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Eating habits and sociodemographic factors impact household dietary greenhouse gas emissions reduction in Great Britain

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Dietary changes can substantially reduce greenhouse gas emissions in Great Britain. Guidelines recommend reducing meat and dairy consumption while increasing plant-based foods, but household purchasing habits achieving these shifts are not well understood. Here we analysed food purchase data from ~30,000 British households (2012–2019), identifying 709 households that reduced their dietary greenhouse gas emissions by 34%. Using latent class analysis, we identified two distinct clusters among these households: plant-based adopters who reduced meat and dairy, adopting healthier diets; and households replacing meat with dairy and convenience foods, showing less healthy dietary changes. Plant-based adopters typically had higher education, higher incomes, were older (45+ years), and smaller in size. Households shifting toward dairy and convenience foods were older and smaller. Supporting healthy and sustainable diets requires targeted policies to enhance affordability, availability, and convenience of nutritious plant-based foods.

The United Kingdom (UK) has committed to achieving net-zero greenhouse gas emissions (GHGE) by 2050[1]. While emissions have already been halved since the 1990s through reductions in the power sector[2], further substantial GHGE reductions can be achieved within the food system, which accounts for ~19% of the UK's total GHGE[3].

High-income nations like the UK typically have diets that produce more GHGE than the global average, characterised by high consumption of animal-based foods, which are the largest contributors to food-related emissions in the UK[4]. Shifting to plant-based diets, which have lower carbon footprints, can substantially reduce GHGE[5]. UK diets also deviate from Public Health England's 'Eatwell Guide', with inadequate intake of fruits, vegetables, and fibre, alongside higher-than-recommended consumption of red meats, sugar, and saturated fats[6]. Diet-related diseases cost the NHS £5 billion annually[7]. Healthy and sustainable diets that have lower GHGE can help the UK meet emission targets, improve public health, and ease healthcare system burdens[8–10].

Despite increasing awareness of the environmental impact of diets, dietary change remains slow, with relatively low adoption rates of meat-free and flexitarian diets[11]. Understanding how a large proportion of people can change their diet to reduce GHGE is crucial for developing effective interventions. Several studies on dietary patterns and GHGE rely on cross-sectional data or hypothetical diet scenarios, such as reducing animal-based products or adopting Mediterranean diets[3,12]. These studies often oversimplify food substitutions—assuming direct replacements of meat with grains or vegetables—without considering the complexity and practicality of changes within the British dietary context. Furthermore, many studies focus on individual food groups, such as increasing fruit and vegetable consumption or replacing meat with plant-based alternatives, but do not consider all food groups in shaping dietary patterns[13,14].

Understanding dietary transitions requires considering socio-demographic factors, as diet quality and consumption patterns are heavily influenced by income, education, occupation, gender, age and time constraints. Higher socio-economic status is often associated to healthier and more sustainable diets with lower consumption of animal-based foods, in particular red meat, and greater consumption of plant-based foods such as fruits and vegetables[15–17]. In contrast, individuals with a lower socio-economic status have been associated with lower diet sustainability and tend

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to consume more energy-dense, nutrient-poor foods due to disparities in income, education, and food affordability[18–20].

Behavioural change theories provide frameworks to help understand the adoption of dietary changes. At the population level, Rogers' Diffusion of Innovations theory suggests that the adoption of new practices occurs gradually, with different groups adopting innovations at different paces, which is influenced by socio-demographic factors that define these groups[21]. Studies focusing on dietary transitions at the individual level also highlight the importance of gradual shifts over time rather than abrupt changes, as incremental adjustments can reduce psychological and practical barriers to behaviour change[22,23]. Flexitarians exemplify this approach, which is individuals who make small changes to their diet, such as reducing meat consumption without eliminating it entirely. Gradual changes, such as reducing portion sizes, have been identified as a significant driver of meat reduction in the UK, contributing to environmental and health benefits[24].

To inform interventions and policies for sustainable eating habits, it is essential to understand real-world dietary changes and the factors influencing the adoption of sustainable diets. This study employs a novel approach by analysing longitudinal data from Kantar's Worldpanel Take Home dataset, which includes detailed household food purchase information from approximately 30,000 households in Great Britain (GB), alongside socio-demographic data from 2012 to 2019. We identified a subset of 'Champion' households that substantially reduced their food-related GHGE footprint over time, driven primarily by decreased meat consumption. By examining changes in their food purchasing patterns, we identified two distinct dietary shifts contributing to lower emissions and explored associated socio-demographic characteristics. This study highlights the need for policies addressing barriers such as cost, availability, and familiarity with plant-based options, particularly to engage lower socio-economic groups and larger households in adopting sustainable diets at scale.

Results

Drivers of GHGE reductions in 'Champion' households

We identified 709 'Champion' households, accounting for 3.3% of the total sample, who have substantially reduced their above-average GHGE footprints between January 2012 and December 2019. These households achieved a 34% reduction in GHGE, decreasing from a mean of 4.4 kg carbon dioxide equivalent (CO_2e) per day in 2012–2014 to 2.9 kg CO_2e per day in 2017–2019 per household member (Fig. 1). The average per capita GHGE footprint across the total sample remained relatively stable over the observation periods, at 3.4 kg CO_2e per day, with only minor fluctuations (Supplementary Fig. 1).

The reduction in GHGE from 'Champion' households was driven by shifts in purchasing patterns across various food categories. In 2012–2014, beef contributed most to GHGE among all food categories. By 2017–2019, GHGE from beef products decreased by ~67%. Pork decreased by 47%, meat-other by 45%, lamb by 42%, poultry by 29%, and cheese by 17%. Milk, yoghurt, and cream were the second-largest contributors to GHGE in 2012–2014 and became the leading contributors in 2017–2019, overtaking beef. GHGE from milk, yoghurt, and cream decreased modestly by 2% over the period.

Shifts in food purchasing in 'Champion' households

The analysis of the average purchase volume per food products in 'Champion' households shows a growing preference for plant-based options from 2012 to 2019, which is reflected in the changing shares of food products in the total purchasing volume. Mean volume shares of food products for the periods 2012–2014 and 2017–2019, as well as the associated percentage changes, are presented in Fig. 2.

The share of plant-based dairy alternatives increased the most, from 0.9% in 2012–2014 to 3.3% in 2017–2019. Similarly, the share of fruits in the purchasing volume increased, from 9.2% to 11.4%, while the share of vegetables increased from 11.4% to 12.9%. Milk, yoghurt, and cream, which already accounted for a high share of household purchases, increased from 18.3% to 19.7%. There was also an increase in plant-based meat alternatives, from 0.2% to 0.6%. Smaller increases were observed in legumes and pulses (+0.2 percentage points), edible ices and desserts (+0.2 ppt), snacks (+0.1 ppt), and nuts and seeds (+0.1 ppt).

Conversely, the share of several animal-sourced and other food categories has decreased on average. The most substantial reduction occurred in poultry, which dropped from 3.4% to 1.8%, followed by beef from 1.5% to 0.4%. Similarly, other meats decreased from 3.1% to 2.1%, while pork fell from 1.7% to 0.8%. Declines were also observed in spices, condiments, and sauces (−0.6 ppt), starchy vegetables (−0.4 ppt), sugars and sweeteners (−0.3 ppt), cereals (−0.3 ppt), lamb (−0.3 ppt), and cheese (−0.3 ppt).

Distinct changes in food purchasing patterns in 'Champion' households

Changes in purchasing patterns among 'Champion' households were grouped into two distinct clusters using Latent Class Analysis (LCA): 'plant-based adopters' (Cluster 1) and 'meat to dairy' (Cluster 2). The 'plant-based adopters' consisted of 277 households, while the 'meat to dairy' cluster included 432 households. While both clusters reduced their purchases of beef, poultry, pork, and other meats at similar rates, they differed substantially in their changes to other food categories (Fig. 3).

Households in the 'plant-based adopters' cluster showed substantial increases in plant-based and healthier options. The largest rise was in vegetables (+4.0 ppt), followed by plant-based dairy alternatives (+3.9 ppt), fruits (+3.8 ppt), and plant-based meat alternatives (+0.9 ppt). Additional increases were observed in legumes and pulses (+0.5 ppt) and nuts and

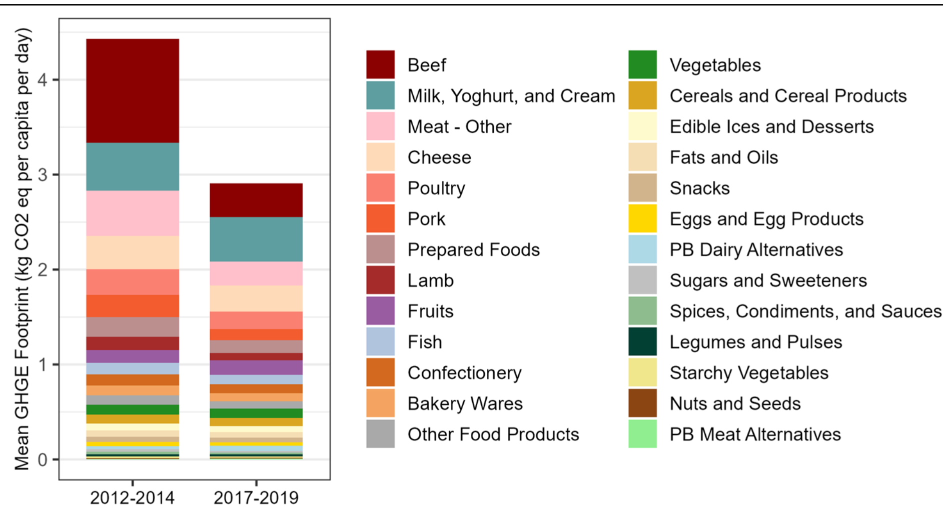

Fig. 1 | Mean daily GHGE from food purchases in 'Champion' households over two periods. Mean daily GHGE per capita (kg CO_2e per day) for 'Champion' households during 2012–2014 and 2017–2019. Each bar represents cumulative emissions segmented by food group. Food groups are ranked vertically according to their contribution to total GHGE in the 2012–2014 period, from highest to lowest. Data source: Kantar Worldpanel Take Home data (52 w/e Dec. 2012–2019), GHGE factors from Clark et al.[25].

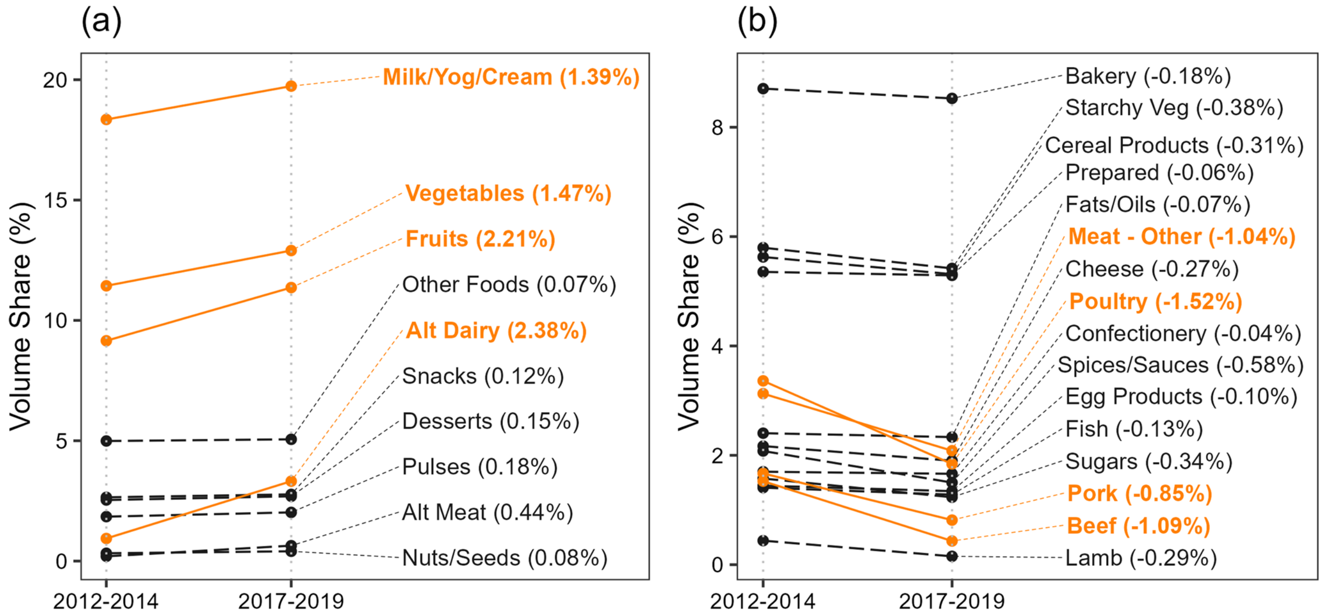

Fig. 2 | Change in food product volume shares for 'Champion' households between 2012–2014 and 2017–2019. Mean change in the share of food products in household shopping volumes from 2012–2014 to 2017–2019 (percentage points). **a** shows food categories with increased volume shares, and (**b**) shows categories with decreased volume shares. Bold orange elements indicate food groups with the greatest increases or decreases in share. Data source: Kantar Worldpanel Take Home data (52 w/e Dec. 2012–2019).

seeds (+0.2 ppt). Conversely, these households reduced the share of animal-based products, such as milk, yoghurt, and cream (−3.8 ppt), poultry (−2.1 ppt), other meats (−1.4 ppt), beef (−1.2 ppt), pork (−1.0 ppt), and lamb (−0.3 ppt).

Households in the 'meat to dairy' cluster demonstrated a different pattern of change, characterised by considerable increases in certain dairy products and reductions in various meats. The largest increase was in milk, yoghurt, and cream (+4.6 ppt), followed by fruits (+1.4 ppt). While increases in plant-based dairy alternatives, desserts, snacks, prepared foods, and bakery wares were observed in this cluster, there was high variability among households. Similar to the 'plant-based adopters', households in the 'meat to dairy' cluster substantially reduced their purchases of meat products, such as poultry (−1.5 ppt), beef (−1.3 ppt), other meats (−1.1 ppt), and pork (−0.9 ppt). Additional reductions occurred in starchy vegetables (-0.7 ppt), cheese (−0.4 ppt), lamb (−0.3 ppt), and fish (−0.3 ppt). Other observed changes in both clusters were less consistent due to high variability between households.

These changes in purchasing patterns resulted in similar relative reductions in GHGE across clusters. The 'plant-based adopters' reduced their GHGE by 35%, from 4.0 kg CO_2e per day to 2.6 kg CO_2e per day, while the 'meat to dairy' cluster achieved a 33% reduction, from 4.8 kg CO_2e per day to 3.2 kg CO_2e per day (Supplementary Fig. 1). Overall shopping volumes also declined, with the largest reduction observed in the 'meat to dairy' cluster (−9.0%), compared to smaller decreases in the 'plant-based adopters' (−1.3%) and the total sample (−3.1%) (Supplementary Fig. 2). Daily per capita kilocalorie (kcal) purchases also declined among 'Champion' households. The 'plant-based adopters' reduced their average energy purchases by 14.3%, from 1283 kcal per day to 1099 kcal per day, while the 'meat to dairy' cluster saw a reduction of 14.4%, from 1500 kcal per day to 1284 kcal per day. In comparison, households in the total sample decreased average energy purchases by 4.4%, from 1190 kcal per day to 1138 kcal per day (Supplementary Fig. 3).

Characteristics of 'plant-based adopters' and 'meat to dairy' households

The logistic regression analysis identified sociodemographic characteristics distinguishing the 'plant-based adopters' and 'meat to dairy' households from the total sample of all households in the dataset. This analysis highlights the unique traits of these clusters compared to the broader population (detailed significance levels are presented in Fig. 4).

'Plant-based adopters' households were predominantly characterised by higher education levels, older age groups, smaller household size, and elevated income. Specifically, households with a degree were 3.1 times more likely to belong to the 'plant-based adopters' cluster compared to households with no educational qualifications (OR = 3.1, 95% CI: 1.7–6.3, $p < 0.001$). Similarly, households holding A level, higher education, or other qualifications had an increased likelihood of membership (OR = 2.8, 95% CI: 1.5–5.5, $p = 0.002$), as did those with GCSE qualifications (UK secondary school qualifications, typically at age 16) (OR = 2.1, 95% CI: 1.1–4.3, $p = 0.033$). Age was another significant factor; households headed by individuals aged 45–64 were 1.5 times more likely to belong to the 'plant-based adopters' cluster compared to those aged 18–44 (OR = 1.5, 95% CI: 1.1–2.0, $p = 0.017$). Household size inversely influenced membership, with households comprising three or more members being 47% less likely to belong to the 'plant-based adopters' cluster compared to single-member households (OR = 0.5, 95% CI: 0.4–0.8, $p = 0.004$). Households with two members also showed a reduced likelihood of affiliation compared to single-member households (OR = 0.7, 95% CI: 0.5–1.0, $p = 0.029$). Higher income levels were positively associated, as households in the highest income bracket (earning over £39,999 per annum) were 1.6 times more likely to belong to the 'plant-based adopters' cluster compared to those earning less than £20,000 per annum (OR = 1.6, 95% CI: 1.1–2.4, $p = 0.012$). Additionally, households identifying as white were 1.8 times more likely to be in the 'plant-based adopters' cluster compared to households of other ethnicities (OR = 1.9, 95% CI: 1.1–3.3, $p = 0.028$), though this was a weak association that did not remain significant after stricter p value criteria.

'Meat to dairy' households were primarily distinguished by older age and smaller household size. Households headed by individuals aged 65 and above were 1.6 times more likely to belong to the 'meat to dairy' cluster compared to those aged 18–44 (OR = 1.6, 95% CI: 1.2–2.1, $p = 0.005$). Similarly, households headed by individuals aged 45–64 were 1.4 times more likely to belong to the 'meat to dairy' cluster compared to the 18–44 age group (OR = 1.4, 95% CI: 1.0–1.9, $p = 0.013$). Household size was also a significant predictor; households with three or more members were 51% less

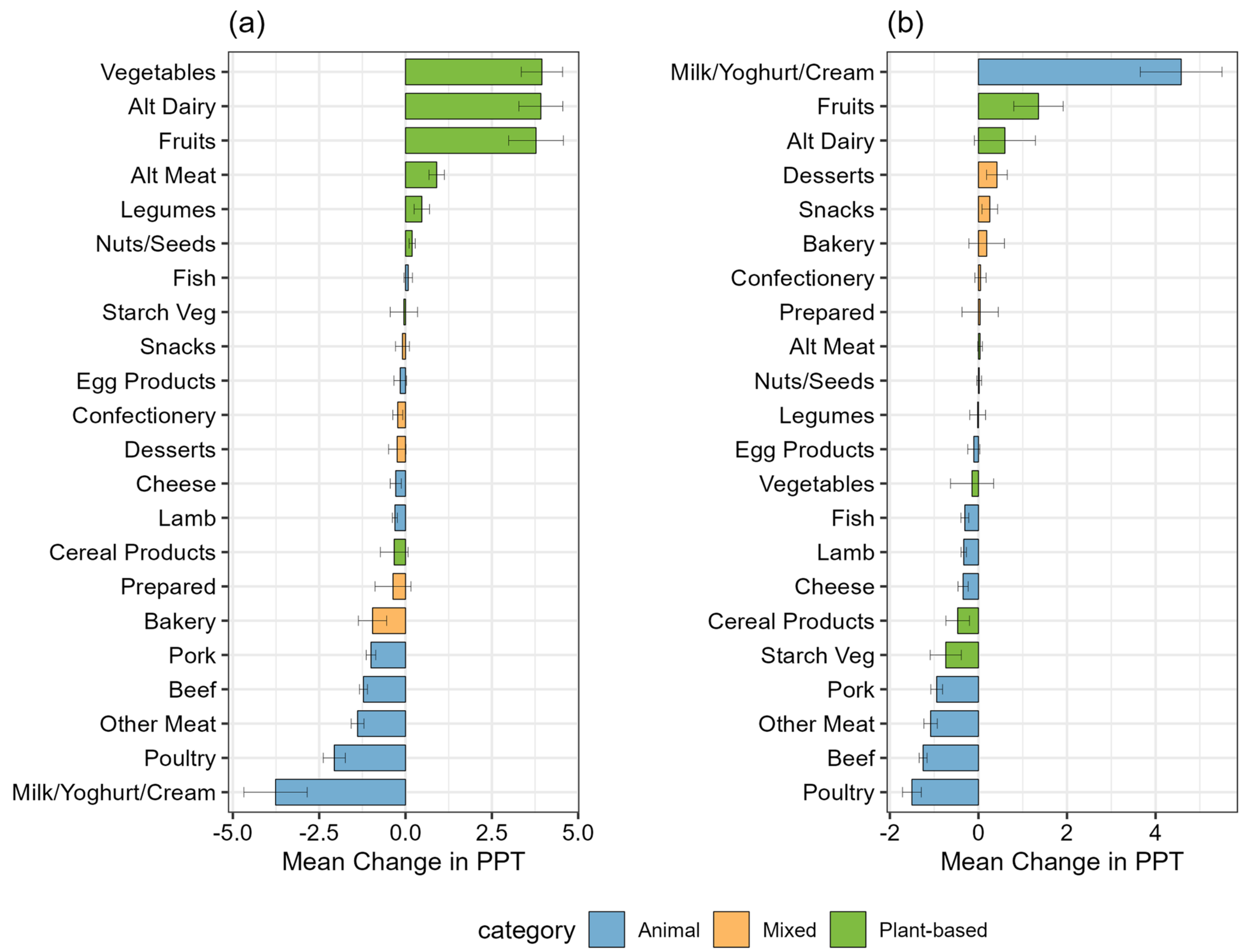

Fig. 3 | Mean change in food product volume shares for clusters based on household purchasing patterns. Mean changes in the share of food products in household shopping volumes from 2012–2014 to 2017–2019. **a** Shows results for the 'plant-based adopters', and (**b**) for the 'meat to dairy' cluster, both identified through latent class analysis (LCA). Bars represent mean changes in food category shares, coloured by category type: animal (blue), mixed (orange), and plant-based (green). Error bars indicate 95% confidence intervals. Data source: Kantar Worldpanel Take Home data (52 w/e Dec. 2012–2019).

likely to belong to the 'meat to dairy' cluster compared to single-member households (OR = 0.5, 95% CI: 0.4–0.7, $p < 0.001$), and two-member households were 23% less likely to be part of the cluster compared to single-member households (OR = 0.8, 95% CI: 0.6–1.0, $p = 0.028$). Additionally, households identifying as white were 1.6 times more likely to belong to the 'meat to dairy' cluster compared to households of other ethnicities (OR = 1.6, 95% CI: 1.0–2.6, $p = 0.043$), but this association did not meet stricter p-value thresholds after corrections. Social class was marginally associated with membership, with higher social classes (Class A–B) being 1.3 times more likely than skilled working class and lower (Class D–E) to belong to the cluster (OR = 1.3, 95% CI: 1.0–1.8, $p = 0.050$), but this also did not hold under stricter p-value criteria.

For both clusters, the presence of children interacted with household size. When household size was excluded from the models, having children significantly reduced the likelihood of belonging to both the 'plant-based adopters' and 'meat to dairy' clusters.

Discussion

Summary of findings

While overall dietary GHGE footprints in GB households remained stable between 2012 and 2019, we identified a subset of 'Champion' households that achieved considerable reductions in their individual footprints, starting from above-average footprints. These reductions were primarily driven by decreased meat purchases. The foods purchased to substitute meat varied and resulted in the identification of two distinct clusters of dietary change: 'Plant-based adopters' increased plant-based food purchases like fruits, vegetables, and plant-based meat and dairy alternatives, while those in the 'meat to dairy' cluster increased dairy, fruits, and convenience food purchases.

Socio-demographic analysis linked 'plant-based adopters' with higher education and incomes, smaller households, and individuals aged 45 and older. The 'meat to dairy' cluster was also linked to older age and smaller households, but other socio-demographic associations were more mixed, indicating varied motivations and influences behind their changes.

Patterns of dietary transition and GHGE reduction

The reduction in GHGE in 'Champion' households was largely driven by decreased meat purchases—especially beef—and shifts towards lower-emission foods. Notably, despite differences in their changing purchasing patterns, both clusters identified in our analysis shared the common factor of reducing meat purchases. This aligns with studies showing that reducing animal-source foods is a key strategy for lowering diet-related GHGE[25–27] and supports the UK's Committee on Climate Change recommendations of meat reduction for achieving net-zero GHGE by 2050[2].

However, the dietary transitions within 'Champion' households were not uniform. Households in the 'plant-based adopter' cluster brought their

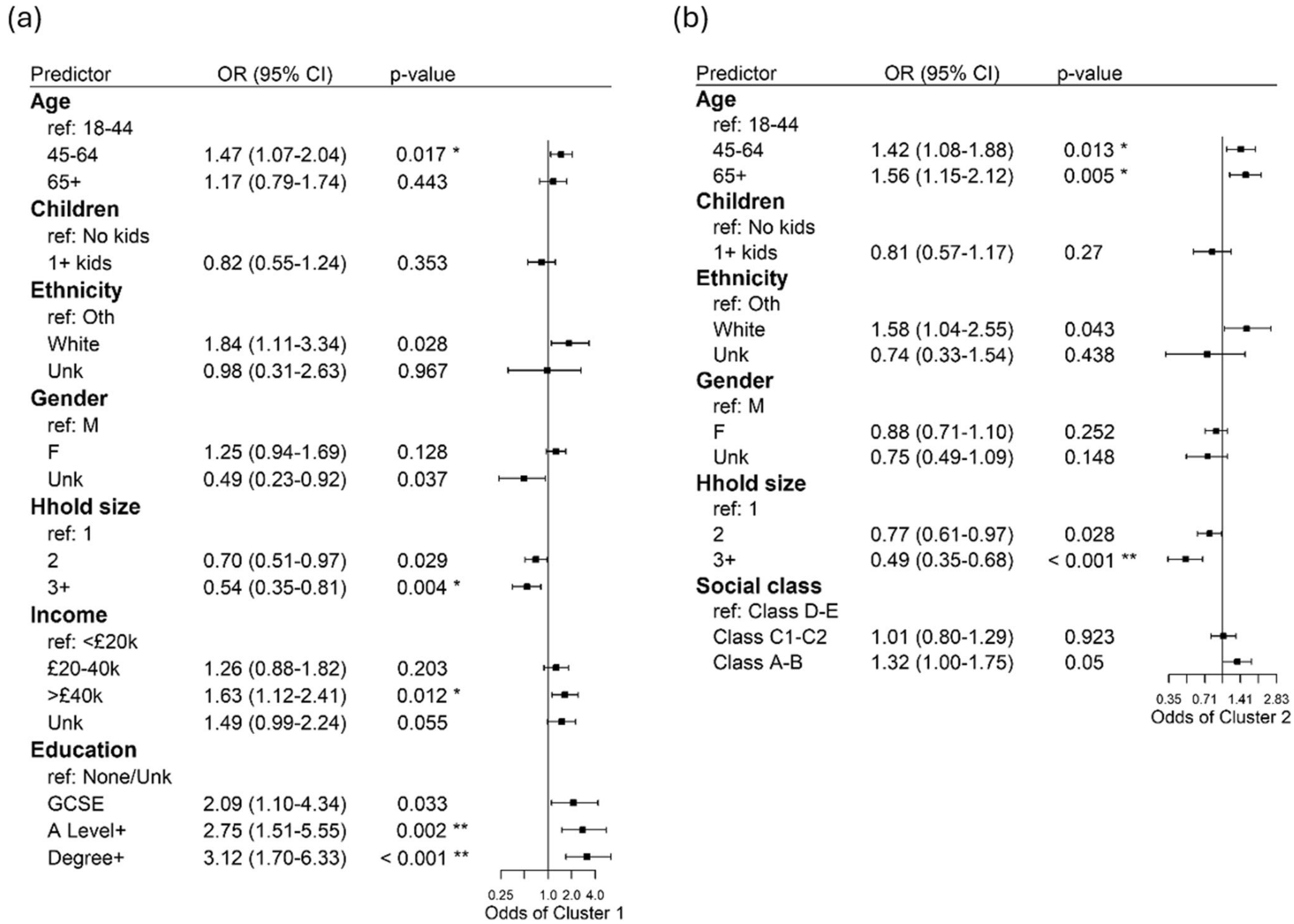

Fig. 4 | Sociodemographic predictors of membership in household purchasing pattern clusters. Comparison of sociodemographic characteristics of two clusters of household purchasing patterns, 'plant-based adopters' (**a**) and 'meat to dairy' clusters (**b**), relative to the total household sample. The odds ratios (OR) and 95% confidence intervals (CIs) from logistic regression analysis indicate the likelihood of belonging to each cluster compared to reference categories (marked as 'ref'). Odds ratios greater than 1 indicate increased likelihood of belonging to the respective cluster, while ratios below 1 indicate reduced likelihood. Statistical significance levels are indicated as follows: (*) significant after false discovery rate (FDR) adjustment ($p < 0.05$); (**) significant after both FDR and Bonferroni adjustments ($p < 0.05$). Data source: Kantar Worldpanel Take Home data (52 w/e Dec. 2012–2019).

purchase patterns more in line with sustainable dietary guidelines such as the EAT-Lancet recommendations, characterised by a low consumption of animal-sourced foods and a relatively high proportion of whole and plant-based foods like fruits, vegetables legumes, and nuts. Such diets are consistently associated with lower mortality and improved health outcomes, particularly in high-income settings[10,28]. Likewise, diets with lower GHGE have been linked to reduced all-cause mortality and increased life expectancy when maintained throughout adulthood[8,9]. The substantial reduction in beef across both clusters is noteworthy, given beef's high GHGE footprints and its links to higher risks of cardiovascular disease and cancer mortality[29].

While households in the 'meat to dairy' cluster also reduced meat intake, they increased their purchases of dairy products and fruits, and to a lesser extent, convenience foods such as snacks and prepared foods. These easy-to-prepare products may reflect lifestyle factors such as limited time, lower cooking skills, or a higher preference for convenience[30,31]. 'Meat to dairy' households appear to consume more snacks and dairy products around the main meals rather than replacing the reduced meat with plant-based alternatives in meals such as legumes or plant-based meat substitutes. Although this shift led to a lower GHGE footprint than their original diet, this transition may not necessarily contribute to a healthy diet. The increased intake of processed foods could have negative health effects[32]. This highlights that reducing GHGE footprints does not always improve health outcomes and underlines the need to consider nutritional adequacy for consumers in policies and interventions promoting dietary sustainability[27].

Both clusters demonstrate a flexible dietary approach at the household level by reducing rather than entirely abstaining from meat. In larger households, these dietary shifts may reflect an average effect across members rather than individual-level changes. More drastic reductions or complete elimination of animal-based foods by some individuals could have been masked by moderate or unchanged consumption by others.

An analysis of the changes in food purchases in single-member 'Champion' households reveals trends consistent with those observed across all 'Champion' households (Supplementary Fig. 4). At the individual level, this flexible pattern reflects an evolving dietary transition, where initial reductions—often triggered by health, environmental and ethical concerns—are reinforced over time by additional motivations and practical factors such as taste preferences, price, and social influences[33,34].

Evidence from high-income countries suggests that targeting reducetarians or flexitarians can facilitate dietary transitions at a much faster pace, as their flexibility lowers the psychological and social barriers of fully giving up animal-sourced products[24]. Studies from these contexts also highlight that improving the availability, price, sensory experience, and convenience of plant-based options in retail is essential to make sustainable choices more accessible[14,35]. Plant-based alternatives that meet consumers' expectations for taste, price, and convenience can support the initial transition and sustained dietary changes[36–38].

Socio-demographic determinants and drivers of dietary change

Dietary choices are influenced by a range of sociodemographic factors. In the UK, shifts towards more sustainable and healthier eating patterns are shaped by economic barriers, cultural preferences, social norms, and education[39]. Compared to non-champions, 'plant-based adopter' included more households with higher education levels and higher incomes. In contrast, the 'meat to dairy' cluster was socio-economically diverse, with no significant associations with education or income levels. While various factors can influence meat reduction, higher socio-economic status (SES) is often associated with reduced meat consumption[40], as well as greater consumption of fruits, vegetables, and other plant-based and lower-GHG products[16,17,19]. Our findings suggest that the trend of higher-educated and higher-income households adopting more healthy and sustainable diets remains relevant for the behaviour change reflected in the 'plant-based adopter' cluster.

Despite the potential for dietary change across all groups, the continued predominance of higher-educated and higher-income households in adopting healthy and sustainable dietary changes highlights a key challenge: how to engage more diverse socio-economic groups in healthy and sustainable eating practices. Given that 'Champion' households represent a group already transitioning towards lower-GHGE diets, their motivations could play an important role in influencing broader adoption. Rogers' Diffusion of Innovations theory[21] explains how new behaviours spread through populations in stages. According to this theory, the population is segmented into groups that adopt innovations at different times, with the 'early majority' representing a pragmatic group that adopts new practices after they have been validated by 'early adopters.' Our 'Champion' households, who have recently reduced meat consumption, are more in line with the 'early majority' rather than the 'early adopters', who embraced plant-forward diets before 2012. Understanding the motivations of these transitioning households provides insight into the likely behavioural patterns of a large segment of the population that could facilitate wider adoption of a plant-based diet.

While our study does not directly assess motivations for dietary change, previous research highlights several key barriers to adopting plant-forward diets. Awareness of health and environmental impacts is often a key driver, but practical factors such as convenience, ease of preparation, and time constraints also shape shopping behaviour, sometimes leading to increased reliance on convenience foods rather than active adoption of plant-based alternatives[41]. Households may intend to reduce meat intake but face challenges such as limited access to plant-based options and uncertainties about meal preparation. Guidance on preparing plant-based and lower GHGE foods, such as recipe cards and cooking workshops, could facilitate successful dietary change away from meat towards increased consumption of legumes and vegetables in daily meals[30,31]. Larger households were less likely to achieve per capita GHGE reductions, possibly because smaller households can implement collective dietary shifts more easily. Families with children face additional challenges in dietary transitions[42], as they need to accommodate varying tastes, nutritional needs, and time constraints, which can complicate the shift towards more sustainable diets.

Future research should investigate the factors driving dietary change in different household contexts and socio-economic groups. Understanding how behaviours spread and what barriers hinder adoption will be key to developing strategies for a broader shift toward sustainable diets. Strategies may need to address cooking and eating habits, education, and the affordability and availability of sustainable food choices to engage a wider range of households in these transitions[43,44].

Considerations of using purchasing data in dietary GHGE analysis

This study used several years of purchasing data, from Kantar's Worldpanel Take Home data, to track dietary transitions and identify the types of households most likely to adopt them. Unlike food questionnaires and surveys, which rely on self-reported data that often underestimates consumption and overlooks food waste, this study captures actual food purchases, and therefore, this method includes foods that may be wasted post-purchase. However, this approach does not account for all sources of household food consumption, such as those from eating out.

The mean dietary footprint recorded here for the British population, including beverages, is 4.3 kg CO_2e per day, somewhat lower than broader UK estimates ranging from 5.7 to 8.2 kg CO_2e per day[3,29]. This slightly lower footprint likely reflects the study's focus on supermarket purchases only. Similar studies across Europe report footprints ranging from 3.7 to 6.5 kg CO_2e per day, with variations due to different methods and factors considered[29].

Since 'Champion' households were selected based on GHGE reductions over two periods, reporting variations could influence the selection. To mitigate this, we averaged GHGE over 3-year periods and set a minimum daily energy intake threshold. While some reporting differences may influence the selection process, a brief sensitivity analysis of the selection process shows that the majority of households remain consistently selected across different thresholds (Supplementary Notes 1).

We observed a decline in daily per capita kilocalorie (kcal) purchases among 'Champion' households and a reduction in shopping volume. The kcal reduction can be partly attributed to the decreased consumption of high-calorie meat and dairy products and increased purchases of lower-calorie products such as fruits, vegetables, and plant-based alternatives. When shopping volume does not increase during a shift to less calorie-dense foods, this naturally results in a decline in overall calorie intake.

The observed decline in shopping volume may have several reasons. Households may have been purchasing only necessary amounts to minimise waste, responding to economic constraints, or intentionally reducing calorie intake. Changes in household demographics, such as aging members with different dietary needs, could also have influenced purchasing amounts. Alternatively, households may have increased their frequency of eating out while maintaining overall dietary intake, which would reduce purchased food volume but potentially lead to smaller actual reductions in dietary GHGE than suggested by our analysis. Finally, data limitations, such as the incomplete recording of all food purchasing sources, could also have contributed to this.

Conclusion

This study highlights the potential for households in GB with high dietary GHGE footprints to substantially reduce emissions through dietary changes. 'Champion' households achieved their food-related GHGE reduction primarily by reducing meat consumption. Two distinct dietary change patterns emerged among these households: 'plant-based adopters' reflect a more conscious shift towards diet choices that benefit both personal and environmental health, while the 'meat to dairy' cluster, with a more diverse socio-economic profile, suggests a broad range of motivations.

The socio-demographic profile of 'plant-based adopters' indicates that higher-educated and higher-income households are more likely to transition to diets that are both healthy and sustainable. This underscores the challenge of engaging lower socio-economic groups to drive broader population-level changes. Addressing barriers such as cost, availability, and education is essential, including guidance on preparing nutritious plant-based meals for those less familiar with these ingredients. Plant-based alternatives were a key part of the dietary changes observed. Providing these alternatives in nutritious, familiar, and convenient formats can support shifts to sustainable diets. For larger households, especially those with children, family-friendly, time-efficient plant-based meals may support similar GHGE reductions seen in smaller households.

While our findings suggest that there are multiple pathways to dietary change, 'Champion' households represented only a small proportion of all households, indicating that barriers still prevent widespread dietary change. Addressing these barriers will be critical to enabling broader adoption of the dietary transitions observed in this study and achieving meaningful reductions in dietary GHGE at scale.

Methods

Study population

Data for this study were obtained from Kantar's Worldpanel Take Home data, which includes information on food and beverage purchases by approximately 30,000 households in GB, covering 52-week periods ending in December each year from 2012 to 2019. The Kantar dataset is a rolling, nationally representative consumer panel that records take-home food purchases by British households. Each year, the panel comprises approximately 30,000 to 34,000 households recruited through stratified sampling to ensure representativeness across several demographic categories, including region, household size, age of the primary shopper, number of children, and occupation[45]. Households are incentivised to remain in the panel through vouchers, with an average annual value of approximately £100 per household. Panel retention rates are high, with a mean follow-up time of 5.5 years per household in 2012. To maintain representativeness, ~3000–4000 new households are enroled each year.

Food purchase data

Food and beverage purchases were recorded by households using handheld barcode scanners. For items without barcodes, such as loose fruits and vegetables, participants use bespoke barcodes provided by Kantar's Worldpanel. The places of purchase include a variety of retail locations, such as supermarkets, convenience stores, newsagents, and specialised retailers like butchers and greengrocers. Beverages (other than milk) were excluded from the dataset due to inconsistent labelling, resulting in a focus solely on solid food and milk consumption patterns. We have categorised all remaining products into 26 distinct food groups.

Sociodemographic data

Panel members provide sociodemographic data upon enrolment and update these data annually. Collected sociodemographic variables include age, gender, ethnicity, education, occupation, income, and household composition. Detailed categorisations and groupings of these variables are provided in Supplementary Table 3.

Greenhouse gas emissions data

GHGE of food products, expressed in kg CO_2e, were obtained from a study covering over 57,000 food products purchased in the UK[25] and provided via personal communication by ref. 25. This study derived GHGE data by estimating ingredient compositions from product labels and pairing this information with environmental impact databases. This data incorporates emissions from agricultural production, processing and transportation to retail stores. We used a string-matching algorithm to align Kantar's Worldpanel Take Home data with the GHGE dataset. This process included automated matching based on product descriptions, followed by manual cheques to ensure accuracy.

Selection of 'Champion' households achieving GHGE footprint reduction

Among our study population, we defined 'Champion' households as households achieving considerable reductions in their annual GHGE footprint over the study period, from 2012 to 2019. Specifically, these households initially had a footprint above the median for all households during the initial period (2012–2014) and reduced their footprint to below the 30th percentile of all households by the end period (2017–2019) (Supplementary Fig. 5).

To ensure meaningful in-home consumption, households with an average reported daily intake below 200 kcal per capita were excluded. This threshold was set low enough to include a broad range of households while ensuring sufficient data to analyse changes in dietary preferences, corresponding to at least 2–3 meals consumed at home per week. Additionally, households with more than 1 year of missing data in either the initial period (2012–2014) or the final period (2017–2019) were removed from the total sample. After applying these criteria, the final sample included 21,795 households from which the 'Champion' households were selected.

Changes in food group volume shares

To analyse changes in the purchasing patterns of 'Champion' households, we calculated volume shares (in percentage), representing the relative contribution of each food group to the total volume (in kg) of food purchased. These shares were calculated for the initial period (2012–2014) and the final period (2017–2019) to enable a comparison over time.

For each household, the volume share of a specific food group was calculated as follows:

$$\textit{Volume Share}_{years,food\ group} = \left(\frac{\textit{Volume from Food Group}_{years}}{\textit{Total Volume from all Food Groups}_{years}}\right) \times 100$$

This allowed us to identify the food groups that showed the greatest shifts in volume shares (in percentage points) and contributed most to the changes in shopping behaviour of 'Champion' households.

Dietary change patterns

The patterns of change in the food purchases of the 'Champion' households were obtained using a Latent Class Analysis (LCA). The LCA model was used to identify clusters of households with similar change patterns and assigned each household to the patterns with the highest probability of belonging.

The change in purchasing patterns is based on the change in the volume share (in percentage points) of each product category within a household's total food purchases. The changes were categorised as decrease, no change, or increase. The categories were defined by thresholds, with increases marked by values above the 25th percentile of all positive changes, and decreases marked by values below the 75th percentile of all negative changes.

The LCA focused on core food groups to identify potential replacement patterns during dietary shifts. Product categories such as 'Fats and Oils', 'Other Food Products', 'Spices, Condiments, and Sauces', and 'Sugars and Sweeteners' were excluded from the analysis. These categories are less relevant to dietary changes and are no important contributors of calories or nutrients compared to core food groups (e.g., fruits, vegetables, proteins, grains).

To determine the optimal number of latent classes (clusters), we conducted a goodness-of-fit analysis, comparing models with different numbers of classes from one to ten. This analysis evaluated improvements in Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), G-squared (G2), and entropy values across models. Significant improvements in these fit indices were observed when increasing the number of classes from one to two, with diminishing improvements beyond two classes. The 2-class model was selected based on its lowest BIC, which indicates an optimal balance between fit and simplicity (Supplementary Table 2).

Socio-demographic characteristics of 'Champion' dietary patterns

We analysed the characteristics of 'Champion' households—including age, gender, ethnicity, education, income and household composition—to identify common traits among those successfully reducing their GHGE footprint. Logistic regression models were used to compare two distinct subgroups identified by Latent Class Analysis (LCA) with the total sample of the GB population. Each LCA-identified cluster was analysed separately to assess socio-demographic characteristics associated with their changing purchasing patterns.

The analysis involved several steps. First, socio- demographic variables were aggregated across groups to increase sample sizes and reduce dispersion. Contingency tables and chi-square tests were generated for each of the two models (cluster 1 vs. total sample and cluster 2 vs. total sample) to inform variable selection. This initial analysis helped identify associations between categorical variables and suggested which predictors might be relevant for further analysis.

Next, univariate regression models were conducted for each explanatory variable independently to assess their influence. Variables with limited predictive power ($p > 0.01$) were marked for potential exclusion from further analysis. The analysis then proceeded to stepwise regression, where variables were iteratively added and removed using both forward and backward selection, optimising the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). Variables consistently excluded by both methods were removed.

For the final model, Bonferroni and False Discovery Rate (FDR) corrections were applied to account for multiple testing. The final model was tested for overdispersion and multicollinearity using Variance Inflation Factor (VIF) tests. No multicollinearity issues and no overdispersion were detected. Details of the regression analysis are provided in Supplementary Tables 3–7.

Reporting summary

Further information on research design is available in Nature Portfolio Reporting Summary linked to this article.

Data availability

Greenhouse gas emissions data were sourced from Clark et al.[25] and obtained via personal communication. GB shopping product data were derived from Kantar's Worldpanel Take Home dataset (52 w/e Dec. 2012–2019). Kantar's Worldpanel Take Home data are not publicly available but can be purchased directly from Kantar Worldpanel (https://www.kantarworldpanel.com/en/Sectors/FMCG/1000). Aggregated data used to generate the results and figures are available in the supplementary materials and on figshare (https://doi.org/10.6084/m9.figshare.28616369.v1). Due to legal reasons, household-level disaggregated data cannot be publicly shared. Upon reasonable request, the authors can consult with Kantar about data access options.

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Author contributions

T.C., A.Z.O., and P.S. conceptualised the study. T.C., A.Z.O., A.R., R.G., and P.S. developed the methodology. T.C., A.Z.O., G.O.D., H.M., S.N.E. and P.S. curated and analysed the data. T.C. wrote the original draft. T.C., A.Z.O., A.R., G.O.D., H.M., S.N.E., R.G. and P.S. reviewed and edited the manuscript. P.S. acquired funding for the study.

Competing interests

The authors declare no competing interests.

Additional information

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