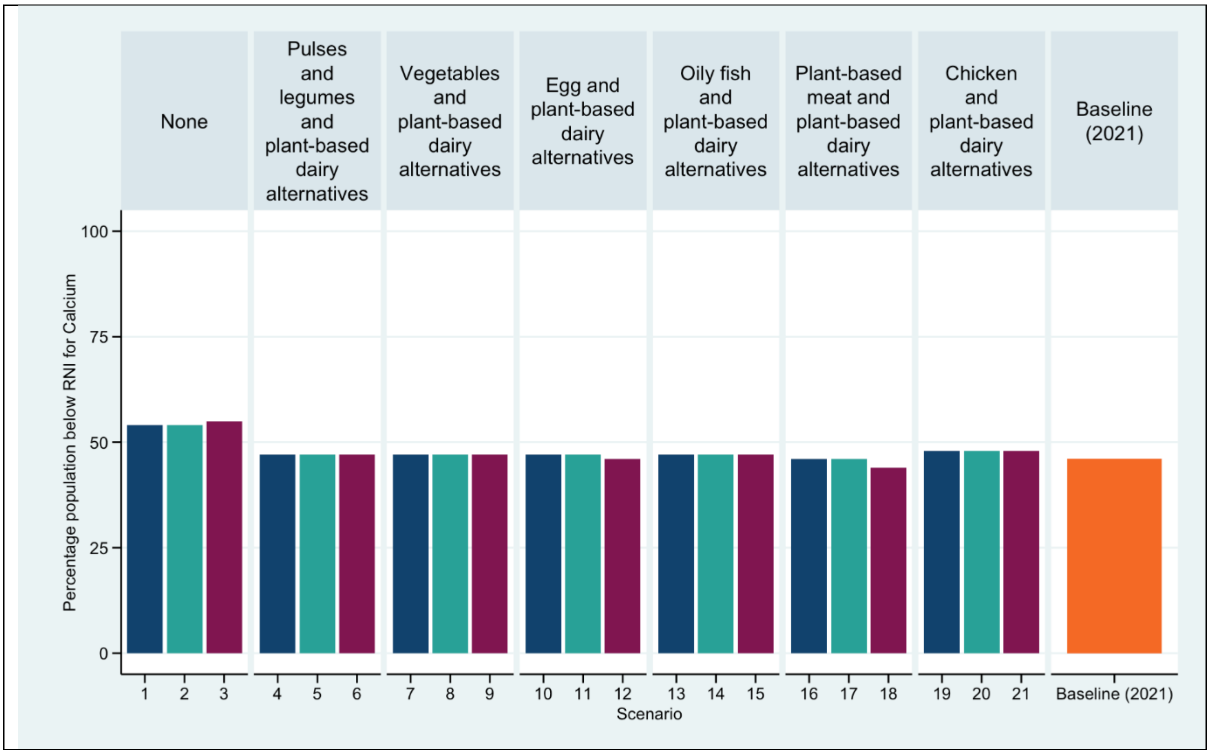


Figure 15. Percentage of participants below the UK Lower Reference Nutrient Intake (LRNI) (A), EFSA Average Requirement (AR) / Adequate Intake (AI) (B), and UK Reference Nutrient Intake (RNI) (C) for calcium for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

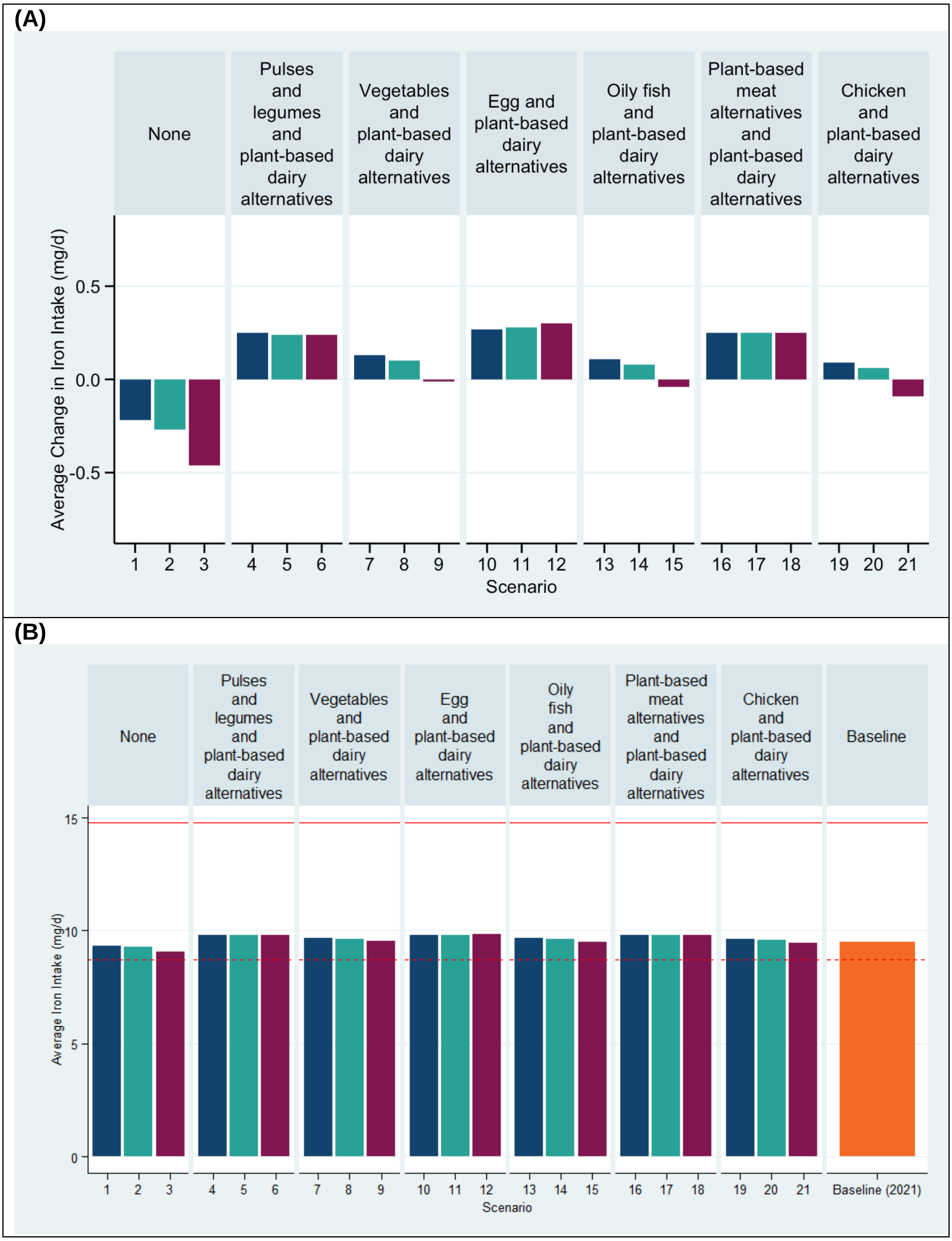
The average change in iron intake ranged from a **decrease of 0.5mg/day** (~5% of baseline iron intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 0.3mg/day** (~4% of baseline iron intake) when red and red processed meat was replaced with egg (**Figure 16**).

There are two chemical forms of iron in our diets: **haem iron** and **non-haem iron**. Haem iron is found in meat and fish whereas non-haem iron is found in both animal and plant foods. Haem iron is more efficiently absorbed than non-haem iron.

However, most of this increase in iron is **non-haem iron** which is less efficiently absorbed than haem iron. Thus, for individuals with an increased need for iron, such as menstruating women, and individuals who have low iron intakes to begin with, further consideration of the chemical form of iron may be warranted.

Average iron intake was below the RNI for women under 55y across all scenarios (**Figure 17, panel A**). Average iron intake among men 16-24y was also below the RNI across all scenarios (**panel B**).

The percentage of the population below the RNI for iron ranged from 63% when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to 55% when red and red processed meat and dairy were replaced with plant-based meat and dairy alternatives, pulses and legumes, or egg (currently 58% of the population are below the RNI for iron) (**Figure *18***).



(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Iron Intake (mg/d)
0.5
0.0
-0.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Iron Intake (mg/d)
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

Figure 16. Average change (A) and average (B) iron intake (mg/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) represents the highest RNI of any gender/age group (women 16-50y); the dotted red line represents the highest LRNI of any gender/age group (women 16-50y).

(A) Women

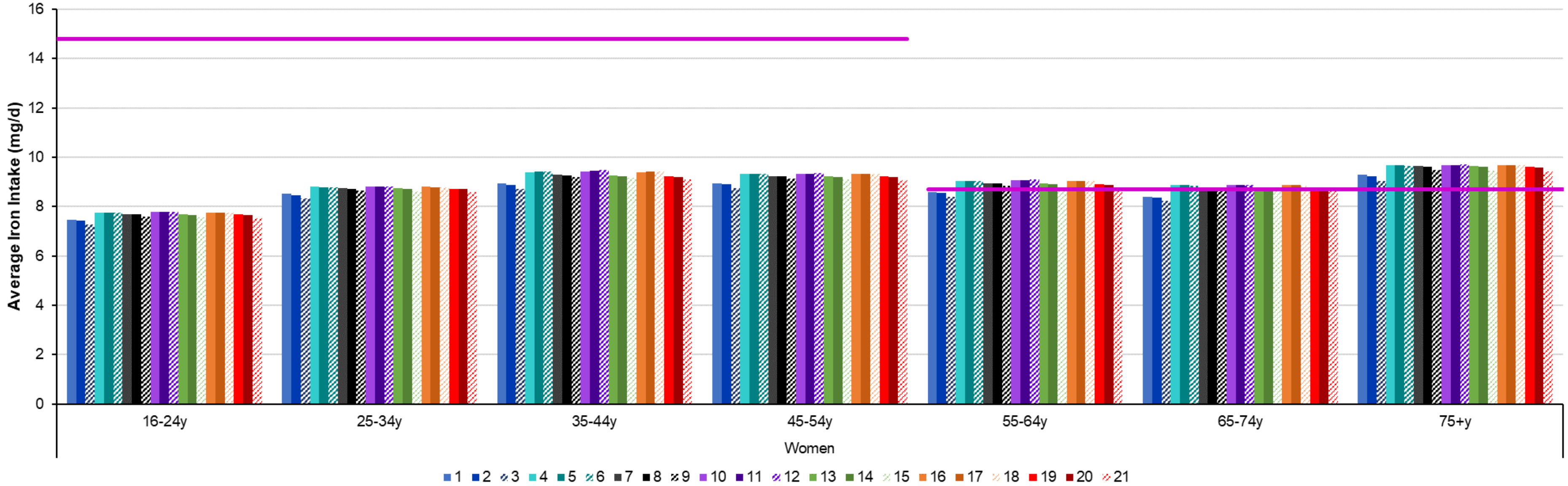


Figure 17. Average iron intake (mg/day) among women (A) and men (B) by age group for 21 meat and dairy reduction scenarios with varying replacements.

Within clusters of three bars, the first represents scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake; the second represents scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake; and the third represents scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid pink line represents the RNI.

(B) Men

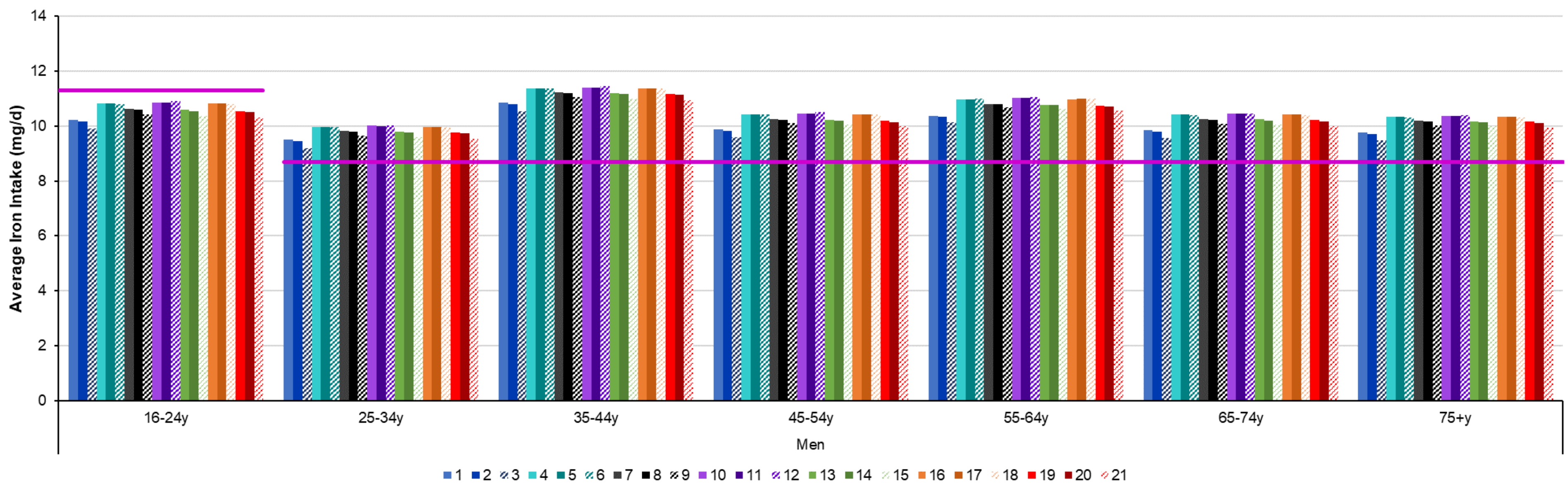
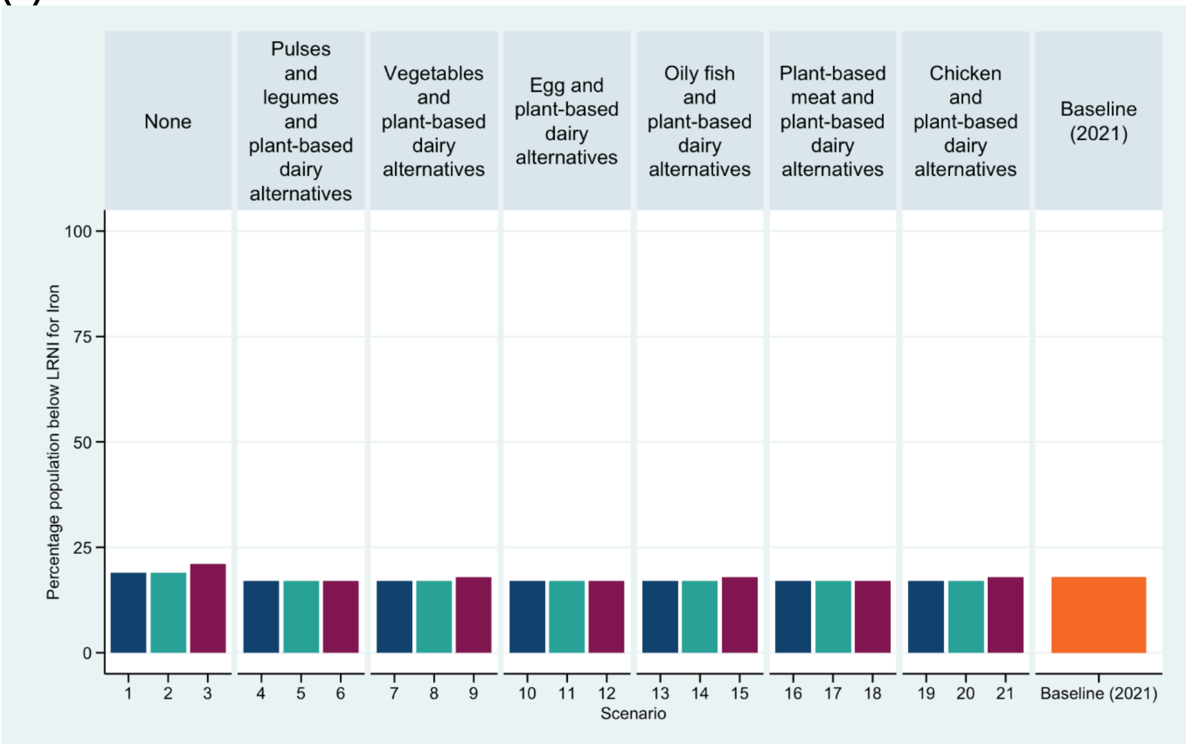
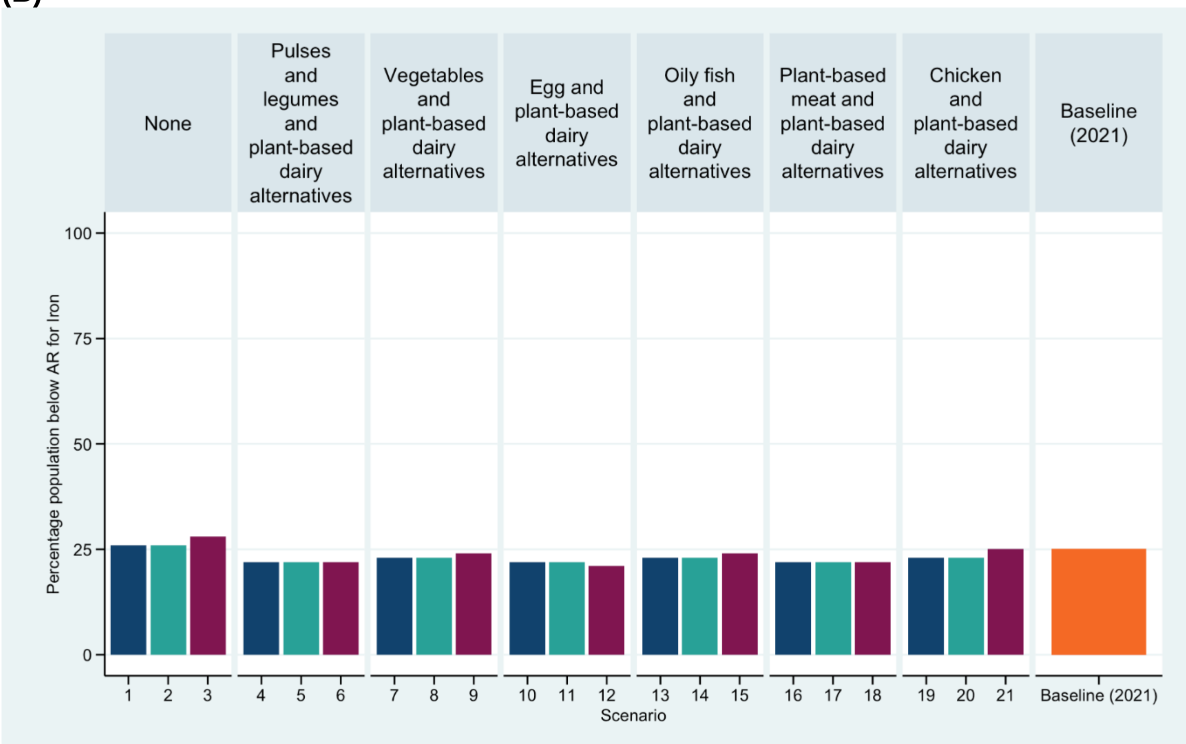


Figure 17. Continued.

(A)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Iron
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(B)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Iron
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

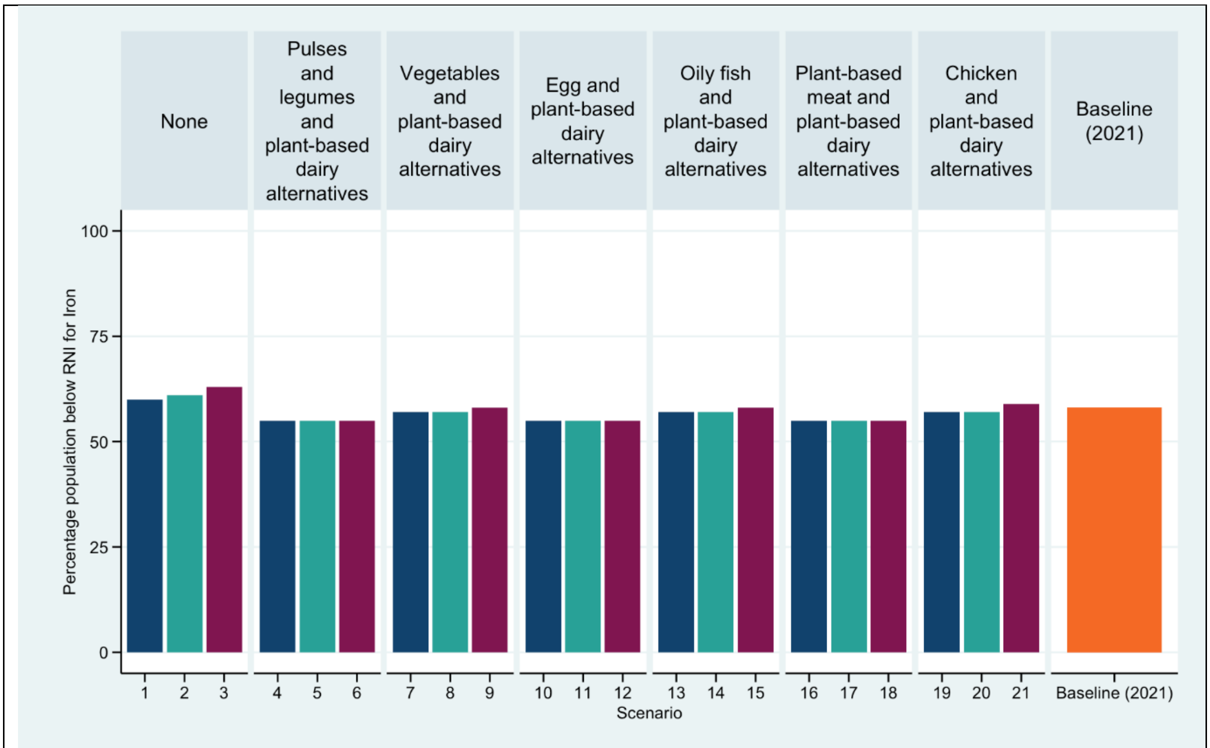
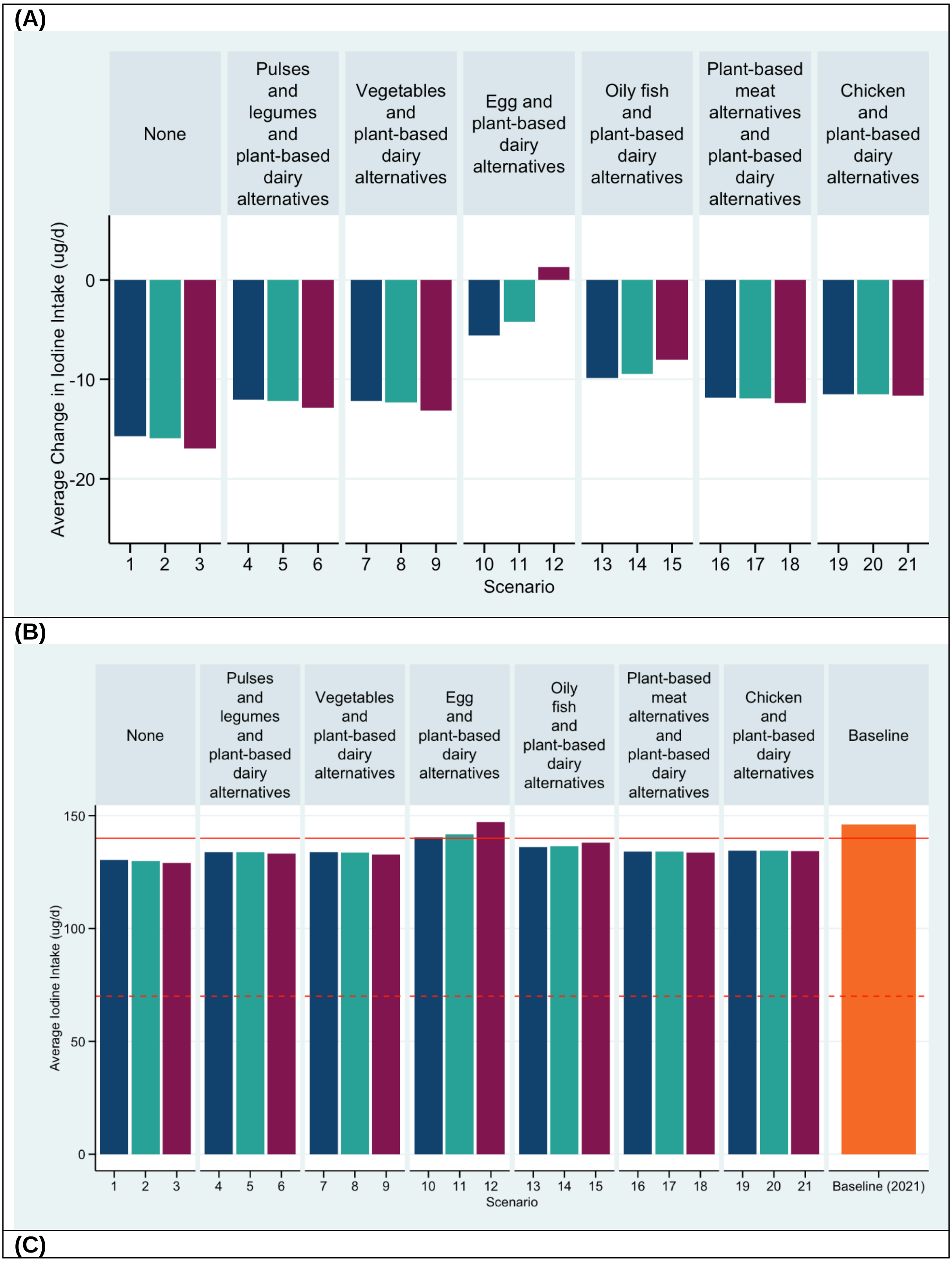


Figure 18. Percentage of participants below the UK Lower Reference Nutrient Intake (LRNI) (A), EFSA Average Requirement (AR) / Adequate Intake (AI) (B), and UK Reference Nutrient Intake (RNI) (C) for iron for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

Iodine intake decreased across nearly all scenarios (**Figure 19, panel A**). The average change ranged from a **decrease of 17µg/day** (~12% of baseline iodine intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 1.3µg/day** (~4% of baseline iodine intake) when red and red processed meat was replaced with egg. Average iodine intake dropped below the RNI except in the scenarios in which red and red processed meat was replaced with egg (**panel B**). However, for women under 65y and men aged 25-34y, even replacement with egg was not sufficient to bring average intake above the RNI (**panel C**).

The percentage of the population below the RNI for iodine ranged from 65% when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to 54% when red and red processed meat was replaced with egg (currently 56% of the population are below the RNI for iodine) (**Figure *20***).


(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Iodine Intake (ug/d)
0
-10
-20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Iodine Intake (ug/d)
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Baseline (2021)
Scenario
(C)

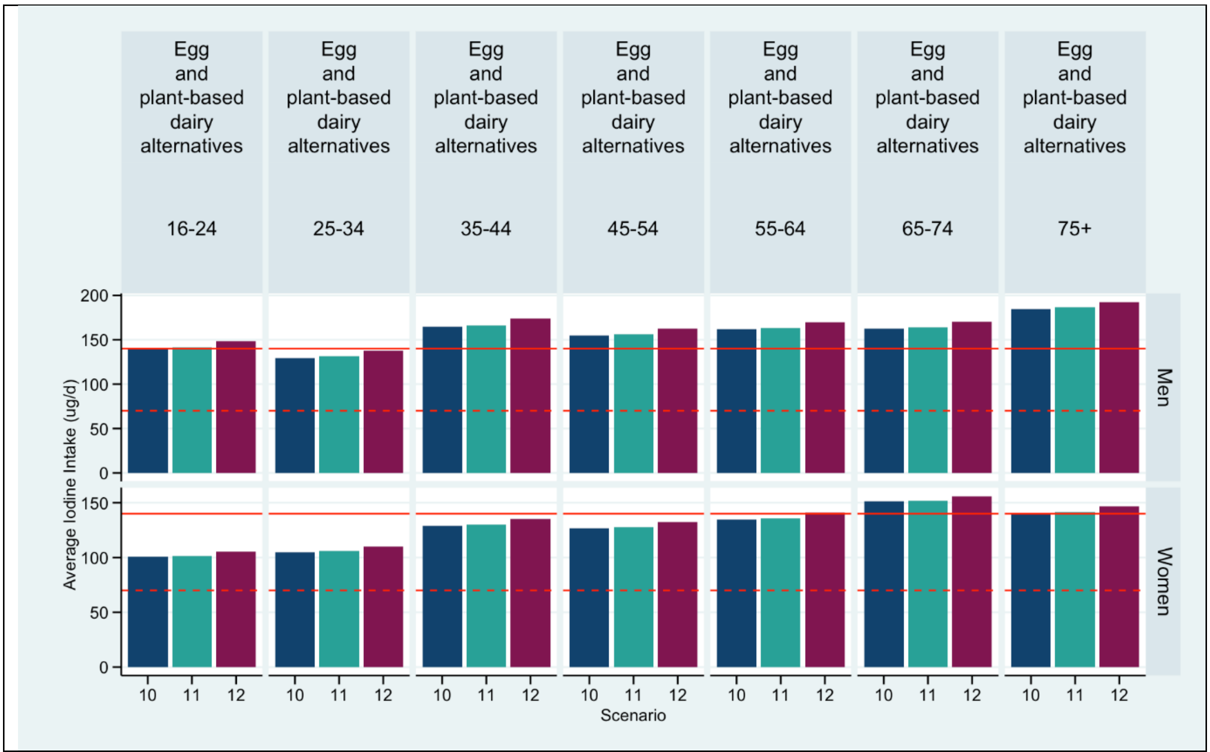
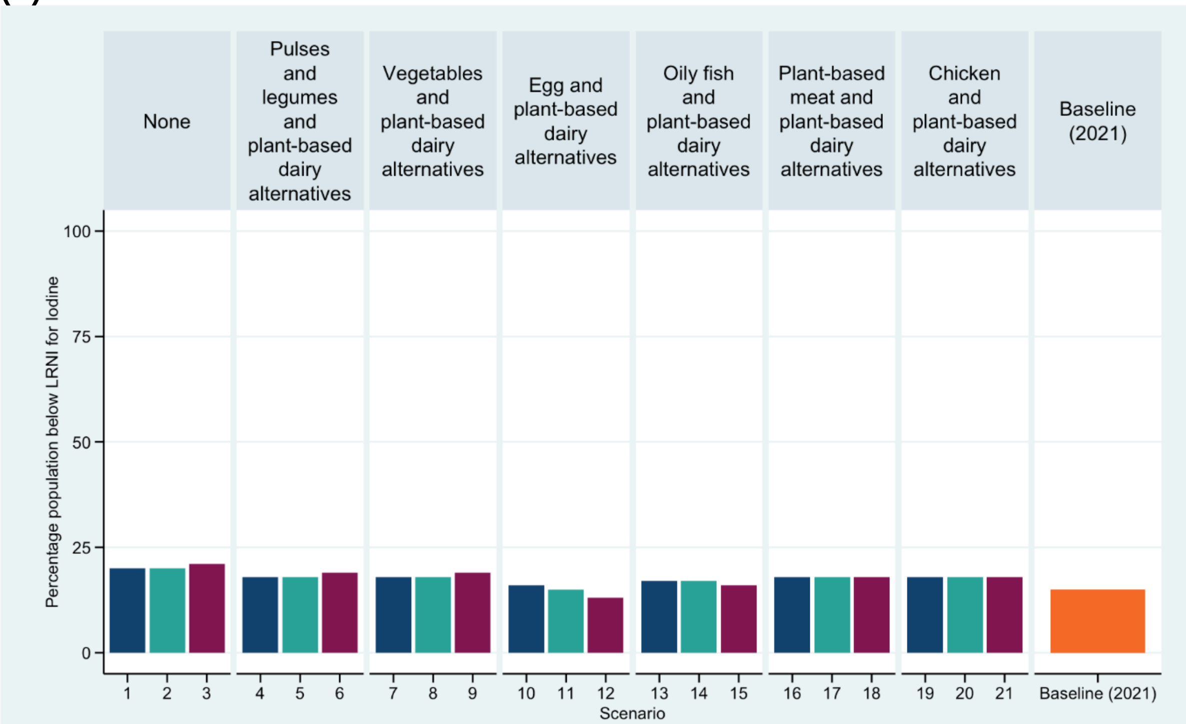


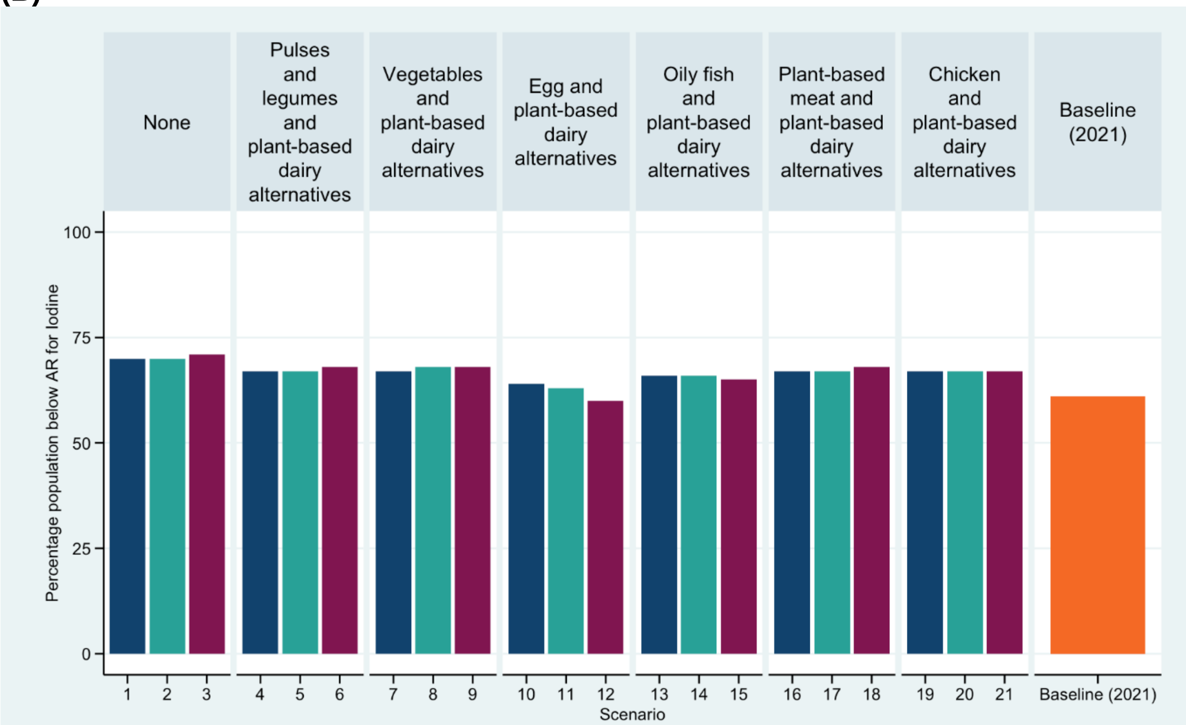
Figure 19. Average change (A) and average iodine intake (µg/day) overall (B) and by gender/age groups (C) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) and (C) represents the RNI; the dotted red line represents the LRNI.

(A)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Iodine
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(B)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Iodine
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

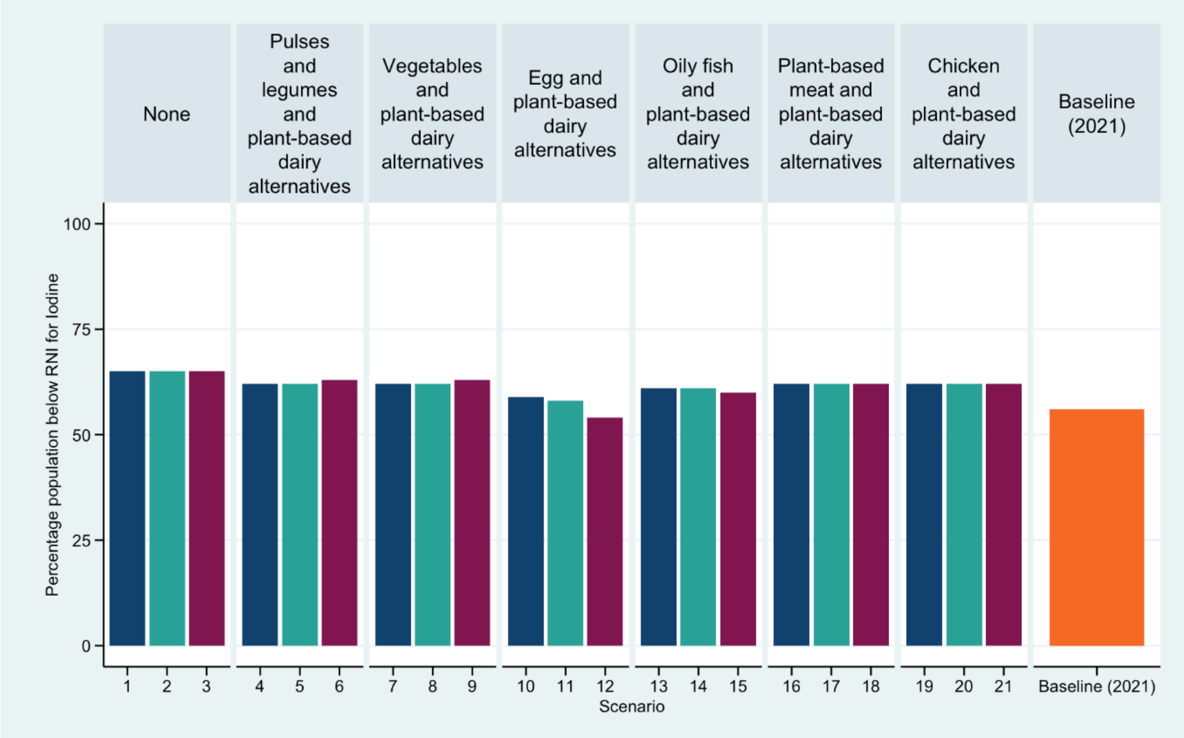


Figure 20. Percentage of participants below the UK Lower Reference Nutrient Intake (LRNI) (A), EFSA Average Requirement (AR) / Adequate Intake (AI) (B), and UK Reference Nutrient Intake (RNI) (C) for iodine for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

The average **change in selenium intake** ranged from a **decrease of 4µg/day** (~9% of baseline selenium intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 4µg/day** (~11% of baseline selenium intake) when red and red processed meat was replaced with egg (**Figure 21, panel A**). Selenium intake decreased in all scenarios except when red and red processed meat was replaced with egg, oily fish, or chicken. At baseline and across all scenarios and all gender/age groups, average selenium intake was well below the RNI (**panel B**).

The percentage of the population below the RNI for selenium ranged from 92% in scenarios with no replacement or in which red and red processed meat was replaced with pulses and legumes or vegetables, to 85% when red and red processed meat was replaced with egg (currently 90% of the population are below the RNI for selenium) (**Figure *22***).

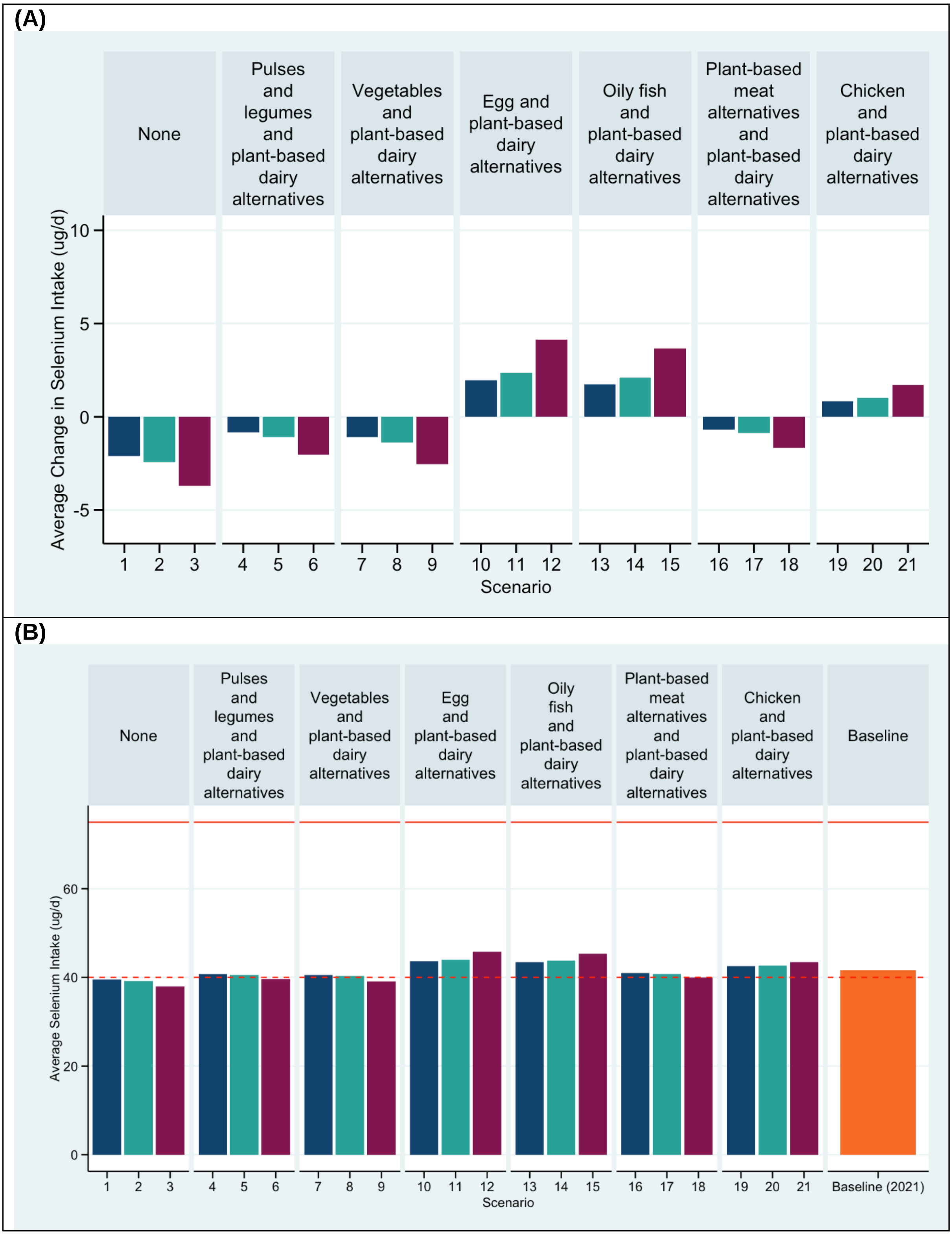
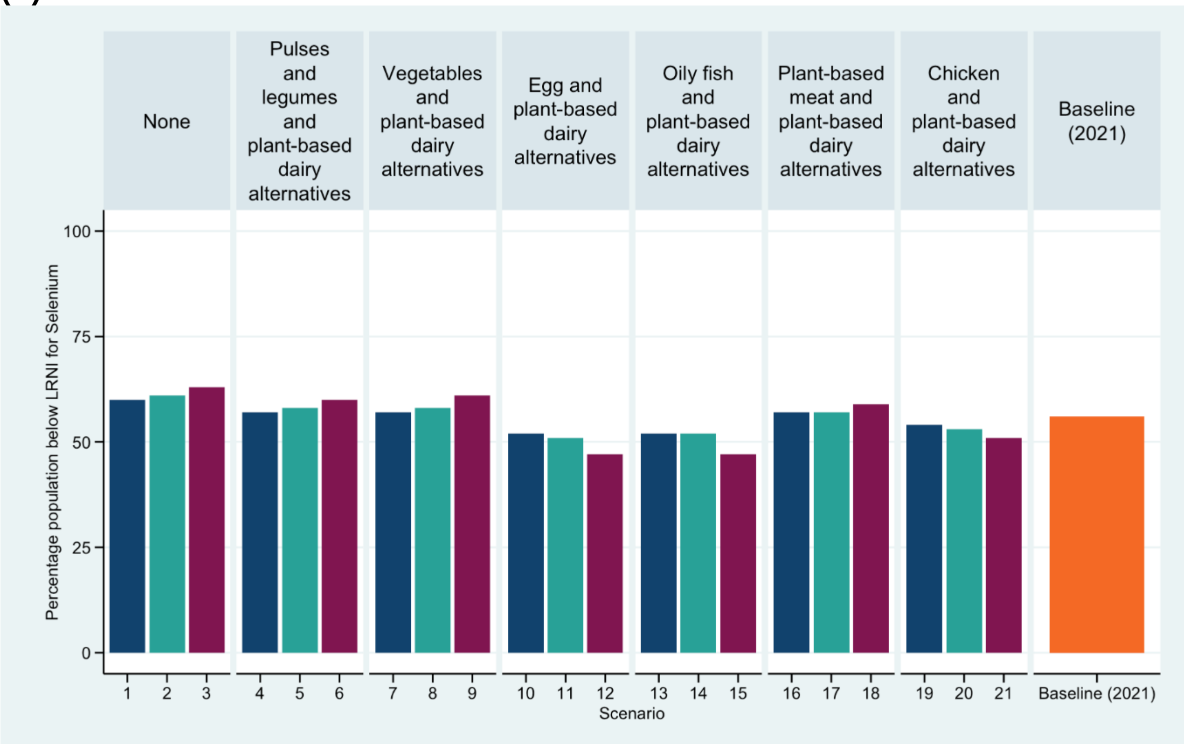

(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Selenium Intake (ug/d)
10
5
0
-5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Selenium Intake (ug/d)
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Baseline (2021)
Scenario

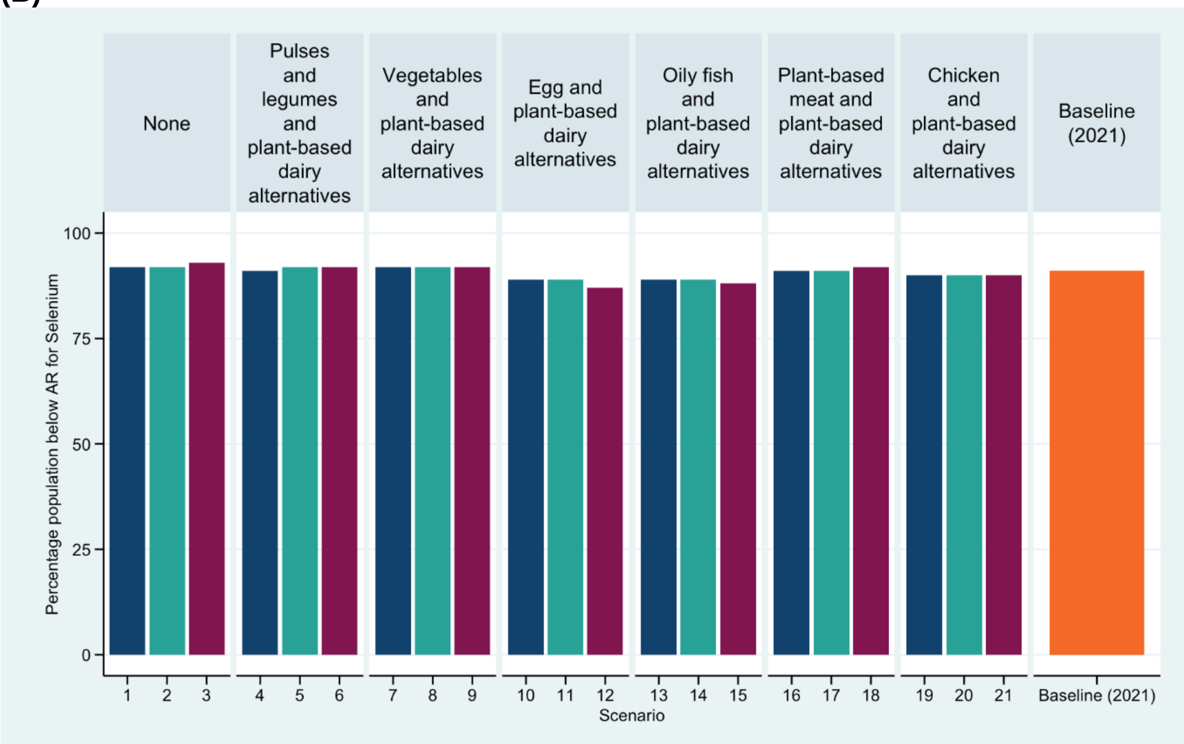
Figure 21. Average change (A) and average (B) selenium intake (µg/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) represents the highest RNI of any gender/age group (men 19+y); the dotted red line represents the LRNI.

(A)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Selenium
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(B)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Selenium
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

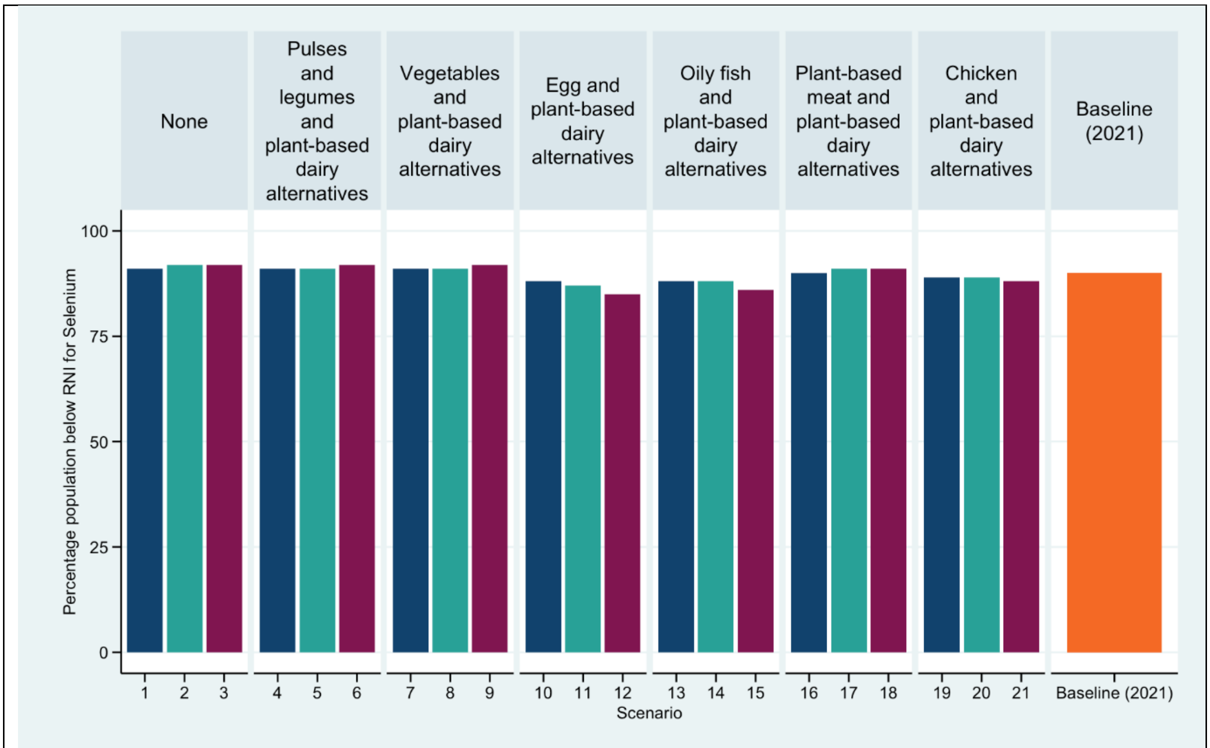


Figure 22. Percentage of participants below the Lower Reference Nutrient Intake (LRNI) (A), Average Requirement (AR) / Adequate Intake (AI) (B), and Reference Nutrient Intake (RNI) (C) for selenium for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

Zinc intake decreased across all scenarios (**Figure 23, panel A**). The average decrease ranged from **1µg/day** (~14% of baseline zinc intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to **0.1µg/day** (~1% of baseline zinc intake) when red and red processed meat was replaced with plant-based meat alternatives (**panel A**). At baseline and across all scenarios average zinc intake was below the RNI (**panel B**). The exceptions to this were women 35-44y and women 65+y when red and red processed meat was replaced with plant-based meat alternatives – in these subgroups under these particular scenarios, average zinc intake was slightly above the RNI.

The percentage of the population below the RNI for zinc ranged from 78% when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to 63% when red and red processed meat was replaced with plant-based meat alternatives (currently 62% of the population are below the RNI for zinc) (**Figure *24***).

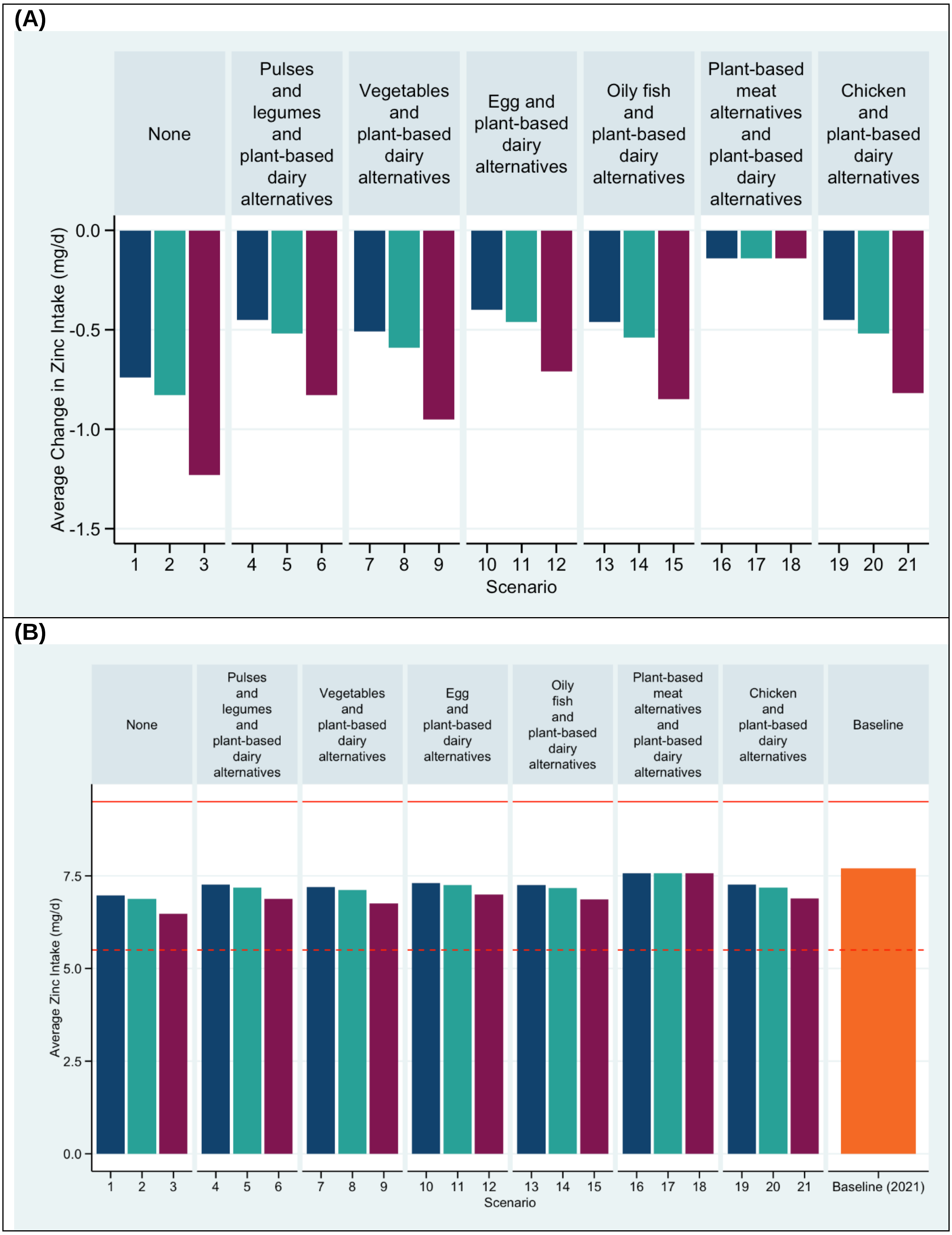
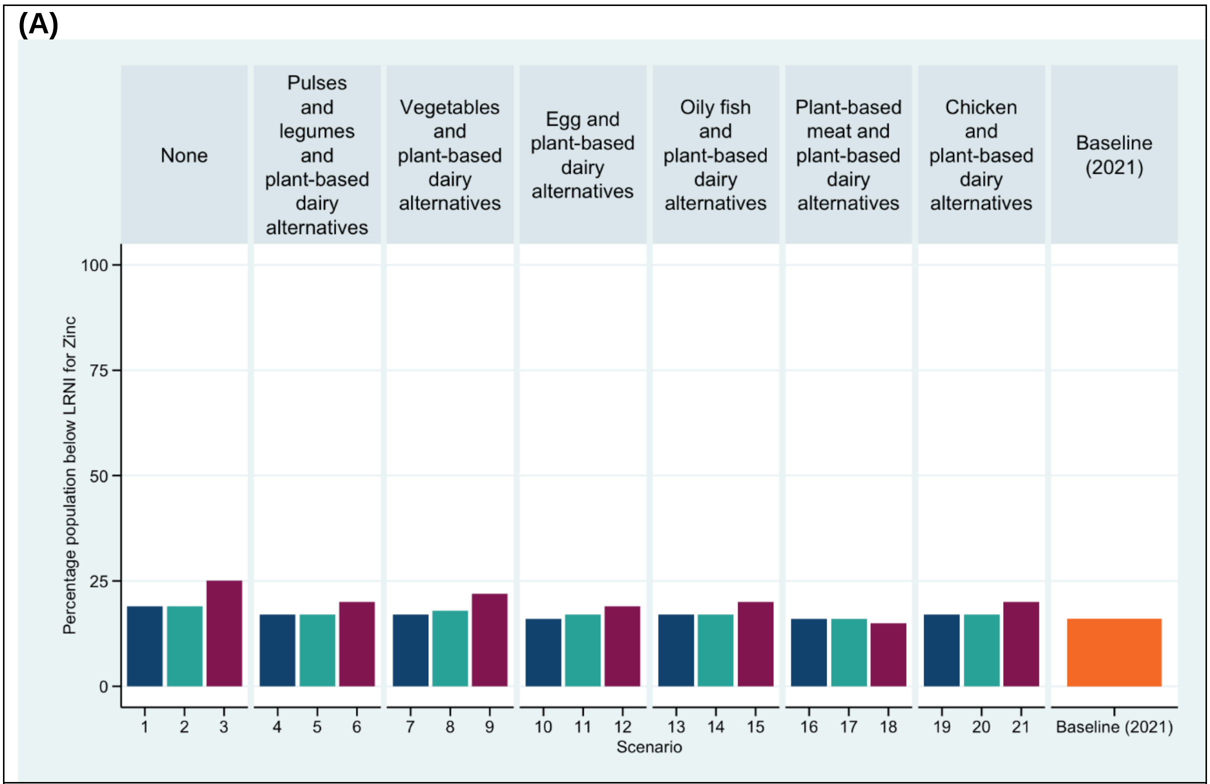
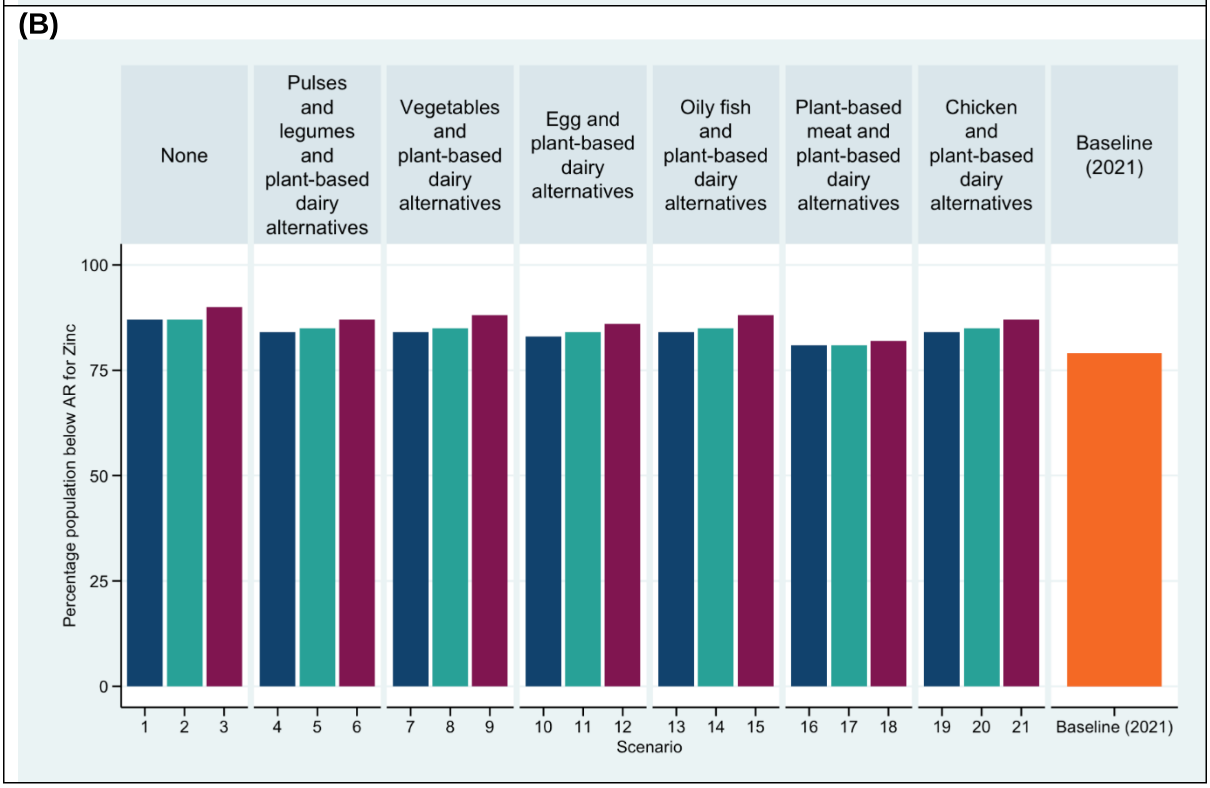

(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Zinc Intake (mg/d)
0.0
-0.5
-1.0
-1.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Zinc Intake (mg/d)
7.5
5.0
2.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Baseline (2021)
Scenario

Figure 23. Average change (A) and average (B) zinc intake (mg/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) indicates the highest RNI of any gender/age group (men 16+y); the dotted red line indicates the highest LRNI of any gender/age group (men 16+y).


(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Zinc
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario


(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Zinc
0
25
50
75
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

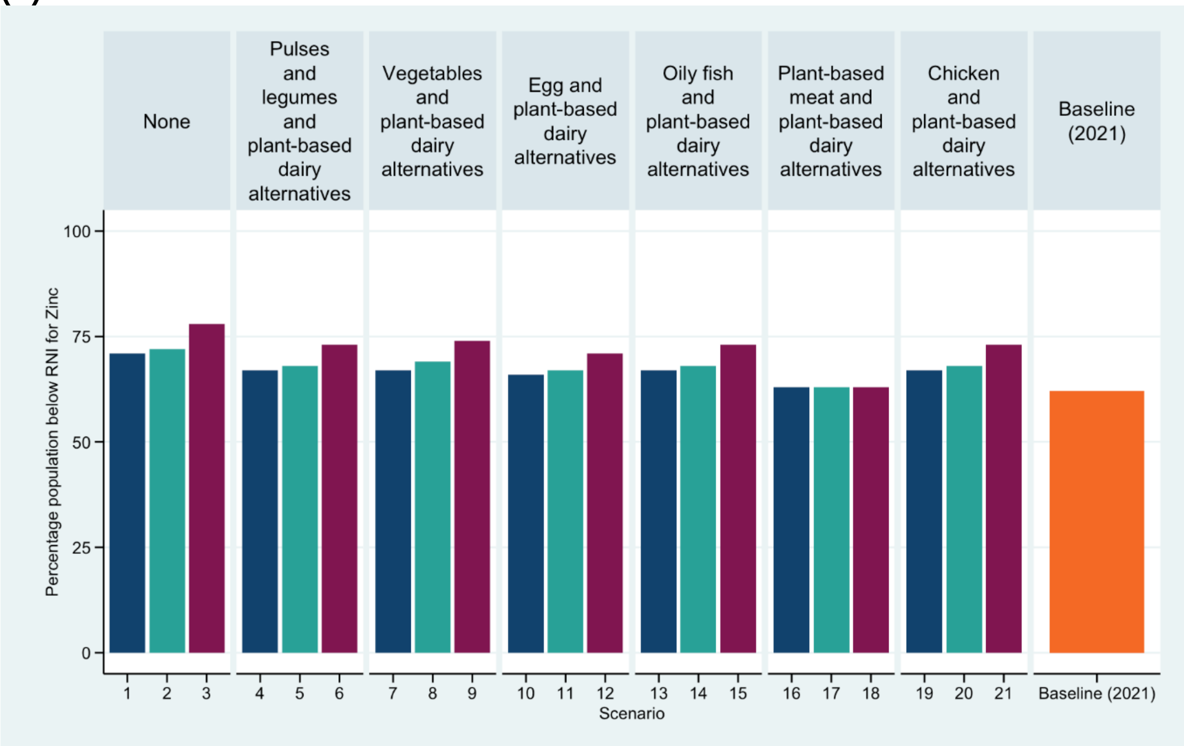


Figure 24. Percentage of participants below the Lower Reference Nutrient Intake (LRNI) (A), Average Requirement (AR) / Adequate Intake (AI) (B), and Reference Nutrient Intake (RNI) (C) for zinc for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

The average **change in vitamin B_{12} intake** ranged from a **decrease of 1μg/day** (~19% of baseline vitamin B_{12} intake) when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to an **increase of 0.6μg/day** (~17% of baseline vitamin B_{12} intake) when red and red processed meat was replaced with oily fish (**Figure 25, panel A**). Nonetheless, average vitamin B_{12} intake was above the RNI for all gender/age groups across all scenarios (**panel B**).

The percentage of the population below the RNI for vitamin B_{12} ranged from 14% when red and red processed meat was reduced to 31g/day and dairy by 20% with no replacement, to 7% when red and red processed meat was replaced with oily fish or egg (currently 8% of the population are below the RNI for vitamin B_{12}) (**Figure *26***).

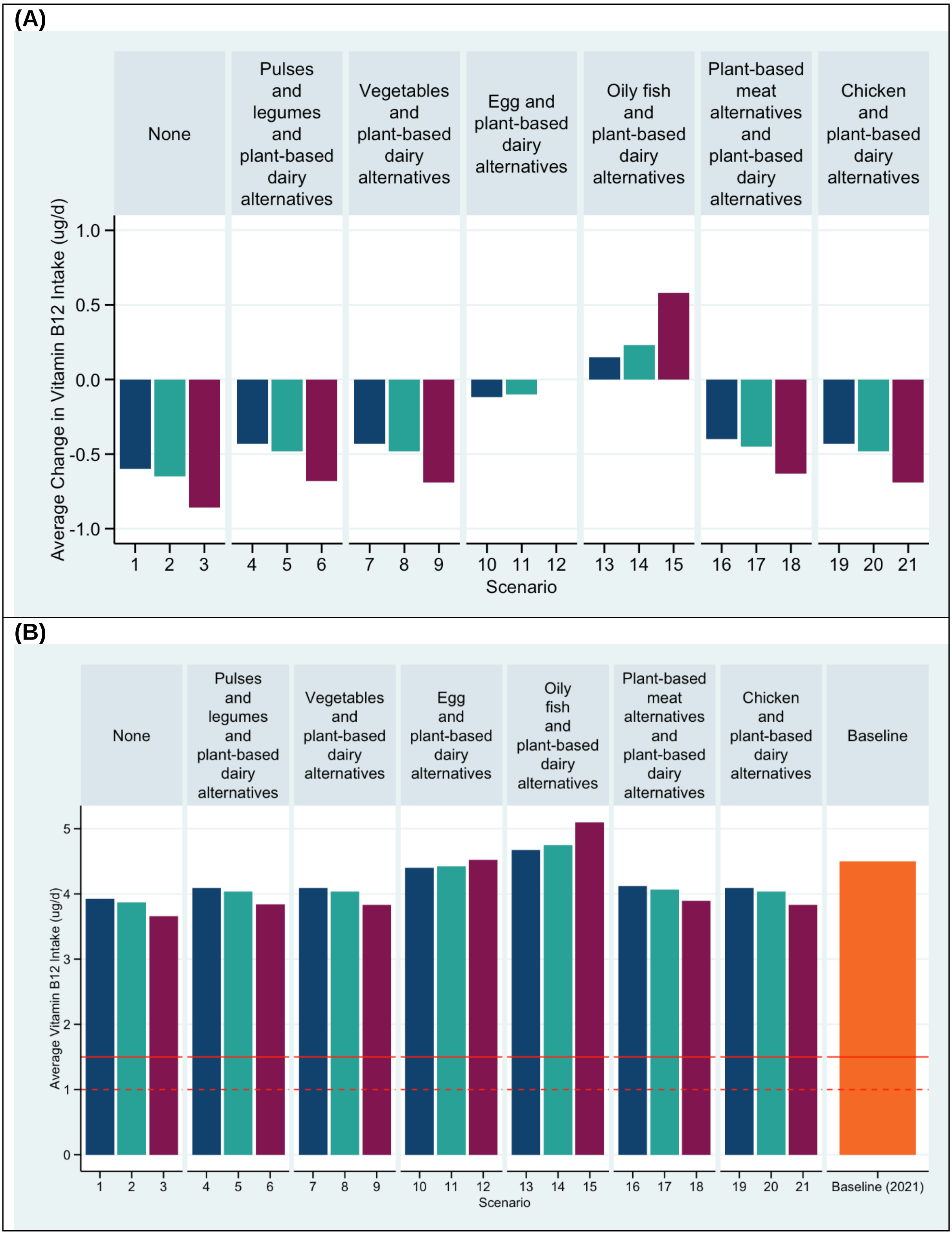
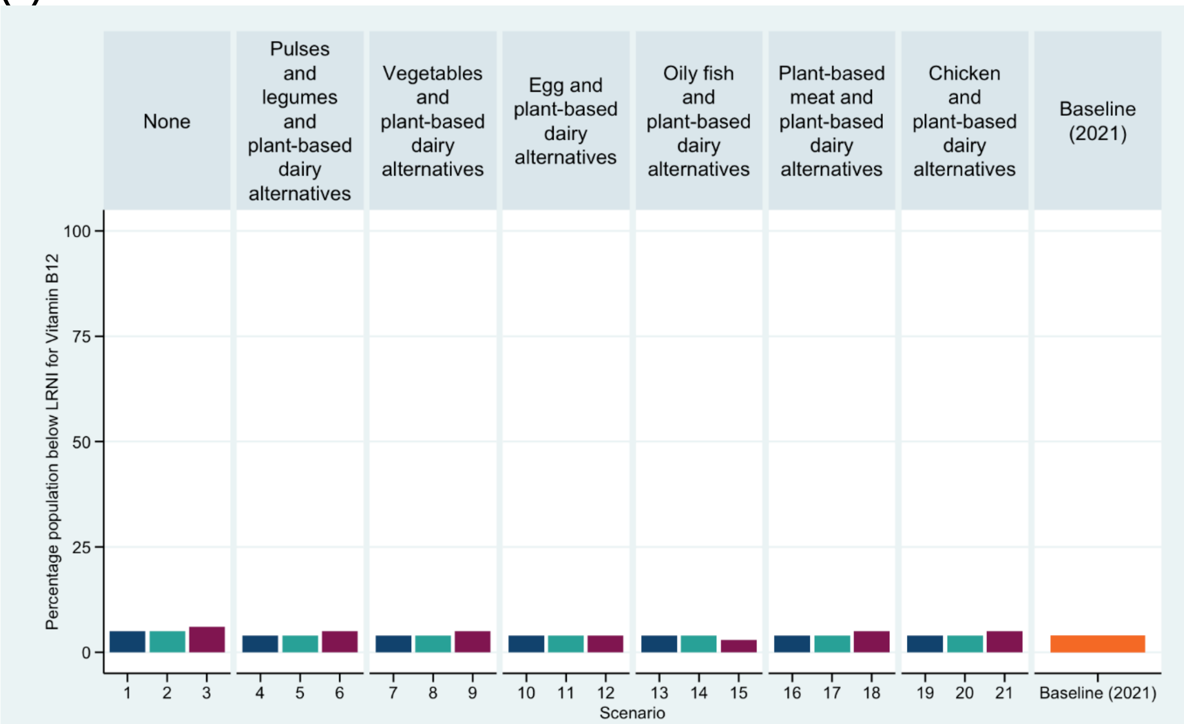

(A)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Average Change in Vitamin B12 Intake (ug/d)
1.0
0.5
0.0
-0.5
-1.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Scenario
(B)
None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat alternatives and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline
Average Vitamin B12 Intake (ug/d)
5
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Baseline (2021)
Scenario

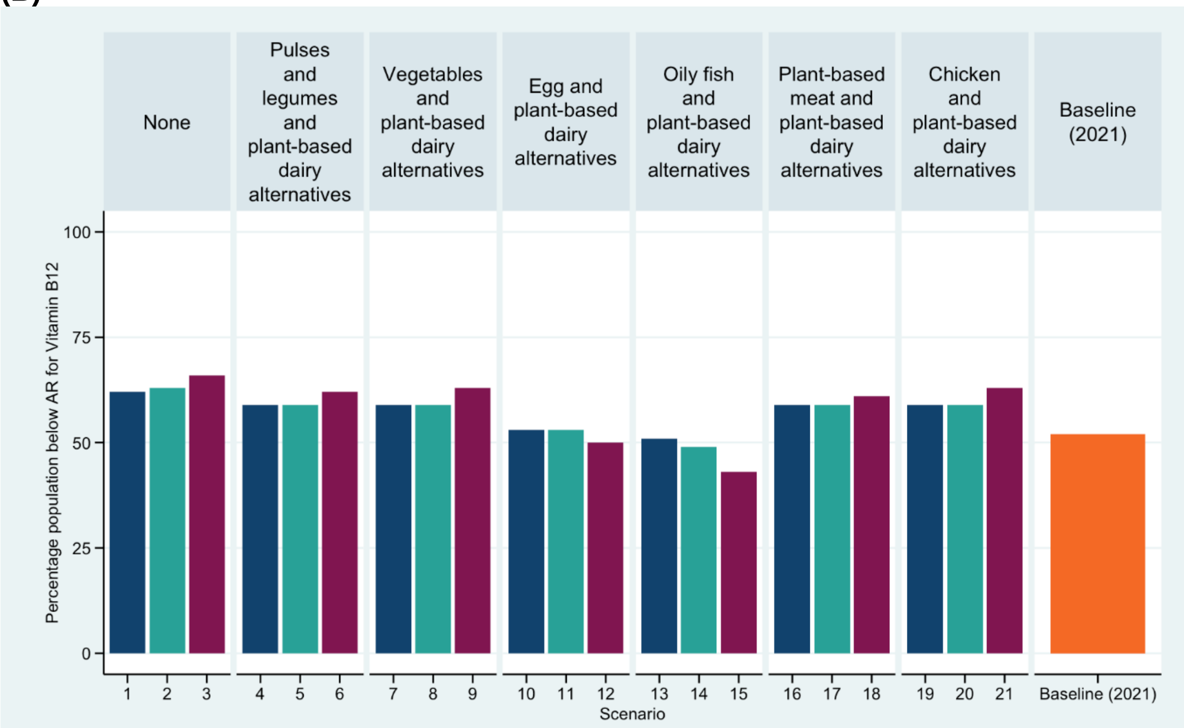
Figure 25. Average change (A) and average (B) vitamin B_{12} intake (µg/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake. The solid red line in (B) represents the RNI; the dotted red line represents the LRNI.

(A)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below LRNI for Vitamin B12
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(B)


None
Pulses and legumes and plant-based dairy alternatives
Vegetables and plant-based dairy alternatives
Egg and plant-based dairy alternatives
Oily fish and plant-based dairy alternatives
Plant-based meat and plant-based dairy alternatives
Chicken and plant-based dairy alternatives
Baseline (2021)
Percentage population below AR for Vitamin B12
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 Baseline (2021)
Scenario

(C)

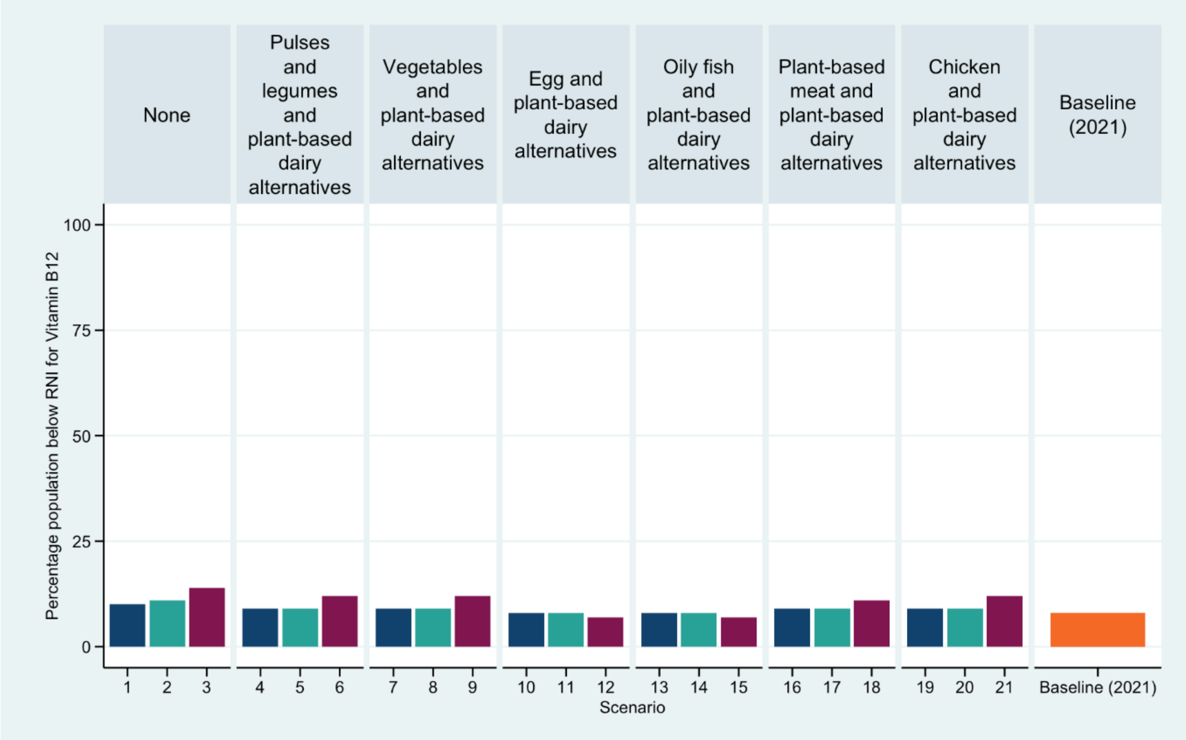


Figure 26. Percentage of participants below the Lower Reference Nutrient Intake (LRNI) (A), Average Requirement (AR) / Adequate Intake (AI) (B), and Reference Nutrient Intake (RNI) (C) for vitamin B_{12} for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

Key Messages: **Impact of Reducing Red and Red Processed Meat and Dairy in Scotland on Nutrient Intake**

1. Under the most useful scenario to demonstrate both the achievement of the public health goal for red and red processed meat, which is the worst-case scenario of no replacement, about 8-9 percentage points more of the population will fall below the RNI for calcium, iodine, and zinc, and about 1-2 percentage points more of the population will fall below the RNI for iron, selenium, and vitamin B_{12}.
2. Under all scenarios with a replacement for meat and dairy, average calcium intake was above the RNI for men and women 19y and older. However, in men and women 16-24y, average calcium intake was below the RNI for 16–18-year-olds across all scenarios.
3. Average iron intake among women under 55y and men 16-24y across nearly all scenarios, including baseline, was below the RNI. Iron intake increased slightly in most scenarios except when meat and dairy were not replaced, but most of this increase was non-haem iron which is less efficiently absorbed than haem iron.
4. Average iodine intake dropped below the RNI except in the scenarios in which red and red processed meat was replaced with egg. However, for women under 65y and men aged 25-34y, even replacement with egg was not sufficient to bring average intake above the RNI.
5. At baseline and across all scenarios – and all gender/age groups – average selenium intake was below the RNI. Selenium intake increased when red and red processed meat was replaced with egg, oily fish, or chicken, but the increase was not sufficient for the average intake to meet the RNI.
6. At baseline and across all scenarios, average zinc intake was below the RNI. The exceptions to this were women 35-44y and women 65+y when red and red processed meat was replaced with plant-based meat alternatives – in these subgroups under these particular scenarios, average zinc intake was slightly above the RNI.
7. Even under the most extreme scenario (reducing high consumers of red and red processed meat to 31g/day and a 20% reduction in dairy with no replacement), average intake of protein and vitamin B_{12} remained well above the RNI for men and women of all ages.

7. Simulation Results: Scottish Dietary Goals

The impact of the 21 simulations on the percent of adults (16+y) living in Scotland who met the Scottish Dietary Goals (SDG) (**Table 19**) was evaluated. Tables with the proportion of the population meeting the SDGs, overall and by population subgroup, are provided for all 21 scenarios in **Appendix 14** (absolute values) and **Appendix 15** (change as compared to current intakes).

Table 19. Summary of Scottish Dietary Goals.[28]

Goal	Description
Calories (energy density)	Average energy density of the diet to be lowered to 125 kcal/100g
Fruit & vegetables	Average intake to reach at least five portions per person per day (≥400g/day)
Red meat	Average intake of red and red processed meat to be limited to around 70g per person per day
Total fat	Average intake of total fat to reduce to no more than 35% food energy
Saturated fat	Average intake of saturated fatty acids to no more than 11% food energy
Trans fat	Average intake of trans fatty acids to remain below 1% food energy
Free sugars	Average intake of free sugars not to exceed 5% of total energy
Total carbohydrates	Average intake of total carbohydrates to be maintained at approximately 50%[29] of total energy
Salt	Average intake of salt to reduce to 6g/day
Fibre	Average intake of fibre to increase to 18g/day

At baseline, 72% of adults met the SDG for red and red processed meat. All scenarios increased the percent of adults meeting the SDG for red and red processed meat to 100%.

There was no 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.

[28] We did not evaluate the impact of reductions on meeting the oily fish SDG given that we only had 1-2 days of dietary recalls and the SDG is to increase oil-rich fish consumption to one portion (140g) per week.

[29] Approximately 50% taken to mean 45-55% for the purposes of this report.

At baseline, 21% of adults met the SDG for energy density. All scenarios increased the percent of adults meeting the SDG for calories (**Figure 27**).

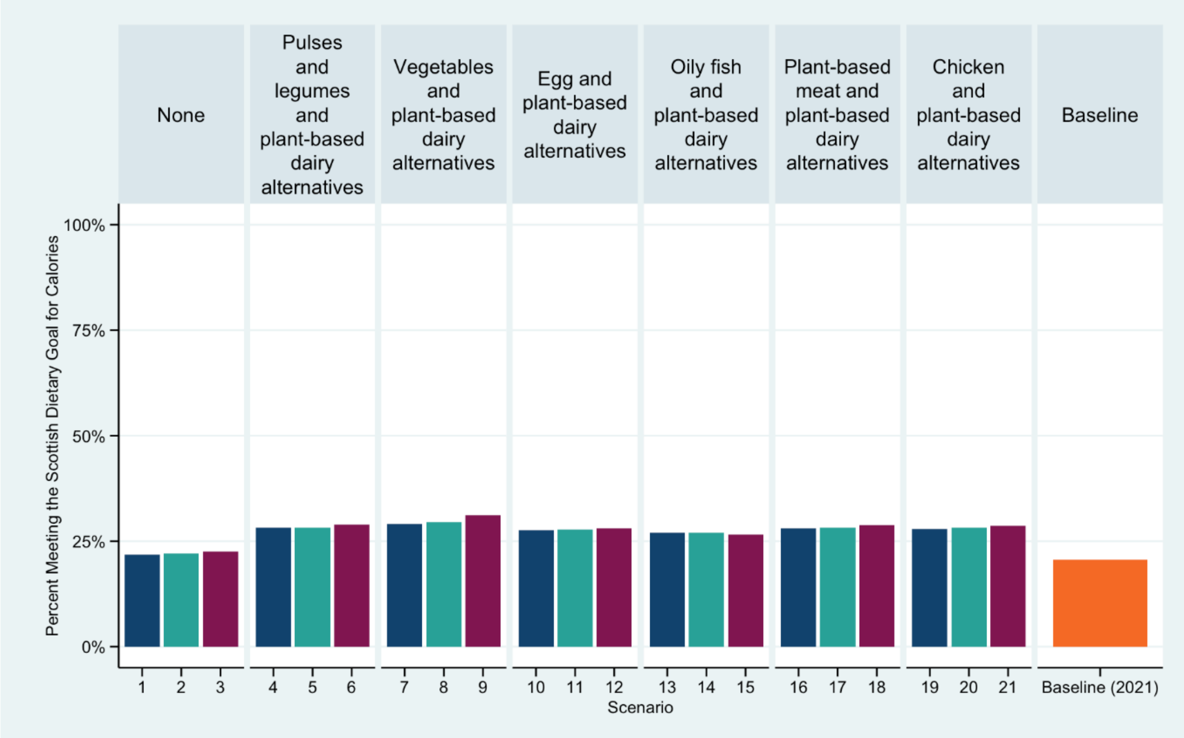


Figure 27. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for energy density of the diet 125 kcal/100g or less for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 22% of adults met the SDG for fruit & vegetables. In scenarios wherein red and red processed meat was replaced with pulses and legumes or vegetables, a slightly higher percentage of adults met the SDG for fruit & vegetables than at baseline (**Figure 28**).

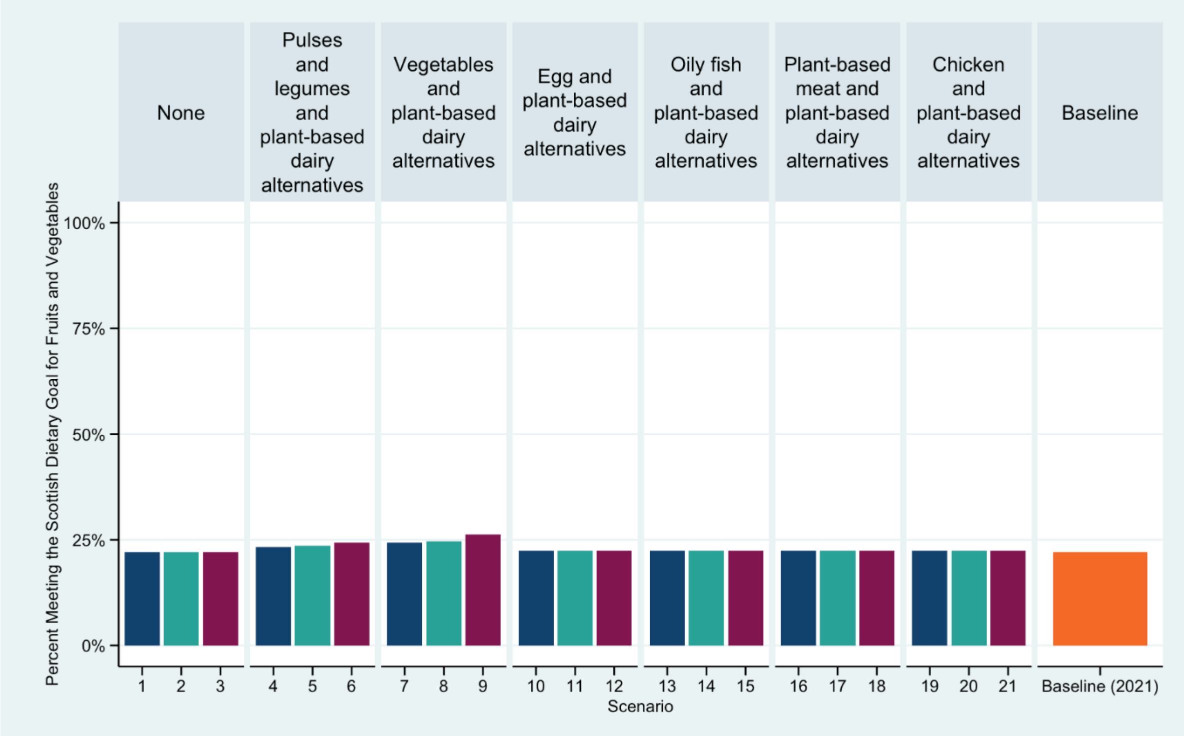


Figure 28. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for fruit & vegetables (intake ≥400g/day) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 49% of adults met the SDG for total fat. All scenarios except when meat was substituted with egg or oily fish slightly increased the percent of adults meeting the SDG for total fat (**Figure 29**).

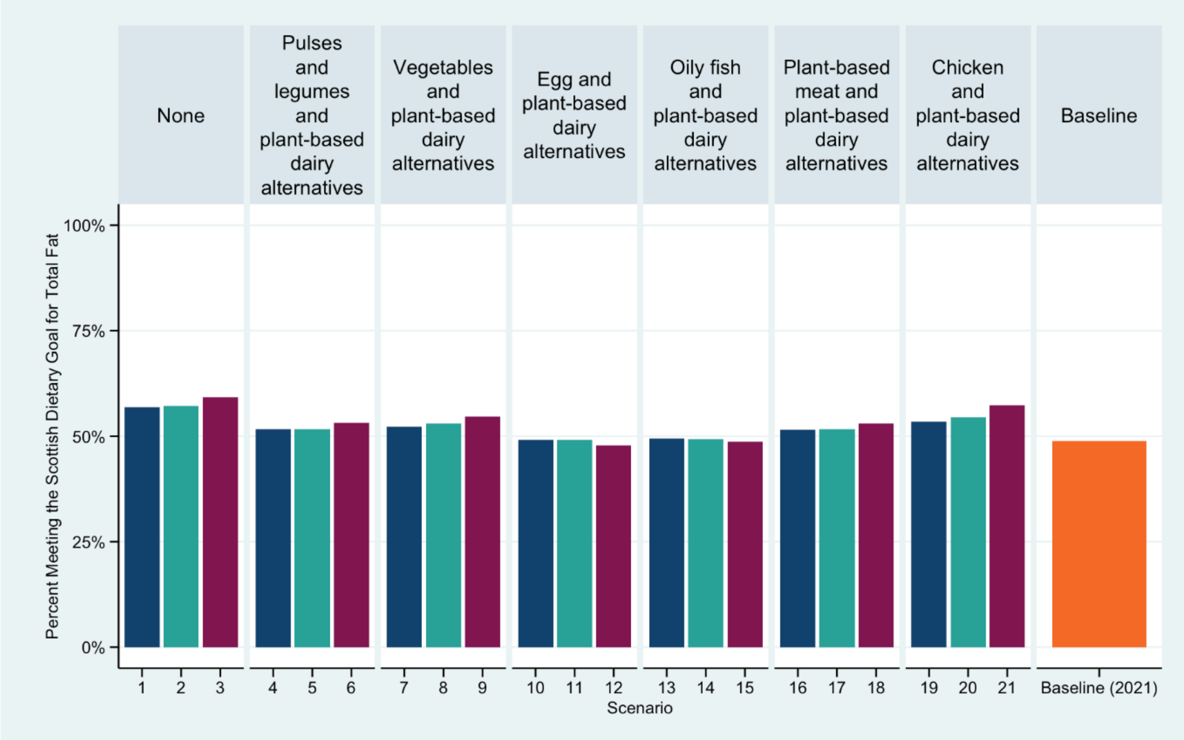


Figure 29. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for total fat (intake ≤35% food energy) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 27% of adults met the SDG for saturated fat. All scenarios increased the percent of adults meeting the SDG for saturated fat (**Figure 30**).

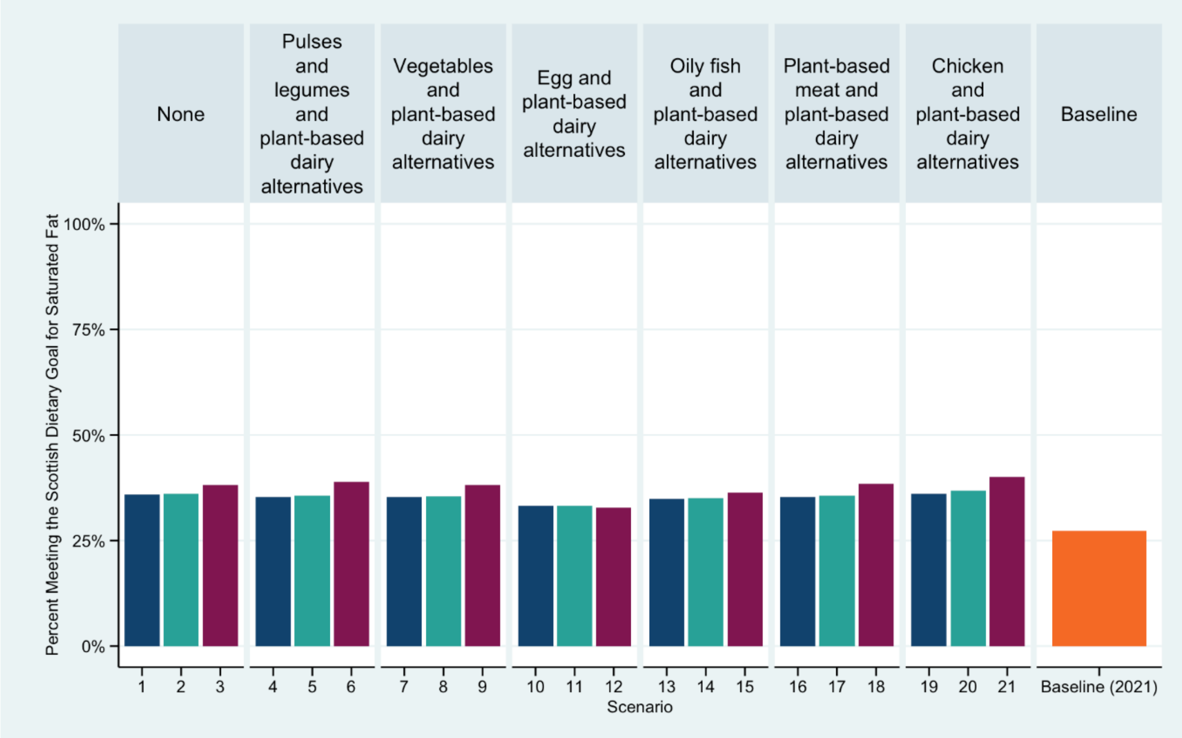


Figure 30. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for saturated fat (intake ≤11% food energy) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 22% of adults met the SDG for free sugars. All scenarios slightly decreased the percent of adults meeting the SDG for free sugars to 19-21% (**Figure 31**). The primary reason for this was a decline in energy intake (see **Figure 12**) rather than an increase in free sugars (<1g/day) (**Figure 33**).[30]

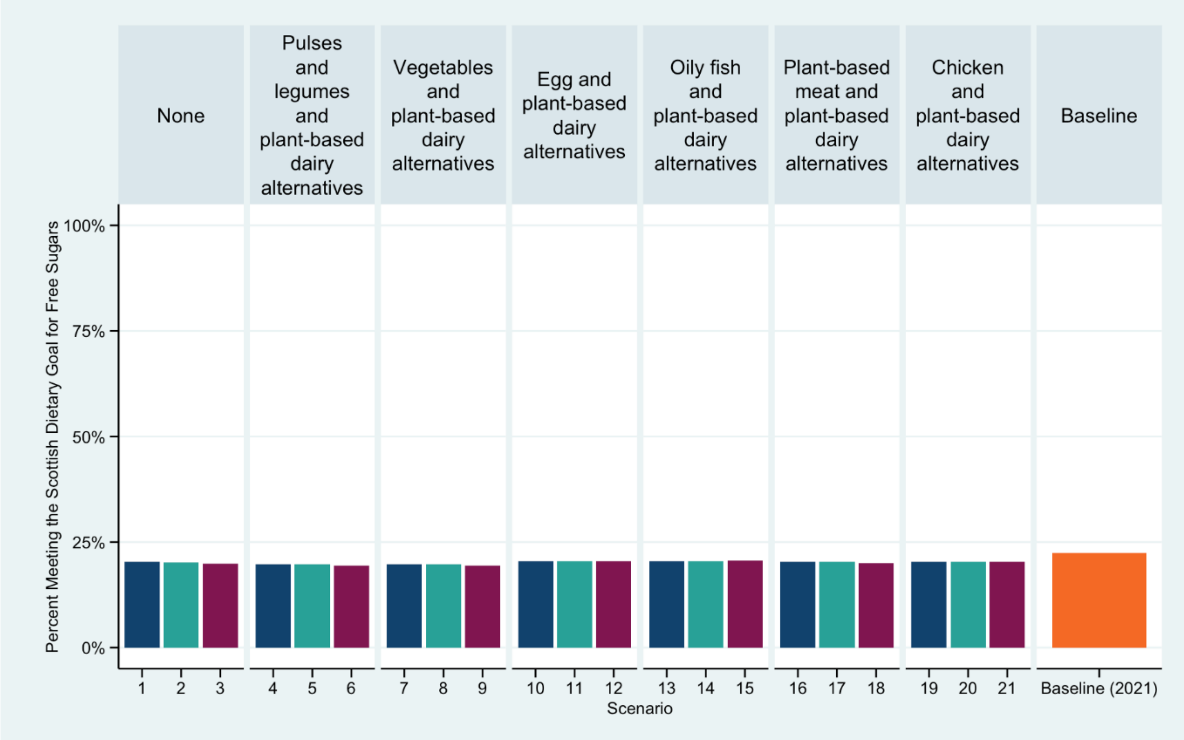


Figure 31. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for free sugars (intake ≤5% total energy) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

[30] The SDG is for average intake of free sugars not to exceed 5% of total energy and thus if total energy intake decreases, even without a change in free sugar intake, the percent of total energy from free sugars will increase.

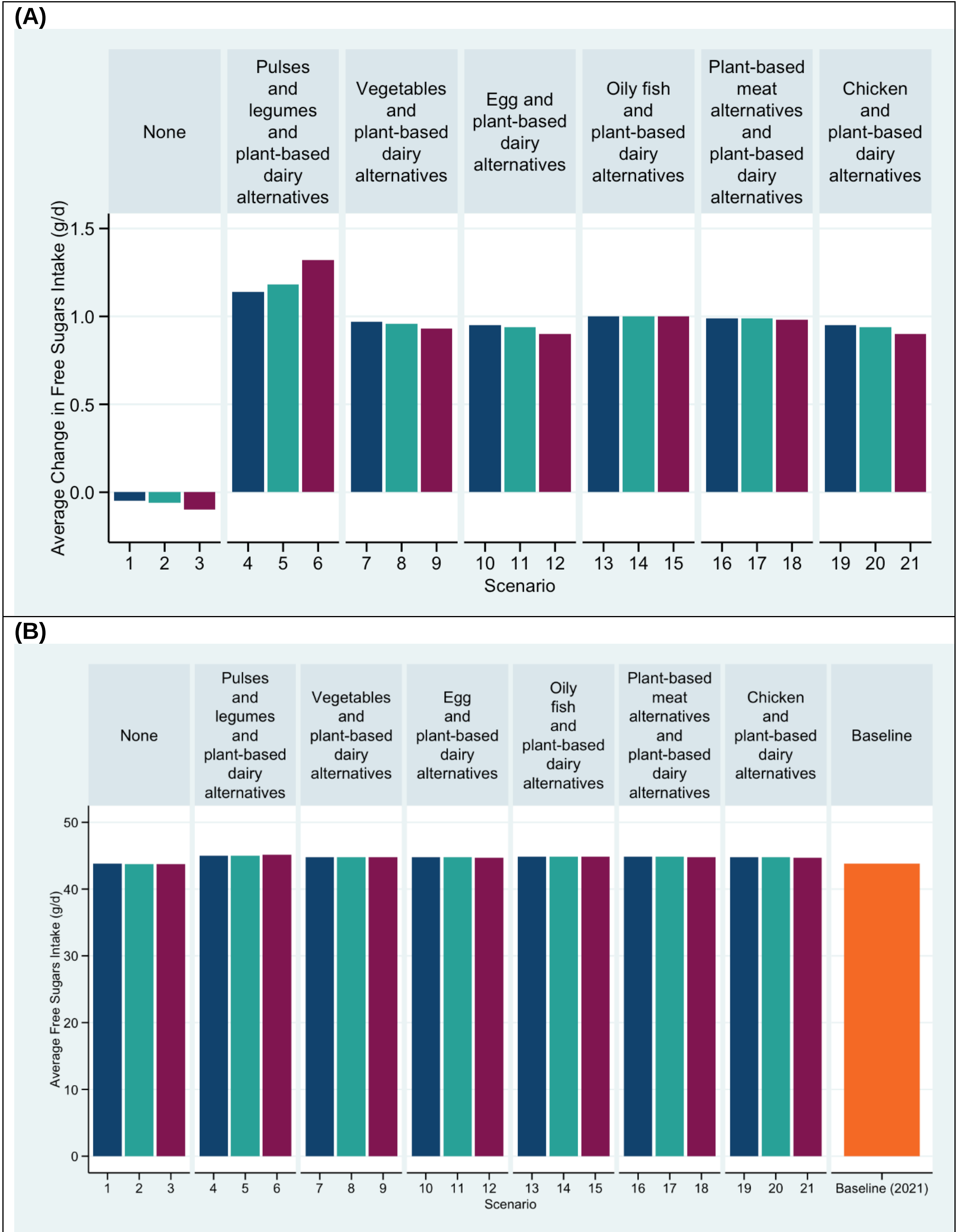


Figure 32. Average change (A) and average (B) free sugar intake (g/day) for 21 meat and dairy reduction scenarios with varying replacements.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 46% of adults met the SDG for total carbohydrates. All scenarios slightly increased the percent of adults meeting the SDG for total carbohydrates (**Figure 33**).

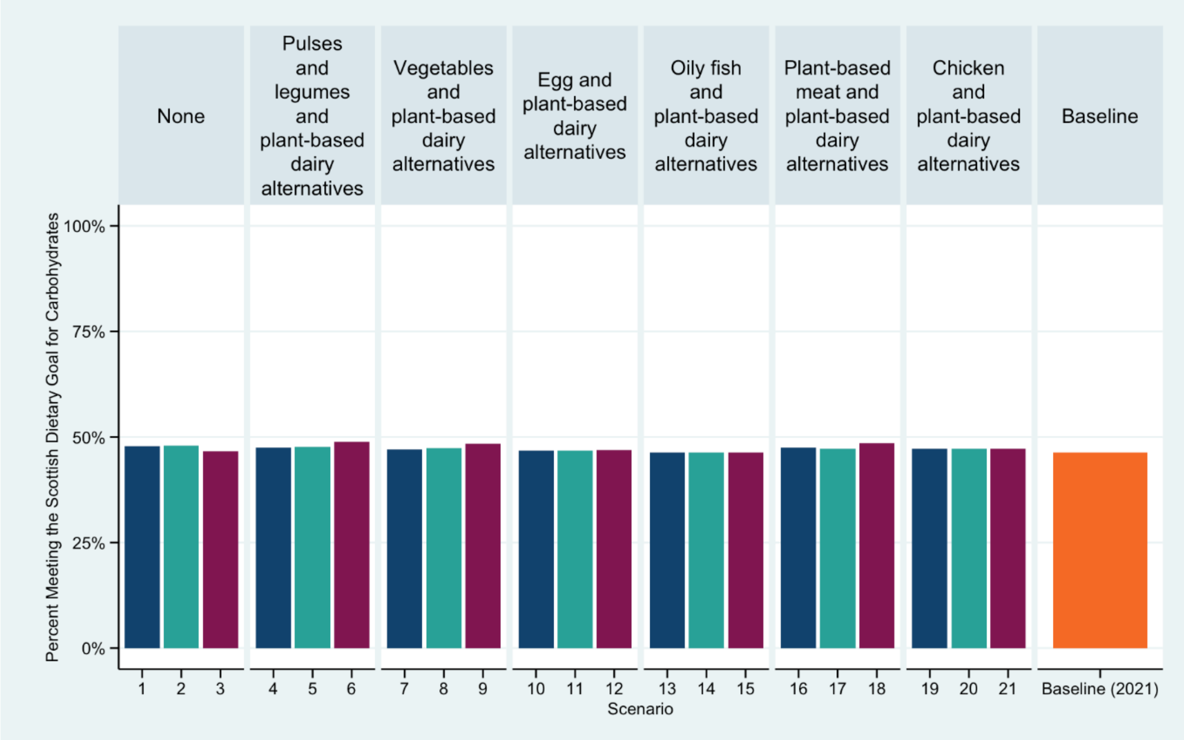


Figure 33. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for total carbohydrates (intake 45-55% total energy) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

At baseline, 77% of adults met the SDG for salt. All scenarios increased the percent of adults meeting the SDG for salt (**Figure 34**). However, it is well established that salt intake from dietary surveys is especially susceptible to measurement error due to challenges in reporting the amount of salt added during cooking and lack of specificity in food composition tables. The 2018/19 England Sodium Survey estimated salt intake for adults (19-64y) to be 8.4g/day using the reference method of 24-h urinary sodium excretion (Ashford et al. 2020), which is well above the SDG of 6g/day.

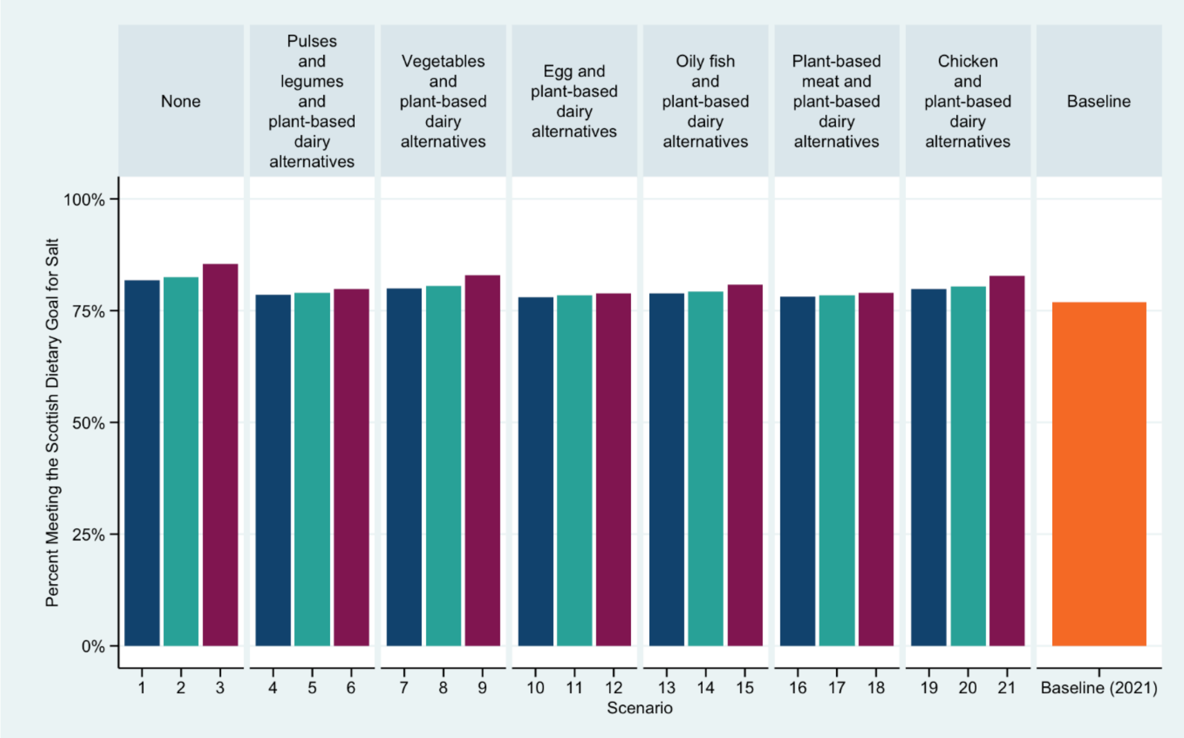


Figure 34. Percent of the adult (16+y) population living in Scotland meeting the Scottish Dietary Goal for salt (intake <6g/day) for 21 meat and dairy reduction scenarios with varying replacements of meat.

Dark blue bars are scenarios with a 20% reduction in dairy and 70g/day maximum red and red processed meat (RRPM) intake. Teal bars are scenarios with a 20% reduction in dairy and 60g/day maximum RRPM intake. Red bars are scenarios with a 20% reduction in dairy and 31g/day maximum RRPM intake.

Key Messages: **Impact of Reducing Meat and Dairy in Scotland on SDGs**

1. All scenarios increased the percent of adults meeting the SDG for red and red processed meat from 72% at baseline (2021) to 100%, and all scenarios increased the percent of adults meeting the SDG for calories.
2. Replacing 16-35% of 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.
3. Replacing 16-35% of meat with egg or oily fish can slightly increase the percent of adults meeting the SDGs for saturated fat, total carbohydrates, and salt.
4. Reducing meat and dairy by 16-35% may slightly reduce the percent of adults meeting the SDG for free sugars from 22% to 19-21% (depending on the replacement), but this is primarily because of a decline in energy intake rather than a major increase in free sugar intake.
5. There was not a meaningful impact of reducing meat and dairy – regardless of replacement – on the percent of adults meeting the SDGs for trans fat or fibre.

8. Simulation Results: Chronic Diseases

8.1. Approach to understanding the impact of reducing meat and dairy consumption on chronic diseases

The micro-Simulation of the Health Impacts of Food Transformations (mSHIFT, pre-print, 2023) was used to estimate:

H1. The impact of all high consumers of red and red processed meat reducing to 70g/day;

H2. The impact of all high consumers of red and red processed meat reducing to 70g/day plus a 20% reduction in all dairy (this is the most useful scenario to demonstrate both the achievement of the public health goal for red and red processed meat, and the worst-case scenario of no replacement – Scenario 1 in **Table 11**)

on the following health outcomes:

- Obesity
- Type 2 diabetes
- Cardiovascular disease (CVD)[31]
- All-cause mortality

The dietary change was assumed to occur in the first year of the simulation and maintained for subsequent years. In scenario H1, the health impacts only apply for those consuming above 70g/day while in scenario H2, all dairy consumers experience health impacts regardless of consumption level as the 20% reduction applies to all dairy consumers. In much of the literature used for the models, the health outcomes associated with unprocessed red meat and processed red meat consumption are distinct. Individuals who consume above 70g/day experience different health outcomes should they either reduce their processed or unprocessed red meat consumption to meet this maximum daily intake. Unprocessed and processed red meat were therefore reduced randomly in 10g increments until the 70g/day threshold was reached, with the range in health outcomes associated with alternate choices of unprocessed or processed red meat reductions being accounted for in the uncertainty interval.

The reduction in red and red processed meat and dairy intake results in a decrease in caloric intake. This decrease in caloric intake was then used to estimate impacts on obesity using an existing model that calculates the change in body weight from a change in caloric intake while accounting for age, sex, and physical activity levels (Hall et al. 2011). The change in weight then translates into a change in BMI, after accounting for height.

To estimate yearly prevented cases of type 2 diabetes and CVD, previously developed risk models (Alva et al. 2017, 217; D'Agostino et al. 2008) were used to calculate a baseline disease risk for each individual in the SHeS 2021 dataset based on non-dietary risk factors such as age, sex, BMI, and smoking status. This baseline risk was then multiplied by a relative risk associated with their average daily intake of unprocessed red meat, processed red meat and total dairy which were taken from meta-analyses (Yang et al. 2020; Feng et al. 2022) and a combined analysis of six US cohort studies (Zhong et al. 2020). No association between total dairy and CVD risk was assumed given meta-analyses do not find consistent effects (Guo

[31] For CVD, the risk prediction involves imputing blood pressure because blood pressure was not measured in SHeS 2021 but is required for predicting CVD risk. Together with the small number of cases of CVD, this results in substantial uncertainty in these estimates relative to obesity and type 2 diabetes.

et al. 2017; Chartres et al. 2020). Yearly baseline mortality risks were estimated based on age and sex-specific all-cause mortality rates in 2019 (National Records of Scotland 2020). Mortality risk for those with either CVD, diabetes, or both was then estimated by multiplying baseline mortality risk by the relative risk of all-cause mortality for those with each respective disease (Tancredi et al. 2015; The Emerging Risk Factors Collaboration 2015). Dietary change did not influence mortality risk directly, but rather indirectly through a change in disease incidence and subsequent mortality risk. Disease and mortality incidence were then estimated by multiplying individual disease risk by their sample weight, before summing over all individuals. Risk estimates were calibrated to ensure that predicted disease incidence matches observed incidence for each disease in the baseline scenario. Prevented cases of each disease were obtained by comparing the incidence in a baseline scenario with no dietary change to that in a scenario with dietary change.

Some caveats should be noted:

- We were not able to simulate the impact on colorectal cancer due to data limitations of SHeS as SHeS does not provide estimates for baseline prevalence of colorectal cancer.
- We did not model replacement of red and red processed meat or dairy with other foods and so results reflect only the reduction in these foods with no replacement.
- We did not separately model the direct effects of reducing meat and dairy on health from the indirect effects via reducing caloric intake. Given more evidence on substitution patterns in the future, these results could be updated. In this report, the effects reflect both direct and indirect effects of reducing meat and dairy with no replacement.
- We did not directly distinguish between the health effects arising from reducing meat versus reducing dairy. However, as noted in the following section, ~1,400 fewer type 2 diabetes cases were prevented over ten years when dairy was reduced, in addition to red and red processed meat. In other words, because of the reduced risk of type 2 diabetes associated with dairy consumption, when both dairy and meat are reduced, the benefits in terms of type 2 diabetes cases prevented are attenuated.

8.2. Overall effects on chronic diseases

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:

- Average BMI reduction: 0.36 kg/m^2 (95% UI, 0.16-0.99) (~1% decrease)
- Type 2 diabetes: 10,036 (95% UI, 7,176-12,803) cases prevented (~5% of new cases)
- CVD: 2,897 (95% UI, 754-4,985) cases prevented (~1% of new cases)
- All-cause mortality: 337 (95% UI, 134-572) 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:

- Average BMI reduction: 1.00 kg/m^2 (95% UI, 0.46-2.70) (~4% decrease)
- Type 2 diabetes: 8,651 (95% UI, 4,955, 12,194) cases prevented (~4% of new cases)
- CVD: 2,847 (95% UI, 682-4,960) cases prevented (~1% of new cases)
- All-cause mortality: 311 (95% UI, 78-561) prevented deaths

8.3. Effects on chronic diseases by population subgroup

The largest health benefits in terms of cases of type 2 diabetes prevented, for both H1 (**Figure 35**) and H2 (**Figure 36**), were observed in men 50-64y: about one-third (~31-32%) of type 2 diabetes cases prevented over a ten-year period were in this population subgroup. The largest health benefits in terms of cases of CVD prevented, for both H1 and H2, were observed in men 65+y: ~37-38% of CVD cases prevented over a ten-year period were in this population subgroup.

About 60% of the type 2 diabetes cases prevented and ~46% of the CVD cases prevented over a ten-year period were in adults with a BMI ≥30 kg/m^2 for both H1 (**Figure 35**) and H2 (**Figure 36**). Adults living in SIMD4 and SIMD5 accounted for the smallest proportion of cases of type 2 diabetes and CVD, ~14-18% of cases for both chronic diseases for both scenarios.

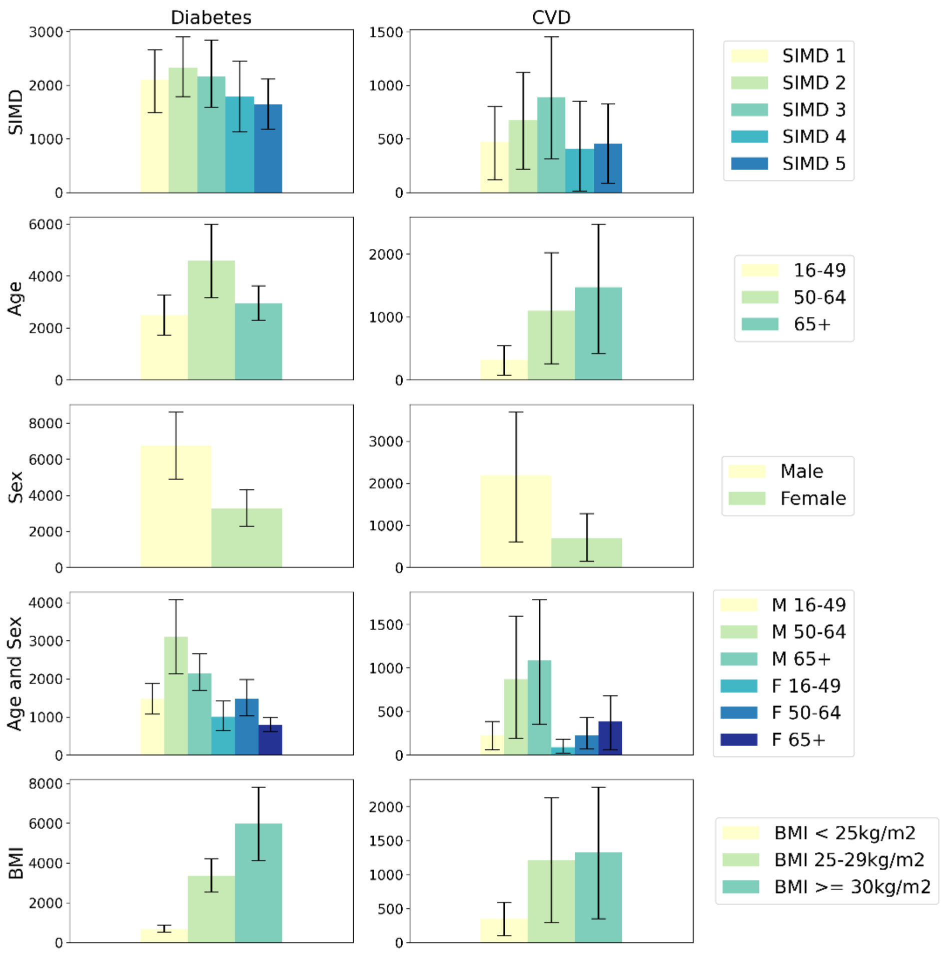


Figure 35. Number of prevented cases of type 2 diabetes and cardiovascular disease (CVD) by population subgroup following a reduction in red and red processed meat intake to a maximum of 70g/day, with no replacement, over a ten-year period.

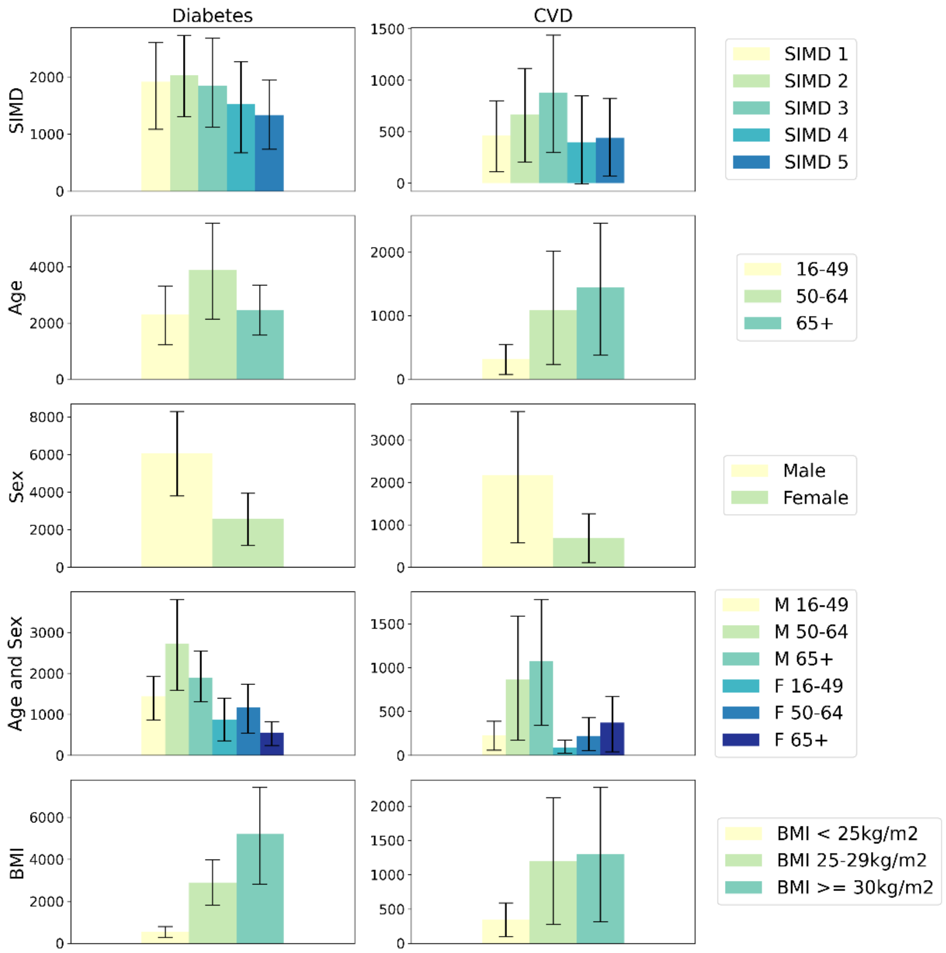


Figure 36. Number of prevented cases of type 2 diabetes and cardiovascular disease (CVD) by population subgroup following a reduction in red and red processed meat intake to a maximum of 70g/day and a 20% reduction in dairy, with no replacement, over a ten-year period.

9. Conclusions

Most people in Scotland reported consuming meat (86% of adults 16+y) and dairy (99%), so any recommended changes to meat and dairy consumption may impact a lot of people. Men aged 25-34y are the highest meat consumers. Men aged 75+y are the highest dairy consumers.

Analyses of current intakes of meat and dairy in Scotland provide insights that can inform advice to help consumers reduce their intake. For example,

- One-quarter of meat consumed is beef.
- Homemade dishes containing chicken or beef, such as a chicken breast or spaghetti Bolognese, and ham sandwiches are some of the most common ways in which adults in Scotland consume meat.
- Consumption of red and red processed meat is highest on Sundays and during dinners.
- 10-12% of red and red processed meat was purchased at cafes, restaurants, pubs, and takeaways.
- More than half of dairy (67%) was consumed as milk.
- Smaller proportions of dairy come from cheese (14%), yoghurt (9%), butter (7%), and cream (2%).

There is evidence of substantial under-reporting of dietary intake overall, and it is not known how this may influence estimates of nutrient intake. It is possible that nutrient insufficiency is over-estimated as a result. More work is needed to understand this reporting gap.

Based on the data at hand, most adults living in Scotland have low intakes of at least one nutrient of interest explored within this research. Due to higher requirements, young people are at higher risk of insufficiency for many nutrients compared to adults. With the exception of vitamin B_{12}, about half of calcium, iodine, selenium and zinc and about three-quarters of iron consumed by adults in Scotland comes from sources other than meat and dairy. Meat contributes about a quarter of selenium and zinc in the diet, and dairy about a third of calcium, iodine, and vitamin B_{12}.

Therefore, reducing meat and dairy without appropriate replacement would increase the percentage of the population with insufficient intakes of these nutrients. In order to minimise this impact, a focus on high consumers, particularly of red and red processed meat, is an alternative approach to recommending all consumers reduce all their meat (including poultry).

- If all adults living in Scotland met the Scottish Dietary Goal for red and processed red meat (70g/day), it would result in a 16% reduction in the population average “all meat” intake as defined by the CCC. This would affect 28% of the population.
- In order to achieve a 20% reduction in the population average “all 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 consumption, 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.

Under the most useful scenario to demonstrate both the achievement of the public health goal for red and red processed meat, which is the worst-case scenario of no replacement,[32]

- The percentages of the population below the RNI for calcium, iodine, and zinc would increase by ~8-9 percentage points.
- The percentages of the population below the RNI for iron, selenium, and vitamin B_{12} would increase by ~1-2 percentage points.
- Intakes of protein are not of concern at baseline or after meat and dairy reductions.
- There were no substantial differences in intakes at baseline or after meat and dairy reductions between SIMD groups.

The modelling with replacement showed that replacement of meat and dairy with alternative foods and drinks such as vegetables, beans and pulses, oily fish, eggs, and plant-based dairy alternatives can help ensure existing insufficiencies do not worsen. Indeed, replacement with some foods improved nutrient intake. For example, replacement of meat with oily fish increased selenium intake, though not enough to meet the RNI in most cases given how low selenium is currently.

The modelling also indicated potential positive impacts on overall diet, when reductions are made and replacements are included. There was a slight increase in the percentages of adults meeting the Scottish Dietary Goals for red and red processed meat, calories, fruit and vegetables, total fat, saturated fat, total carbohydrates, and salt. This translates into modest reductions in population average BMI and ~4-5% of new cases of type 2 diabetes being prevented.

Little is known regarding what people who reduce meat and dairy in Scotland will replace these foods with – if anything. UK-wide trend analyses suggest that red meat and processed meat have been replaced with white meat, and possibly with oily fish, eggs, and plant-based meat alternatives. However, there is wide variability in the nutrient content of plant-based meat and dairy alternatives available in Scotland. Only 45% of the 55 plant-based milk drinks evaluated are fortified with calcium. Only 15% are fortified with iodine and to the best of our knowledge, none are fortified with iron, selenium, or zinc. Similarly, fewer than half of plant-based meat alternatives are fortified with iron.

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 nutrients. The modelling demonstrated that the 20% reduction in all meat can be achieved by cutting intakes of high consumers of red and red processed meat only to 60g, which would help ensure that insufficiencies in intake do not become more widespread in the population. The research has also shown that it is possible to mitigate the negative impact of a shift away from meat and dairy on nutrient intakes, with careful consideration of replacements.

[32] Everyone meeting the Scottish Dietary Goal for red and red processed meat of limiting intake to 70g/day and 20% reduction in dairy, with no replacement for either.

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