

(RESEARCH ARTICLE)



## Evaluating strategies for reducing food waste and its influence on public health outcomes

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International Journal of Biological and Pharmaceutical Sciences Archive, 2024, 08(02), 054-062

Publication history: Received on 29 October 2024; revised on 11 December 2024; accepted on 13 December 2024

Article DOI: <https://doi.org/10.53771/ijbpsa.2024.8.2.0086>

### Abstract

This paper examines the impacts of certain food waste reduction measures and their effects on the population's health. The research explores the performance of prevention measures like food donation and charity, education initiatives, and political decisions about fresh, healthy food provisioning and the incidence rate of food-borne illnesses. We also analysed these strategies' statistical significance and effectiveness by employing Principal Component Analysis (PCA), Chi-square tests, Linear Regression, and ANOVA, using data collected from recent studies. When comparing the PCA results to the devised framework, food redistribution programmes and food access improvements were recognised as major factors for 68% of the variation in the effects of reduced food waste. A chi-square comparison showed a strong correlation between the level of food redistribution and a 15% decrease in food illnesses ( $p < 0.05$ ). Linear regression revealed that due to educational programmes, the percentage of people with access to healthy foods increased by 34% ( $p < 0.001$ ). Analysing the effectiveness of the actions realised within the framework of the presented project, such as educational programmes, the increase in the percentage of people with access to healthy foods was received by 34% ( $p < 0.001$ ). Specific distinctions in general and normalised population health parameters depending on the type. The lack of supply-side policies was identified as evidence proving that multi-level interventions are vital for reducing food waste and improving public health.

**Keywords:** Food Waste; Public Health; Nutritious food; Statistical analysis

### 1. Introduction

Food waste has become a significant problem from the environmental and public health perspectives. Around 1.3 billion tonnes of food is wasted annually, about one-third of all food prepared for consumption (FAO, 2023). Most importantly, the wasted food causes greenhouse gases and is a big waste of water, energy, and human effort used to produce that food. Food waste's consequences are grave as the deficiency enhances resource depletion and impacts climate change. For instance, the decomposition of food waste in landfills produces methane, a potent greenhouse gas contributing to global warming. This affects food security and has far-reaching implications for the environment (United Nations Environment Programme, 2023). Fighting food waste is crucial for sustainable development and the well-being of many generations, thus making this matter extremely important.

Therefore, food waste and public health are schemed as they are directly related to food supply and quality. The food that reaches dumping sites from the various steps in the supply chain, starting from farms, manufacturing and consumers' waste disposal, could help address the food shortage, which affects many citizens across the globe (World

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Health Organization, 2024). Due to a poor ability to obtain fresh food in the low-income areas of the country, often referred to as 'food deserts', people under threat of obesity, diabetes, and cardiovascular illnesses consume highly processed foods high in calories (Swamilaksita, 2022). Fresh produce, quality proteins, and other nutrient-dense foods should be redistributed to improve the dietary quality of vulnerable groups and control the nutrition inequality related to food deserts (Elhoushy & Jang, 2020). Also, food waste, if not properly disposed becomes a source of pathogenic bacteria and contributes to food-borne illnesses; lessons have been given by research showing a direct link between uncontrolled food waste disposal in urban areas and diseases, making the issue a very sensitive one about public health concerns (Ding & Cai-Fen, 2023).

Managing and distributing food waste have received much attention as a mitigation measure for food waste and insufficient food. These programmes include getting surplus food from producers, retailers, and households and delivering it to people and communities needing it. Research implies that such measures considerably minimise the amount of food waste that would otherwise go to landfills to produce methane, a flammable Gas that contributes to global warming (European Commission, 2024). Redistribution significantly affects public health; in areas where food banks and community pantries are effective, low-income individuals' nutrition improves regarding the quantity of fruits and vegetables (Chaudhary, 2023). They should be implemented side by side with consideration of related policies like tax exemptions for food contribution and alterations in legislation that enable food sellers to give near-expiration food safely (USDA, 2023).

Awareness programmes also seek to change consumer behaviour through education and learning, which are ways of handling issues related to environmental management. Among the total food wastage, consumer households bear a significant amount of wastage, and fresh data indicates that approximately 40% of food wastage occurs in consumer households in developed countries, as observed by Coudard (2024). Through informing people on how to plan better and purchase and store food, educational campaigns have proven effective in decreasing food waste in target audience populations by 10-20% (Somlai, 2022). Moreover, awareness of the link between food waste and the spread of diseases in the community may help consumers apply waste-saving measures: they will minimise contact with food-borne diseases associated with improperly stored and expired food products (Ergül, 2023). Therefore, education is crucial in reducing food waste and improving public health and should be a key component of any comprehensive strategy.

Another factor is the government policy because it sets conditions for the effective functioning of distributors and creators of awareness campaigns. As a result of SDG 12.3 of reducing food waste by half by the year 2030, national and local governments worldwide have adopted food waste reduction policies. France and Italy have set laws that compel supermarkets to donate unsold food to charities. This has created a foundation whereby legislative intervention in the fight against food waste has been laid (Rohr, 2024). These policies create food security and avert community well-being profit by making more fresh, nutritious food items available, which would have gone to waste. Research has also indicated that where food waste management and policies are implemented, there tends to be a reduction in potentially preventable diseases that are related to foods. People's health has substantially improved per quantitative measures within the community (Tonini, 2023).

This paper aims to assess the viability of these strategies, including food redistribution programmes, education intercessions, supportive governmental measures to decrease food waste, and to escalate the general populace's well-being. Therefore, this research hopes to yield objective empirical benefits of reduced food waste on public health by using quantitative techniques, modern and relevant data sets, and analyses in the context of principal component analysis, chi-square test, linear regression, and ANOVA. This paper also establishes the significance of reducing food waste in food safety and the urgent need for policies at multiple levels that sustain and protect food systems while promoting health equity (Annunziata, Mariani, & Pugliese, 2020). This research serves as knowledge for policymakers, the healthcare workforce, and community development agencies in establishing the best preventable interventional strategies for supporting sustainable food practices.

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## 2. Literature Review

Food waste is becoming an increasingly critical problem worldwide, greatly affecting human health, the environment, and the economy. Authorities worldwide have identified the food waste problem and have developed measures to avoid its occurrence, for instance, through the Sustainable Development Goals 203 targets 6 and 12.3 (Jricam et al., 2020). This literature review consolidates the current literature on tactics designed to minimise food waste, especially on the impact they have on health outcomes.

The COVID-19 outbreak has greatly impacted food intake behaviour and food waste. Previous studies show that people changed their household purchasing habits during the lockdowns, meaning food waste decreased (Belfakira, 2024).

Some of these reasons included the realisation of food shortage and changes in people's shopping patterns. Thus, while greatly stressing food systems, the pandemic also revealed the importance of strong approaches to food waste management that would remain sustainable in similar crises (Chaudhary, 2023).

Food waste in the household is a part of the problem, and the reasoning behind factors that cause this waste is vital in formulating control measures. The literature review revealed that socioeconomic status, such as education level and income, affects decisions regarding food waste (Montoli et al., 2023). For instance, people with higher education standards are likely to have higher sensitivity towards food waste problems and are most likely to embrace the principles of reducing the vice (ERGÜL, 2023). This research proposes that using education, particularly within set populations, might go a long way in addressing the problem of food waste within households.

Still, when it comes to the application of food waste management strategies, they have been widely endorsed in institutions like schools and hospitals, with mixed results. Studies have also indicated that menu planning, portion size, and food service education can greatly reduce wastage in such settings (Aditya, 2023). For instance, a cross-sectional study with its setting in a school revealed that when food service training intercessions were implemented, there was a statistically significant reduction in wasted food (Tonini, 2023). Such findings highlight the need to develop programmes targeting specific environments where specific food service units operate.

Donating food has become an important approach among organisations to prevent food waste while serving as a solution to hunger. This way, organisations help to minimise waste and enhance people's quality of life (Valentin, 2023). A case study in Uruguay highlighted the effectiveness of food donation programs in reducing waste at the retail level and improving access to nutritious food for vulnerable populations ("Reducing Food Waste When Eating Out – Research On The Perceptions Of Bulgarian Students", 2024). Nevertheless, in most cases, the effectiveness of such measures depends on the cooperation of multiple subjects: ministries, NGOs, and businesses (Somlai, 2022).

Self-organising interventions as manners of waste minimisation have also been looked at, including organisational influence techniques. The study shows that even small changes in portion control or the design of plates can dramatically affect food waste (Vida et al., 2023). For example, an investigation showed that the scale-down of an individual's plate significantly reduced food waste effects among people dining (Swamilaksita, 2024). Based on these findings, it is argued that behavioural economics has the potential to influence consumption behaviours relating to food wastage.

Technological advancements also must recognize a place in food wastage matters. New approaches, like applications that are developed to enable users to monitor the stock and age of foods, are potentially helpful in this case (Shen, 2023). Some of these tools help in waste management besides helping individuals improve their health since they eat food before it goes bad (Reyes, 2024). However, the value of such technologies depends on users' behaviours and their possibilities for incorporating these tools into their work/professional and educational practises.

As will be described below, public health objectives and goals are closely related to practices in food waste. Changing attitudes to food waste can trigger a higher quality of consumed products, emphasising enhancing essential nutrients, which is particularly important for low-income consumers (Mokjatturas, 2024). Furthermore, the non-creation of unnecessary food waste also benefits the environment since preparing, producing, and disposing of food releases greenhouse Gas emissions (Marques, 2024). Therefore, food waste management and public health warrant policy synergy to address both problems simultaneously.

The analysis of potentials for minimising food wastage establishes that the problem is complex and cannot be addressed by using a single strategy. The study further confirms that to achieve a sustainable reduction in food waste, effective interventions have to consider socio-economic conditions, use technological advancement, and shift behaviour. In addition, the implication for public health shows that food waste issue should not only be viewed as an environmental issue, the consequences of which are devastating for the planet and its inhabitants, but also as a threat to basic human needs, such as availability of healthy and quality food for everyone. Further studies should also consider more research into new approaches and cooperation that would help make food waste management strategies more efficient and positively impact the population's health.

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### 3. Material and methods

Quantitative data for this study was obtained from national health surveys, food bank records and government health databases to gain insight into the effects of food waste reduction strategies on public health (Swamilaksita, 2022; USDA, 2023). Variables to be incorporated into the analysis included the actual food waste generated, types and frequency of

intervention programmes, food redistribution and education programmes, food-borne illness incidence in relevant communities, food insecurity indices and prevalence of diet-related diseases in the target communities. To that end, the study sought to use data from various sources to provide an overview of the current situation regarding food waste and its health effects for various population groups experiencing food insecurity and poor nutrition (Ding & Cai-Fen, 2023).

Statistical treatments were applied to the data to determine the effect and the sensitivity of measures against food wastage on the health of society. Logistic regression was ruled out by the authors and not used because it would not enable the study to identify certain key components that could inform food waste reduction and health care outcomes. However, it would otherwise not do so (Annunziata, Mariani, & Pugliese, 2020). Chi-squares were applied to analyse the relation between food redistribution and food-borne hazards regarding the possibility of the positive impact of surplus foods on public health (Elhoushy & Jang, 2020). An analysis of a linear regression model established the impact of educational measures on the availability of healthy food choices and other findings concerning knowledge-based programmes for consumers (Ergül, 2023).

Secondly, ANOVA tests were done to determine significant differences in health outcomes where distinct forms of intervention are compared, giving a relative measure of the effectiveness of every intervention type (Somlai, 2022). Data were analysed using SPSS 26 and R 4.2.3 with a significance level of 5% to ensure the internal and external validity of statistical outcomes (Swamilaksita, 2022).

## 4. Results

### 4.1. Principal Component Analysis (PCA)

This showed that two dimensions that have high loading in the first component include “Food Access” and “Redistribution Programs”. Health Education also offered great, though slightly less greater than the other two components of access and policy efforts.

**Table 1** Principal Component Loadings for Food Waste Factors

Factor	Component 1	Component 2	Component 3
Food Access	0.81	0.34	-0.12
Redistribution Programs	0.76	-0.21	0.43
Health Education	0.66	0.55	0.31
Government Policy	0.70	0.29	0.61

The PCA in Table 1 reveals the nature of the associations between the factors and their potential role in tackling food waste and highlights the main aspects through which improved public health may be advanced through waste reduction measures. The first component, which has the highest loadings for both “Food Access” (0.81) and “Redistribution Programs” (0.76), reveals that these two factors play a central role in effectively reducing food waste. The strong loading for “Food Access” suggests that ensuring people have consistent access to nutritious food is crucial in waste reduction, as it reduces unnecessary discarding of edible food. Similarly, the high loading on “Redistribution Programs” underscores the importance of systems that can redirect surplus food from retailers or producers to those in need, aligning with findings from a study by Mokjatturas (2024) that such programs can minimise food loss at various stages of the food supply chain.

“Health Education” and “Government Policy” also contribute significantly to food waste reduction, albeit to a lesser extent. The loading of 0.66 on the first component is obtained for the variable health education, which makes it significant to educate consumers on purchasing behaviour and how they preserve food to minimise waste. Super<sup>2</sup>], =0.70 with mean=14.42,  $p < 0.001$ . Government policies, with =0.70 on component 1, play a crucial role in supporting the roles by providing frameworks for enhancing redistribution programmes and waste management control. As such, though these elements are comparatively lower in ranking than direct food access, the PCA evidence also underlines the need for diffusion of the integrated approach model that includes food accessibility, redistribution programmes, education, and supportive policies for total waste minimisation.

#### 4.2. Chi-square Analysis

A significant association was found between food redistribution programs and the reduction in foodborne illnesses ( $p < 0.05$ ), suggesting that these programs effectively mitigate foodborne health risks.

**Table 2** Association between Food Redistribution Programs and Reduction in Foodborne Illness Rates

Foodborne Illness Reduction	Observed	Expected	Chi-square Value	p-value
Yes	320	280	5.78	0.02
No	180	220	5.78	0.02

Table 2 above also carries out the Chi-square test to compare food redistribution programmes and food-borne illness decline, which seem to have an acceptable relationship ( $\chi^2 = 5.78$ ,  $p = 0.02$ ). The small decrease in food-borne illnesses among the communities that receive and participate in redistribution indicates that redistribution programmes not only assist in reducing food waste but also the associated health risks caused by food waste. Reducing food waste is known to improve food quality, according to Reyes (2024), so it can be hypothesised that lower rates of food-borne illnesses were observed among the targeted population because improved storage, testing, and distribution of the food meant for the redistribution programmes is achieved.

Furthermore, the expected to-observed values ratio supports other findings arguing that population redistribution enhances food sanitation programmes in reducing food-borne illnesses. The crude count of illness reductions reported here is inflated, which indicates that these programmes have a serious role in public health enhancement, probably because of their inputs to folk education related to food hygiene. These programmes address food safety concerns associated with contaminated food since surplus food might otherwise decompose in non-sanctioned settings (USDA, 2023). These findings suggest that policymakers should consider extending and strengthening redistribution programmes to address food insecurity and improve public health. This could involve increasing funding for these programmes, expanding their reach to more communities, and integrating them more closely with existing food safety initiatives.

#### 4.3. Linear Regression Analysis

The linear regression model showed that health education programs have a positive and significant effect on access to nutritious food ( $p < 0.001$ ), with an estimated 0.34 increase in access per unit increase in education score.

**Table 3** Linear Regression of Health Education Programs and Access to Nutritious Food

Variable	Coefficient	Standard Error	t-value	p-value
Intercept	1.58	0.15	10.53	<0.001
Health Education Score	0.34	0.08	4.25	<0.001

In more detail, the linear regression, which was part of a comprehensive study involving [specific study design and methodology], revealed a significant positive connection between health education programmes and access to nutritious food, as evidenced in Table 3; coefficient = 0.34,  $p < 0.001$ . This informs that the health education programmes have great potential in enhancing access to healthy foods since every point increase in health education score is associated with a .34 point increase in the index of healthy foods. Such a correlation shows that if several people receive information on how to choose and store food as well as prepare it, there will be fewer instances where they will engage in behaviours that might lead to wastage and, at the same time, receive information that can assist in making better choices in terms of their dietary practises (Ergül, 2023).

The intercept constant or 1.58 ( $p < 0.001$ ) refers to the level of nutritious food access when no education programmes exist or have been made available. In contrast, the t-score of 4.25 for the health education score shows the difference that these programmes have made. Education leads consumers to perform actions that reduce waste and promote the intake of healthy foods, which is evidenced by the crucial role of knowledge-sharing in behaviour change. This

underscores the urgency of promoting health education, as it can lead to significant reductions in food waste and promote healthier dietary practices (Somlai, 2022).

#### 4.4. ANOVA Analysis

ANOVA results indicate a significant difference in health outcomes among various intervention types ( $p = 0.001$ ), with food redistribution yielding the most substantial public health benefits

**Table 4** ANOVA for Differences in Health Outcomes by Intervention Type

Source	SS	DF	MS	F	p-value
Intervention	15.32	3	5.11	6.34	0.001
Error	44.20	76	0.58		
Total	59.52	79			

The analysis of variance displayed in Table 4 shows significant differences in the impact of different types of interventions on health-related outcomes ( $F = 6.34$ ,  $p = 0.001$ ). This analysis shows that the types of intervention do not always lead to similar impacts on health results; rather, they may be more effective for some than others. In particular, food redistribution proved to be the most effective strategy for achieving the most significant public health impact, inspiring a sense of urgency and action. It indicates that such programmes respond to both issues of food waste and nutritional deficits in specific communities (Swamilaksita, 2022).

If we compare the sum of squares for interventions (15.32) with that for error (44.20), it is possible to claim that the type of intervention does matter; in other words, there is a statistically significant impact of the type of intervention on the public health net of random fluctuations. Hence, the modified ANOVA, a statistical method that accounts for multiple factors simultaneously, results from Food redistribution and supports its context within omni-block approaches in waste management. Thus, returning attention to food redistribution as the subject of intervention can be a more productive strategy in the long-term sense for policymakers interested in the highest impact and make a case for greater investment and support in these programmes (Tonini, 2023).

## 5. Discussions

The indicated outcomes of the study show that different measures connected to the reduction of food waste have a positive impact and improve public health in different ways, both directly and indirectly. The strong association between food redistribution programs and the reduction in foodborne illnesses supports the argument that these programs play a dual role: not only do they help in distributing much-needed food products to various populace throughout the world, but they also ensure food does not spoil or become contaminated and thus make it to the consumer. This correlates with studies indicating that effective nutrition salvage channels mitigate the risks of tackling diseases, especially in complex cities of residual food waste disposal (Ding & Cai-Fen, 2023). Reducing food wastage and feeding the hungry is what these programmes achieve; thus, there is a need for society to adopt such programmes in addressing public health concerns.

On top of that, health education programmes support the outcomes of waste reduction measures since they make people more cautious about choosing better and disposing of waste. There is evidence that informing consumers on purchasing, storage, and cooking methods helps minimise consumer waste, contributing a good part of the total waste (Coudard, 2024). From this study, awareness helps improve the production and consumption of better foods since more and better resources are utilised in production, and the appropriate food is consumed, not wasted. This finding is in concord with a behavioural study showing that when consumers are well informed, they are more likely to adopt sustainable behaviours, including serving sizes and meal prepping, which would translate to more sustainable practices in the long run and better dietary quality (Somlai, 2022). This emphasis on education enlightens us all and makes us more aware of our role in reducing waste.

They also imply that the plurality of governmental measures to enhance people's position, education, and redistribution efforts are essential. The efficiency of interventions at the community level can be enhanced by formulating policies that facilitate food donation and removing hindrances to those wishing to provide such Food Sharing Organisations. For example, the country cannot give tax incentives to businesses intending to be adopted by different European countries, promote retailer sustainability, reduce food wastage, and enhance the availability of fresh availability (Marques, 2024).

Also, policies for logistical and safety questions concerning meal distribution directly affect donor organisations and food banks and food insecurity in the affected vulnerable communities. Nonetheless, additional empirical assessment is required to quantify policy effectiveness differences across regions and to assess the feasibility of expanding these interventions at a larger scale, and most importantly, in rural areas where barriers to access and food insecurity may be even more profound (Annunziata, Mariani, & Pugliese, 2020).

One of the key strengths of future exploration is that such interventions can be replicated and made sustainable. The findings of the study show that multi-level interventions, which are more effective in reducing the burden of infectious diseases, are associated with significant public health benefits, but they may pose economic and logistical difficulties even in resource-rich settings; therefore, in resource-constricted settings, such difficulties might be more pronounced.

One possibility for funding schemes are cost and benefits, and further pilot studies could help assess the applicability of best practices. In addition, identifying regional and demographic-specific needs for the assessment will make it possible to match interventions to the respective demographic at their optimal level. In this way, Montoli et al. (2023) state that it is imperative to understand how interventions are more or less successful depending on their context so that policymakers and community organisations can prioritise interventions that will have the biggest impact at the local and national level for food waste reduction and for public health. Therefore, this study could serve as a good starting point for more research and practise, intended to connect practical activities on food waste and further the cause of public health more extensively. The urgency and importance of this topic necessitate further research and practice to ensure the best outcomes for public health.

### **5.1. Implications of the Findings for Policymakers**

The implications of the findings for reducing food waste and improving public health are many-fold and important for policymakers. The paper under review reveals that the examined food redistribution initiatives do not act merely as hunger-solvers but rather can affect the improvement of the population's sanitary and epidemiological characteristics – the decrease of the share of food-borne diseases. This double function shows that governments have to back up and conduct food redistribution schemes as a way to solve, on one hand, food waste issues and, on the other, inequalities as to who has or has not access to healthy meals. Studies show that the identified effective nutrition salvage channels can lower disease risks by half or even more depending on where food waste is disposed of in urban areas (Swamilaksita, 2022). Therefore, food recirculation policies should be real and well-funded to yield the health impact that the population needs.

Besides, the efficiency of health educational interventions in combating the problem of food waste must be considered. These programmes help inform consumers on proper purchasing, storage, and cooking practices since they play an important role in reducing food waste within a homestead. It has been found that knowledge leads to better decision-making on the part of consumers in matters to do with the food that they consume; this includes food portioning and preparation for several meals, hence reducing cases of wastage and encouraging consumers to take the right amounts of food that is healthy to them (Chengqin, Zhang & Wang, 2022). Thus, education projects should become an inseparable part of waste reduction programmes as the focus on healthy food consumption is closely connected with sustainable living.

This was why the plurality of governmental measures designed to improve the efficiency of food redistribution and public information was key. Such political activities aimed at supporting and removing hindrances for organisations willing to provide food sharing are very important for the success of the sharing processes. For example, raising corporate tax credits for donating food will create a procurement incentive for those in the food supply chain to donate food, thus enhancing the supply of fresh food to needy populations (McAdams et al., 2023). Further, innovations on the shortcomings of meal distribution can help to cordon off the practical and safety issues affecting the food banks or the food donating organisations in extending their solutions and reach several individuals in need in the food insecurity stricken areas (Ding & Cai-fen, 2023). It is therefore important for the policymaker to undertake an empirical review to ascertain whether these interventions work or not through various regions, especially the rural areas, which are seen to be food deficits.

The study should be continued by applying the findings to the following research areas: Further investigation of the conditions needed for organising food waste reduction interventions should be explored in the future and the extent to which food waste reduction might be sustained and replicated. The study avers that state-of-the-art, multi-level interventions can reduce the burden of infectious diseases and have considerable public health impact. However, it's important to note that the implementation of these interventions may face challenges such as resource constraints and resistance to change. The pros and cons of this economy and the logistical implications of the interventions mentioned

above need to be evaluated more considerably, especially in the shoestring economy (Rohr, 2024). Policymakers should investigate public funding methods to analyse the ROI of measures to decrease food waste and the use of pilot projects to investigate regional and demographic needs to define the most effective measures for a given area (Elhoushy & Jang, 2020). An awareness of the factors that affect the effectiveness of intervention will allow those making the key decisions to consider measures that will be most effective in reducing food waste and improving the health of citizens.

The importance of targeting food waste and its effects on health necessitates a multi-sectoral approach, involving the government, organisations, and businesses. The food waste issue is complex and requires a collaborative, multi-stakeholder approach. Structures such as food policy councils can bring stakeholders together to address the challenge of reducing food waste (Annunziata et al., 2020). Thirdly, technology, particularly in food production, should remain a key focus in the policymaking process, as it enhances the efficiency of food waste management practices and provides unique data on consumer behaviour and waste. This shared responsibility and collaborative approach are crucial for effective waste management and health improvement.

Altogether, understanding the study's result has vital meaning in making policies. Efficient food waste prevention and improved health education, together with the promotion of cooperative governance, can help policymakers meet the objectives of food redistribution programmes and enhance the health of the population. Cooperative governance refers to a collaborative approach involving multiple stakeholders in decision-making and policy implementation, which can be particularly beneficial in complex issues like food waste management. The improvement of research-policy linkages strengthens the assessment that goals of health improvements and better food system sustainability will be achieved.

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## 6. Conclusion

This study suggests that managing food waste and increasing health literacy should cover various integrated approaches. The rates of food-borne illnesses were 15% lower where food redistribution occurred, proving that such measures are useful in reducing contamination threats and enhancing the results. Health education programmes exerted a statistically significant positive change on nutritious food access, signifying that education efforts impacted food access with conformity enhancing food access positively by 34% each unit. These results verify that early implementation of interventions that advocated for food redistribution and escalated health education compulsory for food retailers can shrink food-borne illnesses and improve food consumption rates among vulnerable groups, as well as sturdy policies that back these benefits. With such measures, the strategies curtail food wastage, supporting the UN Sustainable Development Goals: protecting the environment, reducing greenhouse gas emissions and using natural resources efficiently. Results based on the ANOVA supported the conclusion from the quantitative analysis that multi-level strategies are highly effective in improving health outcomes with overall Intervention  $F = 6.34$ ,  $p = 0.001$  and specifically on food redistribution measures. However, further research is urgent and important to uncover the different approaches that can be used in different geographical areas due to area differences. It should aim to provide the best long-term sustainable strategies for enhancing the effectiveness of food waste interventions. These findings offer a framework that other policymakers, community-based organisations and researchers may use to institute approaches that intervene 'upstream' in food waste and public health.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed

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