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Changes in Dietary Characteristics Identified and Recommended in Sustainable Food Procurement: A Systematic Literature Review

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Abstract

This review aims to examine the changes in dietary characteristics that are identified and recommended in the current literature on sustainable public food procurement (food procurement in public institutions that helps protect the environment). The inclusion criteria used for this review were that the articles were written after 2010, in English, about sustainable food procurement, and included changes in dietary characteristics. The content analysis reveals that the most common changes in dietary characteristics were increases in local, organic, and plant-based foods; and decreases in meat consumption. This review can help future researchers identify effective recommendations for studies and policies.

Keywords

Sustainable food procurement, green food procurement, dietary characteristics, health economics, organic, local

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1. Introduction

As efforts increase to reduce the negative global environmental impacts of human activities, governmental programs and the public have started to focus on the significant role that food plays in climate change, with a third of greenhouse gas emissions being traced to food systems. (Crippa et al. 2021) Within food systems, over 80% of those emissions stem from agriculture and the production of livestock. (Vermeulen et al. 2020) In addition, the use of arable land and consumption of fresh water from the use of agriculture and livestock production are estimated to be approximately 40% (Foley et al. 2011) and 70% respectively, (Brauman et al. 2016) in addition to negatively affecting biodiversity and local ecosystems. The environment, in turn, has a significant impact on food systems. Increases in temperature and fluctuations in rainfall will negatively affect crop yields in the future, putting pressure on food systems globally. (Sánchez et al. 2014) The risks to global food systems from climate change include rising prices for food products and lowering access to healthy and nutritious food for many, both of which would disproportionally affect vulnerable populations. (Willett et al. 2019) In order to adapt to climate-related shocks and prevent further damage to the environment, food systems will have to transform to both feed a growing population and lessen their burden on the environment. (Foley et al. 2011)

The large portion of land, water, and greenhouse gas emissions that can be attributed to agriculture and livestock production has led to calls to shift dietary behaviors to make food systems more sustainable. The dietary characteristics of local, organic, and seasonal foods are often included in sustainable food procurement research. (Molin et al. 2021) Organic foods have been included in many sustainability initiatives due to the comparatively low negative impacts they have on biodiversity, local ecosystems, and land, air, and water quality. (Niggli 2018) Local

foods are often cited as another avenue to achieve lower negative environmental impacts because of the shortened supply chain that local foods offer, but findings from the literature have found varying levels of success in lowering environmental impacts through local food initiatives. (Stein & Santini 2022) Seasonal foods, which can be viewed as a subsection of local foods, show more promise as an effective sustainability initiative as they narrow the scope of what local foods can be defined as. (Vargas et. Al 2021) Another consideration in public food procurement programs that has recently been the subject of studies is a transition from animal-based food products to plant-based food products. This is because certain animal-based food products are affiliated with high greenhouse gas emissions and water and land usage. (Pimentel 2003) These studies indicate that transitioning to more plant-based food products could also be an effective sustainability initiative. While generally there is a consensus on the changes to dietary characteristics that have the potential to lower the environmental impacts; cultural norms, preferences, and food environments can discourage the implementation of dietary changes on a large scale that would be beneficial to the environment. (Ronto et al. 2022) Because of these biases and limitations that researchers and policy makers may face in studying and implementing shifts in dietary behaviors, examining the literature surrounding this could offer insights into which dietary characteristics are seen as the most feasible and appropriate in the literature today.

Public food procurement is in a unique position in terms of effecting dietary behaviors because a potential collateral impact of implementing changes to develop sustainable public food procurement programs could be to increase the demand for certain foods. (Food and Agriculture Organization of the United Nations 2021) This increased demand for food products that have lower negative environmental impacts could help make it easier for individual consumers to reduce their own environmental impact. (Ronto et al. 2022) Recognizing this, the field of public

food procurement has, in recent years, started to address the impact it has on the environment and that has led to the development of sustainable food procurement. This is of particular importance considering that public food procurement represents a sizeable demand for food and can act as a driver in implementing sustainable practices in food systems. (Food and Agriculture Organization of the United Nations 2021) Both the FAO and the WHO have identified public food procurement as an important tool to reach climate goals and transform food systems. (Food and Agriculture Organization of the United Nations 2021) Additionally, sustainable public food procurement was included as a goal in the UN's 2030 Agenda for Sustainable Development to help combat climate change. (United Nations, 2015) Sustainable public procurement has evolved to consider multiple facets of sustainability, including social, economic, and environmental impacts, and has expanded significantly in recent years. (Smith et al. 2016) The aim of this paper is to clarify what changes in dietary characteristics are included and recommended in sustainable food procurement, and particularly those that address negative environmental impacts. This addresses gaps in the literature regarding potential biases that may arise from selecting policies or methodologies that focus on one or a few dietary characteristics and may discount or ignore other important dietary characteristics that would need to change in order to meet demands for a lower environmental impact.

2. Methodology

A systematic review of the literature was the preferred method chosen by the researcher to examine the ways in which adjustments in dietary characteristics are identified, recommended, and supported by sustainability initiatives in public food procurement. This approach to research allowed a holistic approach to the research question to connect work in various fields. This can

be particularly relevant to research related to sustainability, as concerns with climate change have led to efforts in many disciplines to implement and study environmentally conscious initiatives. Dietary changes and sustainability initiatives are defined in this work as:

Dietary Characteristics*:* The makeup of meals or food items. In the context of the research this definition is specifically applied toward adjustments in food composition in meals or to the inclusion and/or addition of organic or local foods.

Sustainability initiative*:* Policies, regional programs, or proposals that aim to decrease environmental harm from practices in public food procurement.

These definitions were used to create the search terms and clarify the inclusion or exclusion in the review.

2.1 Search Procedure:

Articles were compiled using *Literature as a research methodology: An overview and guidelines* (Snyder 2019) as a guide to develop the appropriate methodology. To access diverse journals and incorporate an interdisciplinary approach, a search for relevant sources was first performed using databases from Scopus, PubMed, and JSTOR. The search terms that were used to locate relevant material are summarized in Table 1. To ensure that grey literature was included in the review, these same terms were also used to search Google Scholar for appropriate documents. Grey literature provides an opportunity to include research that is too recent to be included on the previous platforms as well as research that may refute assumptions based only on published work due to publication bias. In addition, its inclusion offers a wider range of literature, including government documents, that have the potential to offer insights that may not yet be examined in published articles. While this paper examines literature published in the

realm of sustainable food procurement, the focus is more specifically on environmental outcomes that are studied through literature that proposes or examines changes to dietary behaviors, so articles published that are focused on the economic and health aspects of sustainable food procurement but disregard the environmental aspect are excluded from this review. After these documents were gathered, references within appropriate articles were checked to identify studies that may have been missed by the search terms. The searches for published work and grey literature were conducted between June and August 2022.

Table 1: Inclusion and Exclusion Criteria

	Inclusion	**Exclusion**
Year	>2010	<2009
Language	English	Non-english
Region	No restrictions	
Document type	No restrictions	
Area of focus	Sustainable public food procurement (public food procurement that decreases environmental harm), which mentions changes or recommendations for changes in dietary characteristics.	Sustainable food procurement without mentions or recommendations of changes in dietary characteristics.

2.2 Study selection:

A total of 62 articles were collected from databases, after which 13 examples of grey literature were collected. After this, 4 additional articles, which were referenced within some of the 62 original articles, were added to the collected articles. From the 79 total documents gathered, duplicates were removed, and the remaining articles were kept or discarded according to the inclusion and exclusion criteria, which are summarized in Table 2.

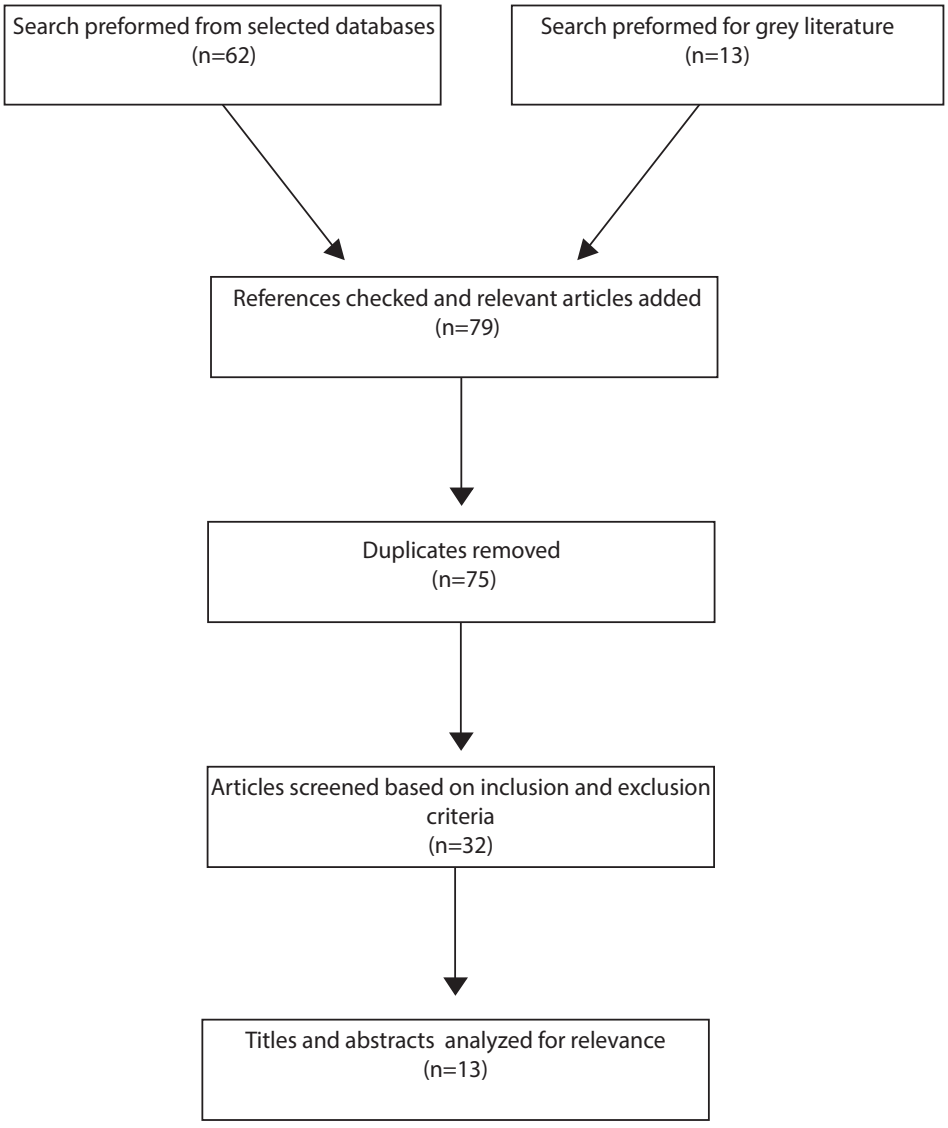
Table 2: Search terms

CATEGORY	SEARCH TERMS
FOOD PROCUREMENT	"Public food procurement" OR "Food Procurement" OR "Farm to prison" OR "Farm to school" OR "farm to hospital" OR "green food procurement" OR "sustainable food procurement" AND
INSTITUTIONS	"school" OR "prison" OR "nursing homes" OR "military" OR "local" OR "municipality" OR "tender" AND
SUSTAINABILITY	"Climate impact" OR "greenhouse gas" OR "emissions" OR "sustainability" OR "food waste" OR "policy" OR "biodiversity" AND
DIETARY CHANGES	"Organic" OR "nutrients" OR "nutrition" OR "diet" OR "meal"

The focus for selection of articles were those within the field of public food procurement which had a major sustainability initiative and included dietary changes as part of the initiative; and sustainability initiatives that recommended dietary changes as part of a proposal. Results are not limited to geographical region to examine global research and initiatives and to include sufficient articles in a narrow research context. In addition, only work published after 2010 is included to ensure the articles examined are relevant and reflect current research and knowledge,

and to reflect a lack of relevant articles before 2010. The title and abstract of remaining documents were then screened, and from these 13 were determined to be relevant and were included in the paper. A flow chart of the review process in provided in Figure 1.

Figure 1: Flow Chart of Review Process



2.3 Content Analysis:

Data was gathered from the 13 included articles and a content analysis was performed. Characteristics of the documents were sorted according to country, measurement of sustainability

improvement, sustainability initiative, type of dietary change, and sector of the food procurement program. A list of the included articles is provided in Table 3.

Table 3: Table of Articles

Title	Country /Region	Dietary change identified and recommended	Procurement characteristics	Methods	Summary
Less animal protein and more whole grain in US school lunches could greatly reduce environmental impacts	United States	Increase in whole grain, reduction in beef consumption	Federally assisted meal program. 40% of U.S. children get lunch through program	This descriptive study used a survey from a nationally representative sample, and used a mean comparison to determine the impacts of certain meals on land and water usage and carbon emissions	This study used a survey to identify the foods included in school lunches. The environmental effects of food groups in the US National School Lunch Program showed greater environmental impacts from meat, and lower impacts from seafood as well as nuts and seeds. More specifically, water usage was high for both meat and fruits and vegetables. The dietary recommendations are to lower the amount of beef and increase whole grains.
Routes to sustainability in public food procurement: An investigation of different models in primary school catering	Croatia, Greece, Italy, Serbia, United Kingdom	Reduce proportion of meat	Croatia: City council created contracts with vendors, schools individually set menus Greece: municipal contracts, no national nutrition standards Italy: menus set at municipal level Serbia: national nutrition standards, meals set by individual school, usually outsourced UK: meals organized at municipal level	Descriptive study analyzing case studies in several countries. 2 cases, one local and one non-local, in each country were compared. Menus were analyzed to determine the carbon footprint of respective meals.	This article used carbon emissions to measure the environmental impact of local vs. non-local foods in school menus. It found that carbon emissions were mostly dependent on the method of waste disposal and menu composition. A reduction in amount of meat served is recommended due to high carbon emissions and it also recommends a higher proportion of fresh produce.

			for most schools		
Agroecological public policies to mitigate climate change: public food procurement for school canteens in the municipality of Ames (Galicia, Spain)	Spain	Increase in organic food, decrease in animal protein, seasonal consumption	National nutrition guidelines, catering provided by local kitchens, supervision by local government.	This simulation used a life cycle analysis using data from 100 school canteens. It examined GHGEs for possible future transitions to low carbon policies using 3 model scenarios: current low carbon policy, and 2 other more intensive policies.	This LCA used carbon policies as a baseline to build model menus. Analysis revealed positive environmental effects if: 65% of food is organic; plant-based food is used in place of meat and fish; fish in place of beef; seasonal meals; local fish in place of imported fish; and local food. Using the 3 scenarios, there is a possibility of reducing GHGE by 47.3% if food is close to fully organic, local to the region, there is low plastic use and renewable energy, and animal proteins and processed foods are minimized.
Diversifying institutional food procurement – opportunities and barriers for integrating biodiversity for food and nutrition in Brazil	Brazil	Increase in local, non-exotic culturally appropriate and biodiverse food in school meals.	Universal school lunch policy, National School Feeding Program dictates 30% of produce must come from family farmers.	This is a descriptive study of 2 case studies using interviews with local communities implementing school programs using local and biodiverse food.	This article focused on case studies in local communities. The first case study is focused on introducing a local fruit (juçara) into Ubatuba school menus which led to a successful increase in the inclusion of the fruit into the menu. It also analyzed local fruits and found better micronutrients within several local fruits. The second study focused on including *quilombola* food culture into school meals, which was not implemented. The report stressed the importance of education on biodiverse foods. It relied on research to support the environmental benefits of biodiverse foods.
Guidance for Healthy and More Climate-Friendly Diets in Nursing Homes—	Denmark	Decrease in animal protein, increase in plant-based proteins like	Meals provided at municipal level. Danish national recommendatio	This simulation created 3 scenarios based on optimization	This paper used a linear optimization to compare the GHGEs of food items and matched these food items to 3 model menus based on protein intake. It

Scenario Analysis Based on a Municipality's Food Procurement		pulses, nuts, and seeds	ns for nursing homes.	of the following dietary patterns. 1-energy and protein-dense 2-standard protein dense 3-combination of 1 and 2. Food groups were optimized to reduce greenhouse gas emissions using menu planning guidelines.	found that meat consumption would be reduced while plant-based protein sources would be increased in all 3 models, which would be included in every meal. An optimal mix of animal and plant proteins would lower GHGEs while providing adequate nutrition to older adults.
Scenario analysis of a municipality's food purchase to simultaneously improve nutritional quality and lower carbon emission for child-care centers	Denmark	Increase in plant-based food, decrease in animal fat, decrease in meat	National plant-rich diet put in place for public institutions (including childcare centers). Meals include breakfast for a lower number of students and lunch for most students.	This simulation used food purchase data which was then matched with GHGEs. 2 scenarios were established based on diet. 1-plant-rich diet 2-lacto-ovo vegetarian diet and compared to original menu.	This paper used the GHGEs of past food purchases, and then adapted those purchases around two diets and then compared these model menus to the original menu. GHGEs were projected to drop 22% in the plant-rich diet and 36% in the lacto-ovo vegetarian diet. The paper recommended decreasing meat consumption to once a week and fish to once a week as well. In both scenarios pulses should be served once a week and protein-rich plant foods such as nuts and seeds should be served daily.
Sustainability and local food procurement: a case study of Finnish public catering	Finland	Increase in local and organic food	Free school meals for all children. Preparation and menu planning is handled at municipal level.	This is a descriptive study which used a case study analysis on a local food supply chain.	The article analyzed a local potato supply chain, the paper found that there was a lack of measurement for quality of sustainability outside of typical guidelines for increased sustainability (local food, organic food, green energy). Having local food would increase sustainability in terms of shortening the supply chain and making to easier for the government to track

					sustainability of producers and waste management in the supply chain. The paper relied on previous research on best environmental practices to make recommendations.
Optimizing School Food Supply: Integrating Environmental, Health, Economic, and Cultural Dimensions of Diet Sustainability with Linear Programming	Sweden	Large dietary changes avoided by changing ratios of food groups, small reduction of dairy, poultry, and red meat.	Free lunches provided to all children 6-15. School food purchases and menus are handled at a municipal level.	This simulation used linear programming on 4 models as follows: 1- GHGE minimization 2- relative deviation from standard diet minimization 3- RD minimization, GHGE stepwise reduction 4- Control for deviation of pairwise ratios	This simulation created 4 model menus for school lunches. The article focused on making minimal changes to diets while reducing the use of non-renewable energy. Model 3 and 4 were identified as the models that were most appropriate in order to reduce GHGEs while keeping menus similar to baseline menus. The model allows for controlling the ratios of food groups to make sure that menus are feasible for implementation.
Strategies and Tools for Eco-Efficient Local Food Supply Scenarios	Italy	Seasonal food, replacing higher impact foods with lower impact foods if nutrition is the same, organic food	Menu and food purchases done at municipal level.	This descriptive study used a food chain model and environmental impact assessment. The effects from different stages of the supply chain- production, processing, storage, transport, and cooking- of local foods were assessed.	The model found greatest environmental effects within the menu studied from beef in terms of energy used for production; pasta and cheese in terms of energy used for processing; and apples in terms of storage (requires longer term cold storage).
Contribution of school meals to climate change and water use in England	United Kingdom	Increase in vegetarian main dishes, replacement of red meat with white meat and fish,	Most menu and food purchase done at municipal level.	This descriptive study used a 2-step assessment using life cycle analysis	This LCA examined individual food items and matched these to menus, the environmental impacts of which were compared using carbon emissions and water use. The analysis

				and water footprint data, which was then matched with school menus and analyzed.	found the greatest environmental impacts from meat, especially red meat, and the greatest contributor to climate impacts from the vegetarian meals was from chocolate desserts. Plate waste was identified as a sizeable contributor to climate impacts.
Modelling, assessing, and ranking public procurement options for a climate-friendly catering service	Italy	Increasing vegetarian meals, increase in organic and local food	Menu and food purchases done at municipal level.	This simulation used a life cycle analysis (LCA) using an average meal, and focused on aspects of production; transportation ; cooking, storage, and serving; and waste management. This was then compared to the life cycle analysis from model menus created using policies aimed at climate impact reduction in all 4 stages of the life cycle.	The LCAs included examined the effects from various model meal plans. The analysis found that a vegetarian diet would lead to reduction of 32% in carbon emissions. Adopting 100% organic food would lower carbon emissions by 11%, particularly if this is locally produced. Energy efficient appliances and more renewable energy would reduce carbon emissions by 7.8%. Better waste management practices would reduce carbon emissions by 10%.
Public Procurement for Sustainable Food Environments	Europe (Case studies from Belgium, Denmark , Finland, Germany , Latvia, Slovenia, Spain	Increasing organic and local foods, increasing plant-based diets	Belgium: municipal level food procurement Denmark: Municipal level procurement and meals Finland: free school lunches, national nutrition guidelines Germany: municipal level	This is a descriptive study which examines 7 case studies in different EU countries to compare current sustainability initiatives in public food procurement. Brief overviews are provided for	This article gave overviews and recommendations for respective food procurement programs as follows: Belgium: initiative focused on food waste, lowering plastic use, smaller tenders Denmark: goal of 90% organic food, increasing food diversity Finland: guidelines for less animal products, more organic and local foods Germany: guidelines for 20% organic food, 30%

			food procurement. Latvia: municipal nutrition and procurement Slovenia: Kindergartens serve 4 meals per day. municipal level procurement Spain: procurement at municipal level	each and used to guide recommendations for the Farm to Fork initiative. It relies on research to support policy recommendations.	organic meat (50% and 90% for kindergartens) and seasonal food Latvia: increase in organic food, excluding GMOs, seasonal food Slovenia: 15% organic food Spain: local foods, prioritize organic food, vegetarian menus
EU GPP criteria for food procurement, catering services and vending machines	Europe	Increase in organic food, vegetarian meals, sustainable marine aquaculture	Guidelines for EU countries, not country/program specific outside of public food procurement	Proposal of new criteria for public procurement using research-backed proposals including aquaculture that avoids fish stock depletions, seasonal food, fair trade products, organic food requirement, vegetarian meal at least once per week	The report examines the guidelines in place for EU food procurement and proposes more sustainable procurement practices. It includes multiple environmental impacts (GHGE, biodiversity, organic foods) to revise current protocols on public procurement. It uses research on best environmental practices to make recommendations.

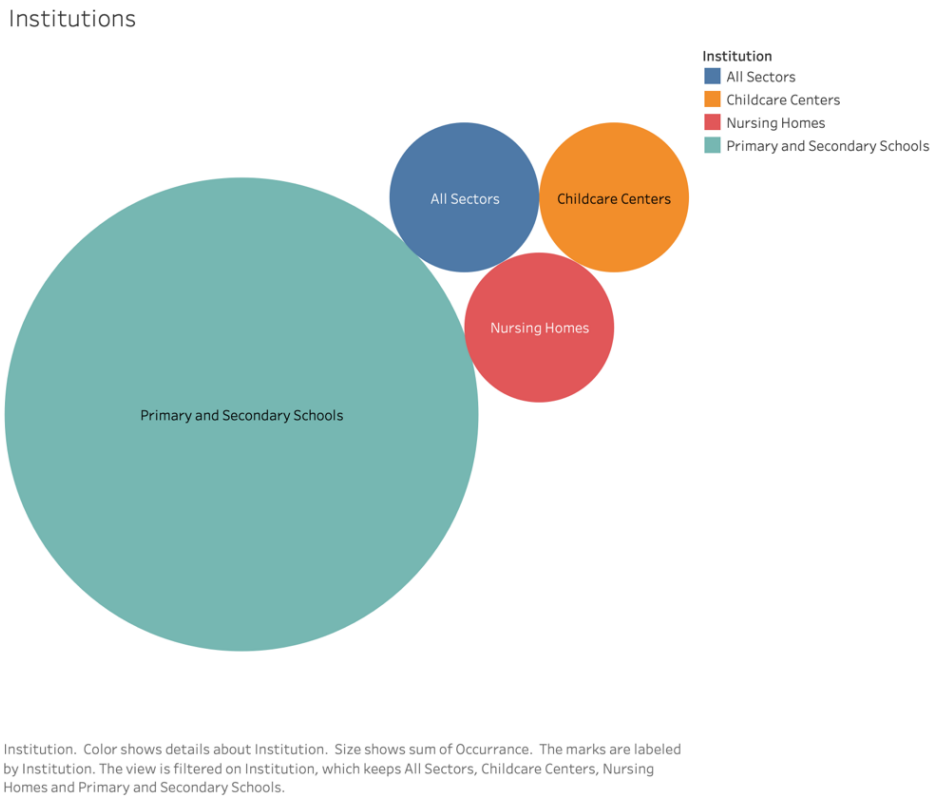
3. Content analysis

3.1 Institutions:

10 studies, which constituted the vast majority of the included articles, used primary and secondary schools as the institution of interest, which is unsurprising considering that schools have been identified as an important institution in sustainable public food procurement by the FAO. (Food and Agriculture Organization of the United Nations 2021) Of the studies which examined schools, two focused solely on primary schools, and the remaining eight included both

secondary and primary schools. Singular studies also examined nursing homes and childcare centers, while one article examined all sectors affected by public food procurement.

Figure 2: Occurrences of Institutions in the Included Articles

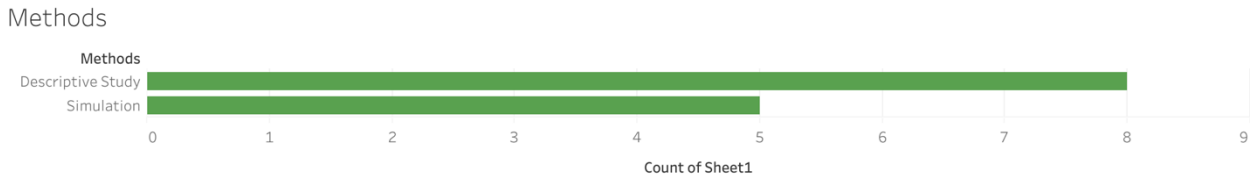


3.2 Methods:

Methods from included studies were not limited to one method, and thus the systematic review included a variety of methods to examine interventions. The approaches which were included can be broadly classified as descriptive analysis, which examined current food procurement programs and included both quantitative and qualitative analysis; and simulations, which created models and sample menus to measure negative environmental impacts. Five articles used a simulation, and eight articles utilized descriptive analysis. Unlike the descriptive studies, which included both quantitative and qualitative approaches and sometimes included multiple metrics, articles that used a simulation were relatively homogeneous in that they relied

on quantitative analysis to measure how dietary adjustments within menu design would theoretically lower either carbon or greenhouse gas emissions.

Figure 3: Occurrences of Methods in the Included Articles

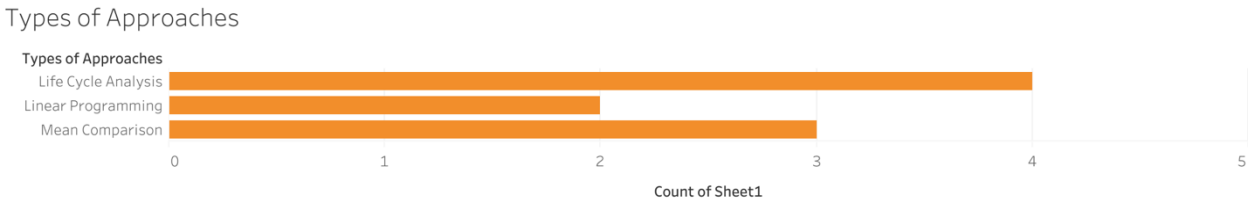


3.3 Types of Approaches:

Analysis of included articles revealed a diversity of approaches in terms of the inclusion and approach of quantitative analysis, as well as variation in the measurement of sustainability. Nine total articles included a quantitative analysis as at least a major part of the publication. Approaches to quantitative analysis included comparisons of means, life cycle analysis, and linear programming. Mean comparison allows for relatively simple analysis of the benefits of certain interventions but may not be thorough enough to easily compare multiple metrics and compare efficient solutions in terms of cost or nutrition, which are typically necessary to implement programs and policies that target negative environmental impacts. Life cycle analysis can include multiple metrics (such as greenhouse gas emissions, and land and water use) and measures those metrics at different steps through the entire life cycle of food products, including but not limited to production, transportation, storage, and waste. (Caputo et al. 2014) The use of life cycle analysis can present issues, however, if certain metrics are omitted or if metrics like biodiversity loss and damage to local ecosystems- which are more difficult to measure- are not considered. Linear programming uses an algorithm to maximize or (in the case of emissions) minimize certain metrics. (Eustachio Colombo et al. 2019) It is useful in public food procurement applications in that constraints like price and nutrition can be accounted for. The

drawbacks from this method in this application is that it can produce menus that are not realistic, which calls for further constraints on certain foods to make sure those foods and the ratios between food types are realistic if using this model to create policies or guidelines. (Eustachio Colombo et al. 2019) Linear programming was used in the included articles to create models of menus that could be implemented in the future to minimize negative environmental impacts, whereas mean comparison and life cycle analysis was primarily used to measure negative environmental impacts from menus and foods. The distribution within these classifications reveals that three articles used a comparison of means, four used a life cycle analysis, and two used linear programming.

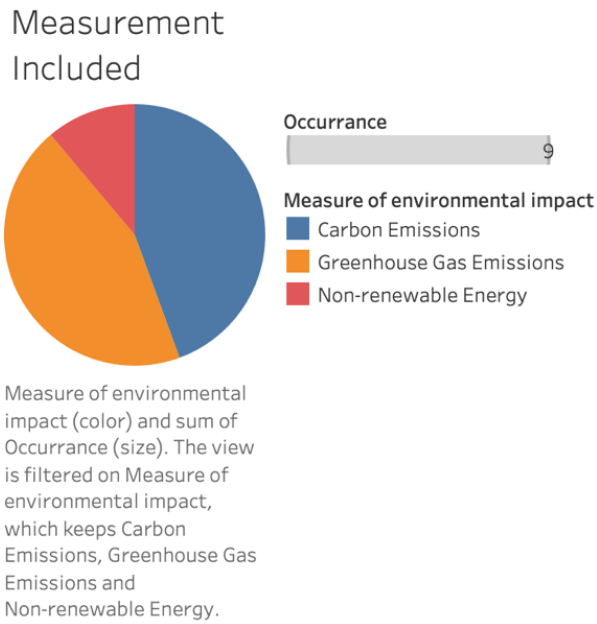
Figure 4: Occurrences of Approaches in Included Articles



Regarding classification and distribution of quantitative measurement of negative environmental impacts, four articles included carbon emissions as the main measure of quantitative analysis, four articles included greenhouse emissions, and one article used non-renewable energy. The approach each article used normally determined the measurement of analysis: linear programming used greenhouse gas emissions; life cycle analysis usually used carbon emissions; and mean comparison used either greenhouse gas or carbon emissions. Articles which did not include a quantitative analysis, or included qualitative measures alongside quantitative analysis, typically relied on previous research into the environmental benefits of certain interventions as a justification for inclusion in the respective article. The most common

measures of sustainability that were not included in quantitative analysis were local, organic, and seasonal foods.

Figure 5: Metric Used to Measure Negative Environmental Impact

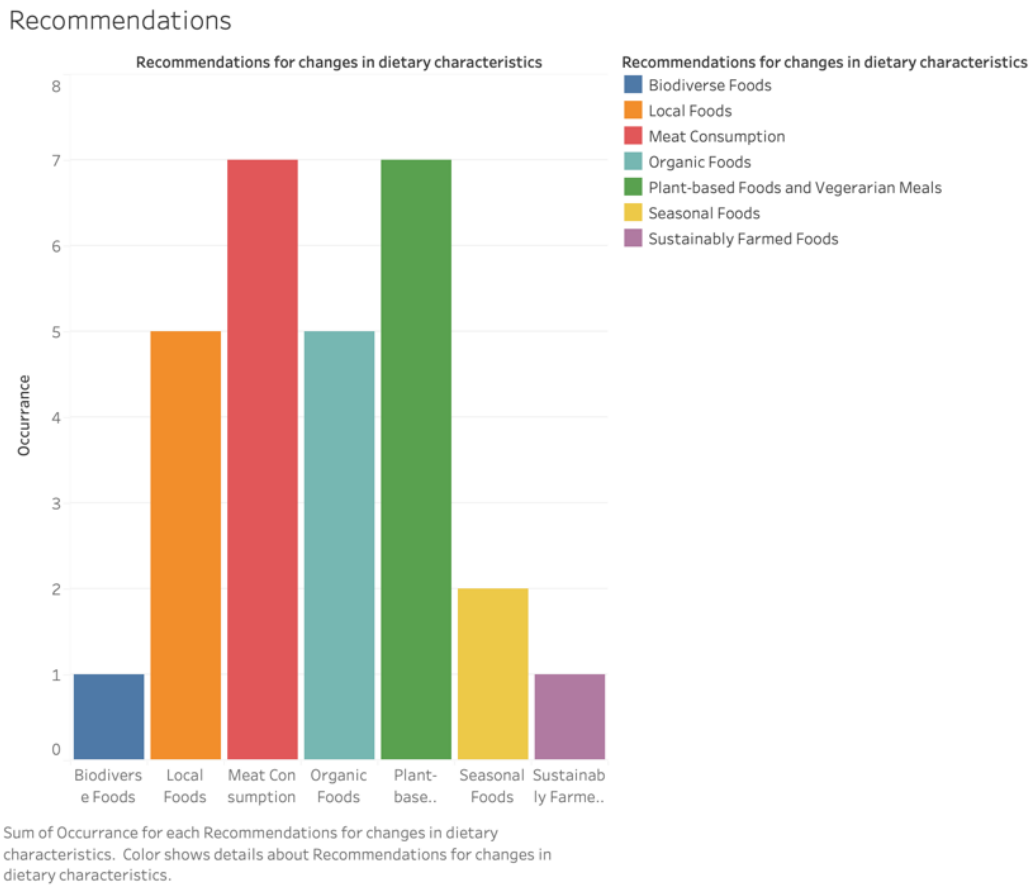


3.4 Recommendations:

Recommendations from the authors of included articles typically showed similar themes, which can be broadly classified as increases in vegetarian and plant-based food, reductions in meat consumption, increases in the proportion of organic food, increases in the proportion of local food, increases in the proportion of seasonal food, increases in the proportion of biodiverse foods, and increases in sustainably farmed foods. The most cited recommendations were reducing meat consumption and increasing vegetarian and plant-based foods, followed closely by recommendations for an increase in the use of organic foods and local foods. Red meat and beef were normally cited when reductions in meat consumption were identified by specific type, and this was justified by the higher share of environmental impact from these products. Many articles suggested removing red meat or beef entirely and substituting it for lower-impact protein

sources, or only serving it once or twice a week. The recommendations to increase vegetarian and plant-based foods largely took the form of recommendations to increase the share of vegetarian meals so it was half or more of the meals served, and specific recommendations regarding what plant-based should be increased took the form of recommendations for whole grains, nuts, seeds, and pulses. Increasing biodiverse foods and choosing sustainably farmed foods had the lowest instances of recommendations.

Figure 6: Recommendations for Changes in Dietary Characteristics



4. Discussion

4.1 Institutions:

The literature reviewed is almost homogenous regarding the institution, being made up almost entirely of articles examining primary and secondary schools. This is unsurprising as both the FAO and the United Nations Food System Summit have focused on public food procurement in education as an avenue toward more sustainable food procurement, particularly after the success of the National School Feeding Program in Brazil, which aimed at increasing the proportion of local foods from family farms in school meals. (Food and Agriculture Organization of the United Nations 2021) This could potentially lead to bias as nutritional recommendations, and therefore menus, vary by institution, such as increasing protein for meals served in nursing homes, so recommendations relevant to the education sector may need to be adjusted when extrapolating to another sector. (Lassen et al., 2021) The menus created and analyzed by the included articles, and the recommendations that the authors provide, should also be studied in the context of other institutions to ensure that those recommendations are appropriate for other institutions. In addition, school menus typically offer less choice in terms of menus as compared to other institutions, which could limit the ability of new menus or foods to effectively lower negative environmental damage if those menus or foods are not adopted. Theoretically, the methodology surrounding menu optimization could simply be adjusted to accommodate different dietary needs as they vary by institution, but the effectiveness of these studies in practice has not yet been examined.

4.2 Methods:

The methods utilized in the included studies are particularly relevant. The inclusion of quantitative analysis in a large proportion of the article points to an increasing prioritization of measurable effects from sustainable practices in public food procurement within current

research. Due to many governments' aims of reducing negative climate impacts in terms of carbon and greenhouse gas emissions, quantitative methods in terms of menu design provide a straightforward avenue to create policy proposals in this field. However, most quantitative studies used simulations to model new menus or guidelines, and there are fewer studies that examine the environmental impacts of the current policies that are in place. Another problem arises in building policies around models that utilize only one metric- which was common in simulations- to measure effectiveness, and this could run the risk of relying on analysis that does not examine sustainable interventions in a holistic manner, such as examining negative impacts to local ecosystems and biodiversity. Initiatives involving the optimization of greenhouse or carbon emissions run the risk of discounting effects on local ecosystems or biodiversity that could benefit from organic farming or increasing the use of biodiversity in meals.

4.3 Direction for future research:

Analysis of the included articles reveals a gap in the literature concerning the long-term and short-term environmental impacts and compliance with policies concerning sustainability through dietary change in public food procurement. Because the initiatives in these studies are recent, the lack of long-term research is not unexpected, but it does allow reveal the need for further examination of these effects in the future. The low number of included articles- even including simulations- also points to a lack of short-term negative environmental impacts that have been studied. The effectiveness of sustainability interventions in this field relies heavily on compliance, made more complicated by the fact that decisions regarding menus and preparation were largely handled at a municipality level. Several of the included studies that used descriptive analysis had already found that compliance with programs varied according to municipality, further exemplifying the need for research into the effects of compliance in sustainable food

procurement programs on environmental outcomes. Further research is also needed to study changes in dietary characteristics within sustainable food procurement in other institutions. In addition, future research should examine the effectiveness of the simulations proposed in a real-world context, ideally through an experimental design to verify if these proposed models of menus are effective outside of the simulations. Finally, research should also be conducted on how to combine metrics such as reductions in land use, water use, GHGEs and carbon emissions with reductions in harm to local ecosystems and biodiversity, in order to study negative environmental impacts in a holistic manner.

4.4 Recommendations

Analysis of the recommendations offered by the included studies offer some insight into best practices in similar literature in the future. The recommendations for best practices within these sustainability initiatives seems highly linked to choices within the methodology. None of the studies that used a qualitative analysis and seven of the nine articles that used quantitative analysis included reductions in the use of meat in menus. In addition, three of the four qualitative articles included local foods and organic foods, whereas two out of the nine quantitative articles used organic food and local foods. This disproportionality is likely due to the measurement of sustainability used in the various qualitative and quantitative studies. The proportion of organic food recommended varied widely, from 20%-90% in descriptive studies to 47%-100% in simulations. In addition, local and organic foods may face logistic challenges because production of these foods can be limited and suppliers may be hard to find, making it less likely to be recommended in the included studies. Reductions in meat consumption and increases in plant-based foods may be easier in comparison, which is possibly the reason why these appeared more

in the recommendations. The qualitative studies included were more likely to focus on policies surrounding the food sources for procurement programs, instead of larger changes to menu composition, which was the focus of most of the quantitative studies. The simulations in particular offer promising recommendations if their effectiveness in a real-world context can be verified, as they were able to produce models that reduced greenhouse gas emissions to levels that were recommended by current policies in the countries studied.

4.5 Limitations

Included studies had several limitations due to the low number of papers included in the review, as well as the reliance on papers that come from grey literature. This arises from the fact that much of the academic work on this topic is relatively new, as are many environmental initiatives being implemented in public food procurement. The low number of articles could potentially lead to results that are inconsistent with findings from similar work in the future as more work is published on the topic. The inclusion of grey literature also means that some included articles did not go through a thorough peer review process and may have bias or may be unreliable. As new research is published, it would be beneficial to revisit the work done in this paper and compare these results with future work, when more research is published on the topic.

5. Conclusion

The aim of this paper was to examine the changes in dietary characteristics that were identified and recommended in the literature for sustainable food procurement. Content analysis from the literature reveals a link between the changes in dietary characteristics that were identified (in addition to those changes which were recommended), with the methodology of the

included studies. This finding was most evident when considering that using a qualitative analysis led to recommendations which lacked reductions in meat consumption, whereas quantitative methods led to strong recommendations for this reduction; and that using local and organic foods were used far more frequently in qualitative analysis in comparison with quantitative analysis. These discrepancies may suggest that future research may be needed to establish quantitative methods that can consider certain dietary characteristics that are more difficult to measure, such as local, organic, and biodiverse foods.

This paper identifies the major dietary characteristics that are included in sustainability initiatives, as well as highlighting recommendations, of which the most common were decreases in meat consumption and increases in plant-based, local, and organic foods. In addition, this paper discusses the ways in which these recommendations are limited in that this systematic review uses a low number of articles and includes grey literature, and the majority of the included papers come from studies on public food procurement in schools. This paper contributes to the existing literature by identifying potential biases in recommendations for dietary characteristics based on the type of methodology selected, these biases being that the methods used for the included studies are linked with the specific dietary characteristics that are recommended by those studies. This can be utilized by research in the future to help establish a protocol for research in this area, in order to include effective changes in dietary characteristics in analysis that may normally be discounted based on the methodology chosen.

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Appendix

Table 4: Table of Articles- Additional Information

Title	Publication	Year	Country/Region	Sustainability initiative type	Institution	Quantitative measurement of Sustainability included?
Less animal protein and more whole grain in US school lunches could greatly reduce environmental impacts	Communications Earth and Environment	2022	United States	Menu improvement	Education/grade school	Yes- Carbon emissions, land use, water consumption, phosphorus eq. freshwater, nitrogen eq. marine eutrophication
Routes to sustainability in public food procurement: An investigation of different models in primary school catering	Journal of Cleaner Production	2022	Croatia, Greece, Italy, Serbia, United Kingdom	Local food	Education/primary schools	Yes- Carbon emissions
Agroecological public policies to mitigate climate change: public food procurement for school canteens in the municipality of Ames (Galicia, Spain)	Agroecology and Sustainable Food Systems	2021	Spain	Menu improvement, Organic food, Seasonal food	Education/grade school	Yes- Greenhouse gas emissions
Diversifying institutional food procurement – opportunities and barriers for integrating biodiversity for food and nutrition in Brazil	Raizes	2016	Brazil	Local foods, Biodiverse food	Education/grade school	No- descriptive results on 2 policies
Guidance for Healthy and More Climate-Friendly Diets in Nursing Homes—Scenario Analysis Based on a Municipality's Food Procurement	Nutrients	2021	Denmark	Menu improvement	Nursing Homes	Yes- Greenhouse gas emissions
Scenario analysis of a municipality's food purchase to simultaneously improve nutritional quality and lower carbon emission for child-care centers	Sustainability (Switzerland)	2021	Denmark	Menu improvement	Childcare centers	Yes- Greenhouse gas emissions
Sustainability and local food procurement: a case study of Finnish public catering	British Food Journal	2012	Finland	Local food, Organic food	Education/grade school	No- critique of lack of appropriate sustainability measurement included in paper
Optimizing School Food Supply: Integrating Environmental, Health, Economic, and Cultural Dimensions of Diet Sustainability with Linear Programming	International Journal of Environmental Research and Public Health	2019	Sweden	Menu improvement	Education/grade school	Yes- Greenhouse gas emissions
Strategies and Tools for Eco-Efficient Local Food Supply Scenarios	Sustainability	2014	Italy	Menu improvement, local food	Education/kindergarten and grade school	Yes- non-renewable energy
Contribution of school meals to climate change and water use in England	Energy Procedia	2017	United Kingdom	Menu improvement	Education/grade school	Yes- carbon emissions and water footprint
Modelling, assessing, and ranking public procurement options for a climate-friendly catering service	The International Journal of Life Cycle Assessment	2018	Italy	Menu improvement	Education/primary school	Yes- carbon emissions
Public Procurement for Sustainable Food Environments	European Public Health Alliance	2019	Europe (Case studies from Belgium, Denmark, Finland, Germany, Latvia, Slovenia, Spain)	Organic food, local foods	Education, government	No- uses research to back sustainability claims

EU GPP criteria for food procurement, catering services and vending machines	EU- Joint Research Center	2019	Europe	Improving guidelines, menu improvement	All sectors (primary sectors: health/wellness, education, business)	No - uses research to back proposal of new criteria