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Promoting dietary changes for achieving health and sustainability targets

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Globally, about 21–37% of total greenhouse gas (GHG) emissions are attributable to food systems. Dietary-related non-communicable diseases have increased significantly from 1990–2019 at a global scale. To achieve carbon emissions targets, increase resilience, and improve health there is a need to increase the sustainability of agricultural practises and change dietary habits. By considering these challenges together and focusing on a closer connection between consumers and sustainable production, we can benefit from a positive interaction between them. Using the 2019 EAT Lancet Commission dietary guidelines, this study analysed interview data and food diaries collected from members of Community Supported Agriculture (CSA) schemes and the wider UK population. By comparing the environmental sustainability and nutritional quality of their respective diets, we found that CSA members consumed diets closer to the EAT Lancet recommendations than controls. We identified significant differences in daily intakes of meat; dairy; vegetables; legumes; and sugar, and the diets of CSA members emitted on average 28% less CO2 compared to controls. We propose that agricultural and wider social and economic policies that increase the accessibility of CSAs for a more diverse demographic could support achieving health, biodiversity, and zero-emission policy targets.

KEYWORDS

consumption, healthy, environmentally sustainable, zero emission targets, community supported agriculture, EAT-lancet diet

1. Introduction

Food systems, and in particular, food production, are key to both mitigation of climate change and resilience to the impacts of climate change. Shifting consumption towards healthy and sustainable diets is a significant opportunity for reducing greenhouse gas (GHG) emissions from food systems and improving health outcomes (Mbow et al., 2019).

Globally, about 21–37% of total greenhouse gas (GHG) emissions are attributed to food systems, specifically agriculture, land use, storage, transport, packaging, processing, retail, and consumption (Mbow et al., 2019). Of these GHG emissions, 9–14% are attributed directly to agriculture itself (Mbow et al., 2019). With the UN Climate Change Conference of the Parties (COP) 28 convening in the UAE in 2023 to discuss the goals of the Paris Agreement and the UN

Framework Convention on Climate Change, discussions about the resilience and sustainability of the global food system are increasingly salient. Given commitments to achieve zero emission targets by 2050, reorienting the global food system to deliver healthy food using low carbon methods is key to achieving this commitment. In 2021 and 2022, there were many subnational governments and civil society organisations supporting initiatives like the Glasgow Declaration calling for action to reduce GHG emissions from food systems, build sustainable food systems and deliver safe, healthy, accessible, affordable, and sustainable diets for all (IPES-Food and Nourish Scotland, 2020; CGIAR, FAO and The Rockefeller Foundation, 2022), demonstrating both a clear commitment to tackle the climate emergency through integrated food policies, and pressure on national governments to act. At COP 27, for the first time, agriculture featured as one of the thematic days and the number of COP pavilions with all-day programming on food and agriculture issues jumped from zero to five. "There will be many opportunities to make further progress on food, agriculture, and climate in the year ahead —thanks to the newfound prominence on the global climate agenda" (United Nations Foundation, 2022).

Whilst agriculture has a role to play in mitigating climate change, it is also subject to the impacts of climate change such as drought, storms and flooding. Understood in resilience terms, these are climate change-induced shocks to the food system. The Intergovernmental Panel on Climate Change defines resilience as the capacity of interconnected social, economic and ecological systems to cope with such 'shocks': hazardous events, trends or disturbances, responding or reorganising in ways that maintain their essential function, identity and structure (IPCC, 2019). A resilient food system is robust, able to recover quickly after disruption or shocks, and actively reorienting towards more sustainable environmental and health outcomes (Global Food Security, 2019). Nearly every nation in the world (191 countries plus the European Union) has joined the Paris Climate Agreement to the United Nations Framework Convention on Climate Change (UNFCCC), to "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change" (United Nations (UN), 2015, p. 3). The mitigation potential of dietary changes, to more sustainably produced food with less meat consumption, is estimated as 0.7–8.0 GtCO2-eq yr–1 by 2050 (Mbow et al., 2019). Sustainable food production systems would also increase ecosystems' ability to resist and recover from extreme weather, thereby increasing resilience of food production (Food Farming and Countryside Commission, 2021).

From a health perspective, there is also potential to enhance public health resilience to diseases by shifting to healthier diets. A population that consumes healthier foods is more likely to be robust against threats posed by both non-communicable diseases (e.g., type II diabetes, cardiovascular disease and certain cancers), and communicable diseases (e.g., influenza, COVID-19) (Afshin et al., 2019). People who achieve better nutrition levels, which are associated with favourable physiological parameters such as lower body mass index and lower prevalence of hypertension, are also likely to recover more quickly from acute and chronic illnesses.

Thus, dietary change is a key way in which both carbon emissions and public health can simultaneously be addressed. The 'EAT–Lancet Commission on healthy diets from sustainable food systems' (Willett et al., 2019) recommended a 'reference diet' (the 'EAT' diet), based on a literature review of existing dietary patterns and the health and environmental outcomes associated with different foods. As far as existing data allowed, Willet et al. aimed to provide a generally applicable evidence-based target diet, which could be refined to account for local variation in existing diets, as well as cultural and environmental factors. The EAT diet largely comprises non-starchy vegetables, fruit, grains, legumes (pulses), nuts, seafood, poultry, dairy products, with a small amount of starchy vegetables, red meat, processed meat and added sugar. Since the publication of the report there have been a small number of studies aiming to build upon and discuss its findings and recommendations.

Springmann et al. (2020) modelled the effects of the hypothetical adoption of existing 85 national dietary guidelines on health and environment and compared these outcomes with two global dietary recommendations: the World Health Organisation's (WHO) recommendations and those of the EAT–Lancet Commission. This study found that the recommendations developed by the EAT-Lancet Commission are associated with greater health benefits than the national level and WHO dietary guidelines and would reduce environmental resource use in line with internationally agreed targets. Another study found similar results, proposing that a difference in approach was the underlying reason for the projected high efficacy of the EAT diet (Blackstone and Conrad, 2020). They argued that national guidelines are policy documents which, though informed by existing evidence on health, are developed within a health policy context that takes a harm reduction approach (small changes to diet can have a large effect on health, whereas difficult to achieve recommendations risk overwhelming citizens). Many national level targets are less certain about whether sustainability is a societal concern that should be integrated into government guidelines on diet, or a matter of individual choice; they are 'gently' normative about health, but less so about sustainability (Santaoja and Jauho, 2020). One contrary example to this is Wales. In their Carbon Budget for 2021–2025, Welsh Government states, "Welsh Government has agreed to develop a long-term strategy to promote a dietary shift towards the UK Government's 'EatWell Guide' by encouraging Welsh consumers to eat healthier, more sustainably sourced food, to eat and waste less." (Welsh Government, 2021, p. 156).

There are examples of studies which examine how the EAT diet could be adapted to account for cultural and social context, with Lassen et al. (2020) offering two regimens based on data on Danish diets and national dietary guidelines as well as consideration of the limitations of change within this context. Reynolds et al. (2019) contributed an analysis of UK diets and greenhouse gas emissions which offers similar insights for different income groups within the UK population, indicating that a more sustainable diet would look different for different segments of the population, accounting for the affordability of different foods and the differing cooking and eating habits of people within British society. They argue for a tailored approach which is informed by social and income constraints within the population to achieve maximum success in reducing the environmental impacts of dietary habits.

1.1. Achieving sustainable healthy diets in the UK

Building upon this body of work, our study aimed to consider how a healthier and more environmentally sustainable diet could

be achieved given commitments under the Paris Agreement. The data collected herein relate to UK households, but the results and lessons learned are applicable across the world, where globalised food supply chains have increased the distance between producers and consumers and alienated consumers from the source of their food. In line with Article 4 of the Paris Agreement, the UK Government has committed to a 68% reduction in GHG emissions (compared to 1990 levels) by 2030 (UK Government, 2020). As part of its commitment to the UNFCCC the UK has said it will deliver a national shift to healthy diets supported by sustainable food production which contributes towards a reduction in GHG emissions. Around 61% of UK citizens are overweight or obese, resulting in approximately 70,000 premature deaths annually due to diet-related ill health (The Parliamentary Office of Science and Technology, 2020). The UK is in a unique moment of change as it navigates the disruption of the COVID-19 pandemic and the war in Ukraine on food supply chains and the increase in household food insecurity to 20% (Armstrong et al., 2023), as well as its exit from the European Union, and the resulting new trade agreements and domestic agricultural policies. These changes create a window of opportunity for implementing changes across the food system that can result in healthy, environmentally sustainable and accessible diets for all. To investigate how an EAT diet could be achieved, we focus on a sub-population of people motivated by health and environmental concerns who have joined a Community Supported Agriculture (CSA) scheme and compare their food behaviours to a randomly selected control group.

1.2. Community supported agriculture

A CSA is a partnership between farmers and consumers in which the responsibilities, risks and rewards of farming are shared (European CSA Research Group, 2016; Community Supported Agriculture Network UK, 2020). Whilst there are a wide variety of governance arrangements amongst CSAs, the consumer typically offers something more to the CSA than just a straightforward exchange of money for produce. For example, they may contribute labour, take some financial risk or invest in the CSA, play a part in decision-making, and/or accept a variable share of produce. CSAs are established as a sizable part of the agricultural sector in the USA and France, with 3,000 and 12,500 active CSAs respectively, but are still only a very small part of the food system in the UK, which has 179 CSAs, many of which are not yet wholly established or are inactive (Saltmarsh et al., 2011; Community Supported Agriculture Network UK, 2020).

There are a few studies that have examined how CSA membership may affect diet (Wilkins et al., 2015; Allen IV et al., 2017; Hanson et al., 2017), which suggest that there may be movement towards more healthy and sustainable diets in this population. However, there is little evidence of this in the UK context and what it would mean for meeting net zero GHG targets. In this paper, we examine whether CSA members consume a diet that more closely resembles the EAT diet than non-CSA members in the UK. We aimed to answer the following research questions:

1. Are CSA participants' diets more environmentally sustainable than those of control group participants?
2. Are CSA participants' diets more nutritious compared to those of control group participants?

2. Methodology

We used semi-structured interview data and food diaries collected from members of CSA schemes and the general population to compare environmental sustainability and nutritional quality of diets between these two groups. We hypothesised that CSA members engage in a diet that is healthier and more environmentally sustainable than the general UK population.

2.1. Recruitment

A total of 113 participants were recruited (CSAs $n=46$, control group $n=67$). Participants in the CSA group were recruited through collaboration with four CSA organisations (two in South Wales and two in Southeast England). In this case, we purposely recruited CSA members who had joined within the last year, since one of the aims of the wider study (not reported upon in this paper) was to explore if and how joining a CSA might change food behaviours over time. Participants were given an incentive to join the study, receiving either free organic vegetables from the host CSA or a similar financial equivalent. The control group was recruited by approaching shoppers at random outside supermarkets local to the CSA schemes. Control group participants were provided with a similar incentive for taking part in the study, namely shopping vouchers which could be redeemed for goods. The main research challenge with both groups was scheduling the interview to fit into participants' busy everyday lives; as a result, some participants dropped out, and thus the difference in the number of participants in the two groups. An application of research ethics was approved by Cardiff University School of Geography and Planning ethics committee. Participants gave written consent after reading a participant information sheet and having had the opportunity to ask questions. The participant information sheet detailed the purpose of the study, why they were being invited to participate, confidentiality and anonymity, how their data was to be used and protected, what they needed to do to participate, and how study results would be used.

2.2. Semi-structured interviews

One-to-one interviews were conducted with CSA members and control group participants either face-to-face, by phone or *via* Zoom (depending on preference and timing of interviews). We asked participants about their household food culture, i.e., their food purchasing, preparation and consumption routines, and their views and attitudes towards their dietary approach. The interview also collected some basic socio-economic data: the age, gender and occupations of the members of each household, as well as overall household income. Participants were encouraged to discuss their household food practises in depth, giving the interviewer some insight into why they might choose particular options. This depth was gained by asking follow-up questions to probe emerging themes and concepts brought up by the interviewee. All interviews were audio-recorded, transcribed and anonymized.

2.3. Dietary recall with intake24

After the interviews, research participants were requested to complete food diaries for three consecutive days using Intake24

software (see below). Food diaries were anonymised and were conducted online. We analysed a total of 162 food diary entries, with 97 entries from CSA members and 64 entries from the control group participants. Participants were advised to choose two weekdays and a weekend day that best represented their typical food and drink intake as far as possible. Data collected from the food diaries was used to verify the accuracy of interview responses regarding general patterns of weekly food consumption.

Intake24 is an online 24 h dietary recall system that enables users to self-report their dietary intake. The tool is based on the automated multiple pass method and has over 2,400 food photographs featuring more than 100 foods for portion size estimation based on reporting in the UK National Diet and Nutrition Surveys (Smithers et al., 2000). Photographs have been previously validated against four-day weighed intake records and in a feeding study (Foster et al., 2008, 2010). More than 2,300 foods are included in the database, which is regularly expanded to include new foods. Intake24 also incorporates a 'missing foods' function which permits users to identify any foods or drinks that are not currently available. An additional tool enables participants to 'make your own sandwich/salad' and add their own recipes. GHGs associated with each food group were drawn from an extensive database of GHG data linked to all foods identified in the National Diet and Nutrition Survey (Bates et al., 2019) and were reported as grammes of carbon dioxide equivalent (gCO_2e). A video tutorial outlines the main features of the system and contextual help buttons provide additional guidance on specific features.

2.4. Data analysis

Calorie intake for CSA and control group participants was estimated for each of the food groupings highlighted in the EAT Lancet dietary guidelines, namely wholegrains, tubers/starchy vegetables, vegetables, fruits, dairy foods, protein sources (beef/lamb/pork, chicken/other poultry, eggs, fish, legumes, nuts), added fats and added sugars. Due to some discrepancies between food groupings used in Intake24 and EAT Lancet guidance, certain foods were re-classified for our analysis according to a hierarchical process based on the dominant food ingredient (for example, sweet pastries were classified as sugar, whereas savoury pastries were classified as wholegrain, unless they were meat pastries, which were classified as meat (see Appendix 1). Data for CSA and control group participants were analysed using the SPSS 26 statistical software package to compare means for participants' daily consumption between the two groups. Analysis of variance (ANOVA) was used to compare the CSA and control group for all EAT Lancet food categories, as well as for income, overall daily caloric intake, fat, saturated fat, sugar, protein, carbohydrates and gCO_2e. Ordinal regression analysis was also used to compare frequency of organic produce purchases between the CSA and Control groups.

2.5. Strengths and limitations of the methods

Our approach of using food diaries and semi-structured interviews made it possible to triangulate consumption data and derive insight into the drivers behind trends in food diary data, for example, why CSA members consumed more vegetables. We included members from four CSAs in England and Wales, which resulted in data from different geographical areas, enabling potential generalisation of our findings. The use of Intake 24, an objective dietary assessment tool, which has favourable validation, gives validity to the accuracy of the dietary data and made it possible to consider a wide range of dietary components as well as environmental impact (gCO_2e). The finding that dietary data corresponded well with self-reported consumption patterns in the interview data also indicates the veracity of interview results.

The study has the following limitations. Firstly, to compare the Intake24 output with the EAT diet, we had to convert NDNS food categories, of which there were 118 categories, into the 13 EAT diet categories (see Appendix 1). Certain NDNS food categories could potentially be classified into multiple EAT diet categories (e.g., meat pasty), with resulting imprecision in the allocation of associated gCO_2e. See Appendix 1 for how NDNS food categories were grouped and the rationale. Secondly, greenhouse gas emissions were used as a single measure of environmental impact, when in reality there are many other environmental impacts associated with dietary choices (e.g., impacts of pesticides, herbicides and synthetic fertilizers, erosion and water use).

3. Results

3.1. Socio-economic characteristics

Our study showed a significant difference in age, income and socio-economic status between the CSA members and control group, which may mean some of the differences between our groups could be attributed to age, household income or socioeconomic class. The ANOVA analysis showed that there was a difference in age and average household adjusted income: age for the control group was slightly higher, and income was lower, when compared to the CSA group (value of p <0.10) (see Table 1). The most recent reliable data from the Annual Population Survey (Office of National Statistics, 2021) indicates that our control group is similar in its occupational status to the UK population. The results from an ordinal regression analysis of Socio-Economic Classification (Office of National Statistics, 2020) and CSA and Control group participants gave statistically significant results (value of $p = 0.000$), with a positive CSA coefficient value (2.76), which suggests that participants in the CSA group have above average socio-economic status: they are more likely to be employed in higher professional and managerial occupations than participants in the control group.

TABLE 1 Results from ANOVA for income [equivalised household disposable income, using the modified Organisation for Economic Co-operation and Development (OECD) scale] and age.

Dependent variable	Control group mean	CSA group mean	*F*-value	value of *p*
Age (years)	51	46	2.888	0.092
Income (£/year)	£27,115	£35,254	13.707	0.000

3.2. Dietary findings

We found significant differences between the CSA members and our control group in daily intake of food groups for beef, lamb and pork; dairy; vegetables; legumes; and sugar (calories day^{-1}) (see Table 2). The means for daily nutrient intake for fat, saturated fat, protein, carbohydrates, sugar, and the consumption-associated calculated gCO_2e were also significantly different (Table 3).

CSA diets emitted on average 28% less gCO_2e compared to the control group diet. There was no significant difference in mean daily caloric intake between groups. Thus, whilst total calories consumed were not different, dietary composition differed significantly across a broad range of components.

Of our control group, 3% were vegetarian and 1.5% were vegan (see Figure 1A). A greater proportion of CSA members reported having some form of dietary preference other than omnivorous with: 13% vegan, 6.5% vegetarian and 4% pescatarian. The CSA group had a larger percentage of participants that never ate meat: 26%, compared to 6% in the control group. We found that 94% of control group members and 60% of CSA members ate meat at least once or twice a week (Figure 1B). This is also reflected in the food diary data.

We found that 89% of our control group ate dairy at least once a week, with 77% eating it every day. CSA members reported eating and drinking dairy products less frequently and consuming smaller amounts than did the control group (Figure 1C). Eating fish regularly (once a week or more) was similar for CSA members (61%) and the control group (59%). However, not eating fish at all was more common amongst CSA members (22%) than the control group (8%; see Figure 1D).

The food diary data ANOVA analysis showed a statistically significant difference between CSA and control group for vegetable consumption, with CSA participants consuming an average of 47% more calories from vegetables. In an unprompted open question 37% of CSA participants mentioned eating a wider variety of quality vegetables, 27% reported eating more vegetables, 22% reported enjoying an improved quality and taste of their vegetables, and 10% of participants mentioned putting the vegetables they receive at the centre of their meal planning since they had joined a CSA. Finally, whilst meat consumption was lower for CSA members, legume consumption was greater for CSA members, as was confirmed by the interview data (Figure 1E).

The EAT-Lancet Commission also recommends cutting down on processed food. Both CSA members and the control group prepared most of their food from basic ingredients, although this tendency was more pronounced amongst CSA members: 93% of CSA members prepared their main meal from basic ingredients 4 times or more a week, whereas in control group households this figure reduced to 77%. This trend was reflected in how households described their use of prepared or processed foods in cooking. Approximately 20% of both groups reported never using pre-prepared or processed foods at home. Of the remaining households, 56.5% of CSA members and 48% of control group households reported preparing their main meal with pre-prepared ingredients once a week or less. Often households had a few things they regularly bought ready-made, like passata, chips, Quorn, or canned beans, whereas others usually cooked with basic ingredients every day, but supplemented their children's meals with some processed foods, e.g., "I cook a meal from scratch every day, but also supplement with processed food which the kids will eat, like pizza, garlic bread, pasta and sauce from a jar" (Interviewee OT6).

TABLE 2 Mean daily calories consumed by the control group and the CSA group according to EAT Lancet food category and comparison with dietary recommendations.

Food group	EAT lancet diet	CSA diet	Control group diet	value of *p*
Whole grains	811	609	505	0.201
Tubers and starchy vegetables	39	93	100	0.749
Vegetables*	78	93	43	0.001
Fruits	126	117	103	0.512
Dairy foods*	153	205	284	0.065
Beef, lamb and pork*	30	46	121	0.029
Chicken and other poultry	62	46	59	0.500
Eggs	19	25	45	0.154
Fish	40	40	32	0.625
Legumes*	284	42	19	0.077
Nuts	291	66	33	0.176
Added fats	450	11	4	0.273
All sugars*	120	268	389	0.107

*Indicates a statistically significant difference between the control and CSA groups, with value of p <0.10.

TABLE 3 Results from ANOVA run for aggregated daily food consumption, comparing the control group with the CSA group for key variables indicating health and sustainability of diet.

Daily intake	Control group mean	CSA group mean	*F*-value	value of *p*
Calories (kcal)	1737	1,655	0.348	0.556
Fat (g)*	101	64	4.959	0.027
Saturated fat (g)*	31	20	9.262	0.003
Protein (g)*	74	56	6.569	0.011
Carbohydrates (g)*	212	178	3.085	0.081
Sugar (g)*	106	70	11.980	0.001
GHG emissions (gCO_2e)*	3,823	2,995	5.313	0.022

*Indicates a statistically significant difference between the control and CSA groups, with value of p <0.10.

3.3. Environmental outcomes

In addition to the 28% difference identified in gCO_2e between the control group and CSA members, further sustainability impacts were illustrated by the interview data on organic food purchases. We asked participants how often they purchased organic produce, when the option was available (Table 4). Analysis yielded statistically significant results showing CSA members were likely to purchase organic foods more frequently compared to control group participants, with coefficient value −1.76 and value of $p = 0.000$. This would likely have a positive impact on environmental sustainability both with respect to gCO_2e and for biodiversity and water and air pollution (Clark and Tilman, 2017; Willett et al., 2019).

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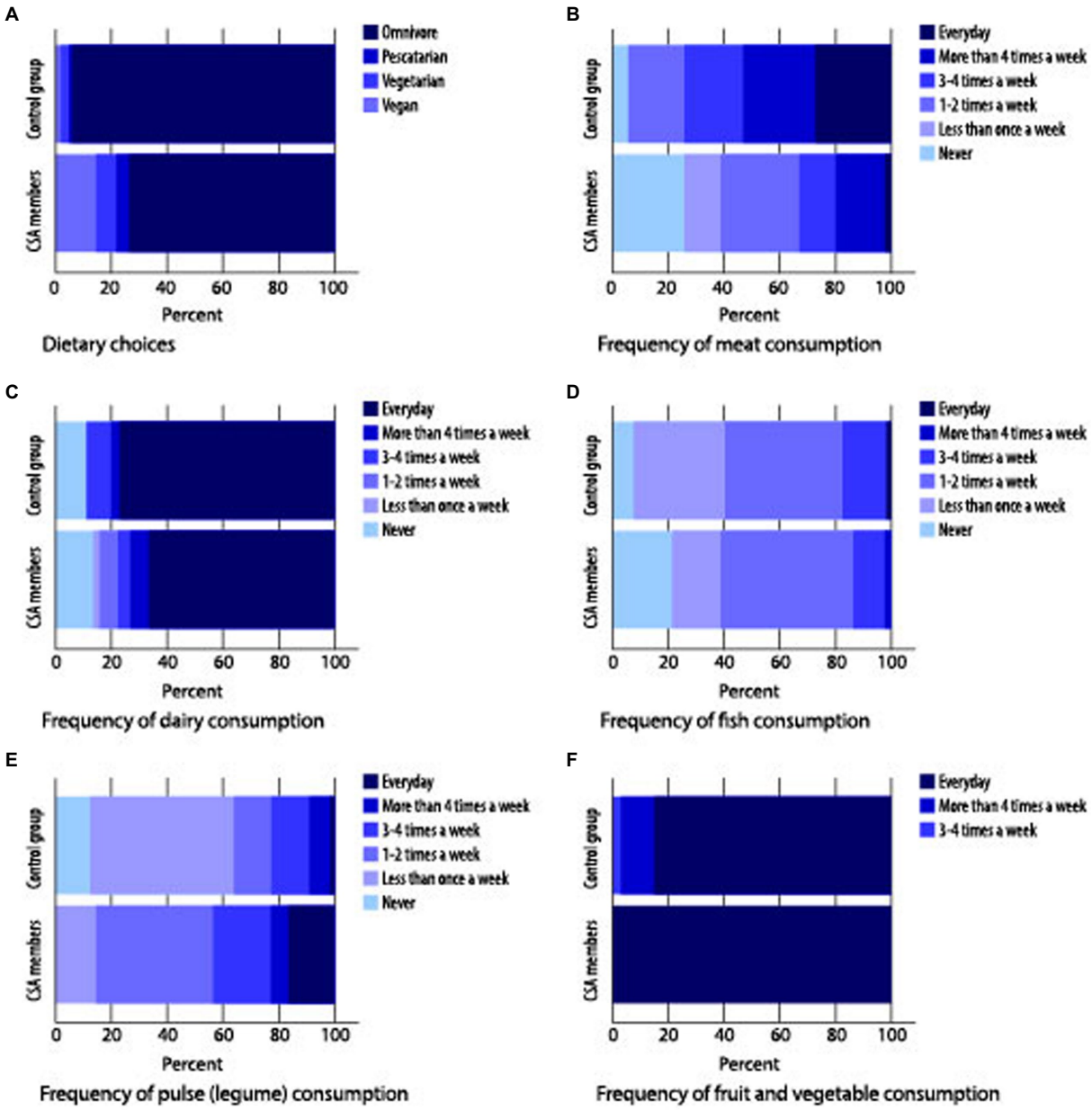

FIGURE 1
Stacked bar charts for interview questions answered by CSA members (n=47) and control group (n=67) participants showing the percentage of each group adhering to different dietary choices **(A)**, and the frequency of their consumption of meat **(B)**, dairy **(C)**, fish **(D)**, pulses (legumes; **E**, and fruit and vegetables **(F)**.

In response to an open-ended question of whether receiving a vegetable box had changed the way they cook or impacted their diet, 22% of CSA participants reported eating more healthily since joining the CSA. This was attributed both to eating a wider variety of quality vegetables, and to knowing that the vegetables were produced organically. When asked for their reflections on dietary changes 26% of participants mentioned that receiving the vegetables meant they ate in a way that they perceived to be more environmentally sustainable.

3.4. Drivers of dietary changes

Interview data indicated that CSA participants decided to join a CSA for the following reasons: 50% wanted to source food locally, 42% were interested in growing food as part of a community group, 54% had environmental concerns and 27% wanted to grow their own food. These motivations were embedded within the participants' specific circumstances and life experiences. Health conditions (cancer/tumours, heart disease/high blood pressure, allergies) sometimes provided a reference point, which participants referred to when they talked about the lifestyle changes they hoped to make or were already embarking upon. These personal circumstances could be entwined with wider changes that participants believed needed to happen within society more generally. Sometimes they saw the CSA as a way of contributing towards a more environmentally sustainable local economy. Often participants felt positive about the origins of their vegetables and that made them feel good about themselves: "A feel-good feeling of knowing their food is produced

TABLE 4 Cross tabulation of frequency of purchasing organic food when grocery shopping (as often as possible, half of the time, less than half of the time, never) comparing CSA members and control group participants.

	Control group	CSA group	Total
As often as possible	8	19	27
Half of the time	9	13	22
Less than half of the time	12	7	19
Rarely or never	37	8	45
Total	66	47	113

organically, is good quality, which has not been affected by the application of all sorts of nasty chemicals, fertilizers and pesticides" (SF10).

There seemed to be a group of linked positive effects attributable to membership of a CSA and/or receiving produce from a CSA. Visiting the CSA site improved mood and mental health for some participants, there was a sense of connectedness which participants felt when they were working together as a community, and a sense of wellbeing gained from eating what they perceived to be "healthy nutrient dense food" (OT8). Furthermore, there was a feeling of connectedness with nature when participants felt they were becoming more aware of the seasons through their involvement in the CSAs. It was common for participants to feel excited about what they may receive in their vegetable box each week. Over 90% of participants receive vegetables from the CSA that they would not normally buy or eat. Participants frequently said they wanted to avoid wasting the vegetables so they ate things they received that they otherwise would not have bought or eaten. CSA membership led to diversification of diets and increased value attributed to their vegetables, which was being produced on their behalf or in partnership with other CSA members.

4. Discussion

4.1. Health implications

Our research illustrates that there is an appetite amongst the UK population for changing diets, and it is possible to shift UK diets to better align with the EAT-Lancet dietary recommendations. The CSA group reflected current trends reported in recent consumer surveys that indicate that more people are adopting a flexitarian dietary pattern (Steenson and Buttriss, 2020; World Economic Forum, 2022), motivated by concerns about sustainability, animal welfare and health (Duckett et al., 2020). Nonetheless, even for the CSA diets, reductions are still needed in the consumption of tubers/starchy vegetables, dairy, beef/lamb/pork, eggs, and sugar; and increased consumption of wholegrains, legumes and nuts to align with EAT Lancet recommendations. Shifts in CSA members' diets will likely help to build resilience to nutrition-related non-communicable diseases such as Type II diabetes, cardiovascular disease and certain cancers, as well as potentially improving outcomes from infectious diseases. This has been highlighted through the COVID-19 pandemic, illustrated by the relationship between increasing obesity and poor disease outcomes (Public Health England, 2020; The Open Safely Collaborative et al., 2020).

4.2. Environmental implications

In addition to this, we measured CO2 emissions of foods consumed, and found lower emissions for the diets consumed by CSA participants compared to control group participants. Whilst our data analysis shows an average of almost ⅓ fewer CO2 emissions from dietary intake, we suggest that an overall reduction in environmental impacts may be larger, owing to the agroecological methods used in the production of the vegetables that CSA participants are consuming. Agroecological production practises rely on a largely closed system, where nutrients are recycled through the system, soil organic matter is promoted (which leads to higher soil carbon storage) and only local resources are used to promote productivity. In addition to very low to negative CO2 emissions, agroecology also promotes biodiversity both on the farm and in the surrounding ecosystems, generating multi-functional landscapes that are capable of supporting food production and biodiversity and are more resilient to both environmental and social shocks and stressors (Food Farming and Countryside Commission, 2021). Other sustainability impacts associated with CSA diets that should also be considered include: organic production of meat, eggs and fresh produce, eliminating the use of synthetic pesticides and fertilizers in production practises; and very low food miles and zero air miles used to transport food from farm to fork.

In this case, dietary changes to achieve either improved environmental sustainability or improved health outcomes are co-beneficial; i.e. a dietary shift for one reason or the other will achieve both benefits.

4.3. Accessibility implications

Considering further the question of affordability and cultural amenability of healthy and sustainable diets, prior to the COVID-19 pandemic in March 2020, in the UK, the rates of household food insecurity for households with children was already high, estimated at 11% of UK households (Sosenko et al., 2019). After the pandemic, this was estimated to have increased to 14% (Goudie and McIntyre, 2021), and further since the cost-of-living crisis, with current calculations of food insecurity in the UK at 20% (Armstrong et al., 2023). Similar increases in food insecurity have been experienced globally (World Bank, 2021). Austerity policies from 2010 to 2018 have been widely criticised as a driver for increased food insecurity and poverty in the UK (Alston, 2018), with approximately 20% of the population living below the poverty line (Social Metrics Commission, 2018). As has been reported in previous research (Galt et al., 2017), we found that CSA member households have higher than average income (see Table 1). Further research highlights that in the UK pre-pandemic, 26.9% of households would need to spend more than a quarter of their disposable income after housing costs to meet the costs of eating according to the Eatwell Guide (Scott et al., 2018). This is made worse by the cost-of-living crisis, where household disposable income will decrease by 7% over the two-year period between 2021 and 2023 (Office of Budget Responsibility, 2022). This raises a food justice issue, where a large

percent of the population is unable to afford a healthy diet. Given that our data indicated that the diets consumed by CSA members were lower in CO2 emissions than those consumed by control group participants, if these healthier diets are less affordable then environmental implications are also at stake. Widespread dietary change will remain elusive to a large proportion of the population, and therefore limits the scope for achieving net zero targets or improving resilience.

4.4. Policy implications

With this in mind, we suggest that approaches that would reduce the cost of a CSA diet for low-income and food-insecure households could be beneficial. Within the current UK policy context of the UK's withdrawal from the European Union, the UK government and the devolved governments (Scottish Parliament, Senedd Cymru and the Northern Ireland Assembly) are now in the process of implementing new agricultural policies. These are primarily based on the principle of paying public money for the provision of public goods, which holds that subsidy payments to farmers should be based on the provision of benefits such as better air and water quality, improved access to the countryside or measures to reduce flooding. This approach is similar to agricultural subsidy policies in the EU and Japan. Given that CSAs' production practises are based on agroecological principles, and indeed most CSAs are certified organic, these types of farming systems could benefit financially from such a policy approach and serve to achieve additional reductions in carbon emissions beyond that gained from changing consumption patterns. Here, we argue that public health is also a public good and should be recognised as such through receipt of additional subsidy payments for benefits rendered. In addition, food aid vouchers issued by local authorities could be used, for example by qualifying for double value when used for purchasing veg boxes, to support accessibility. Research by Bellmann (2019) indicates that payment transfers to consumers can play a significant role not only in ensuring food accessibility, but also in fostering healthy diets for food insecure households. Food aid vouchers specifically for vegetable consumption *via* small-scale horticulture farms would also serve to counteract the imbalance of commodity transfers for a small number of calorie-dense crops suited to large-scale industrial farming (three-quarters of total global commodity transfers by the 20 largest producing countries are for rice, maize, pig meat, beef and veal and milk, followed by wheat; Bellmann, 2019) and support reductions in global dependence on cereal crops that are relatively poor in nutrients; it further has the potential to increase demand for sustainably produced food.

Innovative social and solidarity economy approaches to food production and provisioning (Loh and Agyeman, 2019) can be another mechanism for reversing what can be viewed as exclusionary food practises, by engaging all households, regardless of income level, in healthy and sustainable food culture. Follow-on pilot research with food insecure households receiving a subsidised vegetable box indicates the important role of social capital at the community scale for generating healthy, sustainable and just outcomes for community-scale food systems (Verfuerth and Sanderson Bellamy, 2022). Social and solidarity economy is increasingly recognised by policy makers as a means for inclusive and sustainable development (Fonteneau et al., 2011; Mendell, 2014; Utting, 2017) and as a form of economy that is 'people-centred and planet-sensitive' (Zhongming et al., 2013). It has generated growing interest as a significant element in transformative change and achieving the United Nations Sustainable Development Goals.

Scotland's recent Good Food Nation Act illustrates political will to ensure that all people can afford a healthy and sustainable diet. The Food Policy Alliance Cymru (2021) has advocated for similar policy approaches in Wales where the Welsh Assembly is currently developing its Community Food Strategy and debating the Food (Wales) Bill. In England, the National Food Strategy (Dimbleby, 2021) advocates for community-based approaches to addressing healthy, sustainable and accessible diets. Common across these strategies is the recognition of the importance of community-scale approaches to achieving health, sustainability and accessibility objectives. There are opportunities in the legislative and policy spheres for change that could improve the accessibility of healthy diets and reduce GHGs. Our research suggests that accessible CSA models can play an important role in improving the health and sustainability of diets. Whilst this study shows the applicability of such an approach in the UK, it contributes to a body of literature illustrating such effects elsewhere, such as in the US, and contributes to a better understanding of how we might reorientate the food system to improve resilience for sustainable and healthy outcomes.

5. Conclusion

Our research illustrates that there is an appetite for changing diets, and it is possible to shift British diets to better align with the EAT-Lancet diet. We have addressed critiques in the literature that the EAT-Lancet diet is not appropriately tailored to the cultural context of different regions. Data from our CSA participants gives some indication of how British diets may be amenable to adhering more closely to the EAT-Lancet recommendations. However, significant changes are still required to align with international health and sustainability targets. Even for the CSA diets, reductions are still needed in consumption of tubers/starchy vegetables, dairy, beef/lamb /pork, eggs, and sugar; and increased consumption of wholegrains, legumes and nuts.

The data presented here is based on an initial study conducted to first understand if a CSA diet can deliver health and environmental sustainability benefits. Having found that it does, there are still several questions left to further investigate and answer. Principle amongst these is the question of motivation to change diets. Our research results show that households that join a CSA are motivated to make a change to the diet, often either for environmental sustainability or health reasons. However, further investigation is needed to understand whether the impact of a CSA diet can be extended to the rest of the population, which may not be motivated to make changes. We suggest exploring the dynamics of joining a CSA, which may serve to further inspire dietary changes; and researching the role that building relationships into the food system plays in motivating change. Policy approaches suggested herein will be required to support nations in generating more resilient consumption patterns that align with health, biodiversity, and zero-emission policy targets.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Cardiff University and University of the West of England. The patients/participants provided their written informed consent to participate in this study.

Author contributions

AB, EF, SM, AC, SF, EM, AM, and RS contributed to the project aims and objectives and the experimental design. AB and EF did data collection and analysis. AB, EF, and SM wrote the manuscript with significant input of ideas and edits from AC, SF, EM, AM, and RS. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023.1160627/full#supplementary-material

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