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XIV Edition

EU Economy And Its Main Priorities

Coordinator:
Simona Moagăr-Poladian

Bucharest

2024

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Improving the Sustainability of Hospital Food Service by Measuring Food Waste and its Associated Water Footprint

Vera AMICARELLI[1*], Paola GEATTI[2], Giada M.A. DE RUVO[3]

Abstract

In 2022, Italy has been the third European food waster producing more than 8 Mt of food waste of which restaurants and food service account for the 6%. It has been estimated that in the Italian hospital food service, 30 meals out of 100 served become waste. To improve the sustainability of hospital food service is essential to minimize food waste production and its associated environmental impacts. In the light of these premises, the aim of this study is to measure food waste production and its associated water footprint. The study is based on the life cycle approach, a cradle-to-grave one, and the mass-balance principle is used to estimate food and water flows. Water footprint will be calculated with the volumetric-oriented methodology. Nine hospitals and 60 hospital wards located in Apulia, belonging to the Local Health Authority (ASL) of Bari, are the observed study area. The sample size is composed of 3408 patients and the study period includes one single week per year from 2021 to 2023. Moreover, to overcome the lack of data that affects this type of analysis the use of artificial intelligence-based tools will be discussed. The results achieved are useful to improve the sustainability of hospital food service, highlighting how it is possible to manage menus increasing food waste reduction and the related water footprint.

Keywords: hospital food service, food waste, water footprint, artificial intelligence-based tools, sustainability

JEL Classification: *Q2; Q3; Q4; O13.*

1. Introduction

Due to complex health conditions, dietary restrictions and personal food preferences, hospital food services generate significant amounts of food waste (FW), estimated in approximately 30% of served meals in Italian hospitals (GURI, 2020). The difficulty of accurately predicting food consumption and the diversity of dietary needs make it a challenge to strike a balance between

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providing appropriate meals and minimizing waste. In addition, the preparation of meals requires the use of resources such as water, energy, raw and natural materials, resulting in the generation of solid and liquid waste at all stages of food production, distribution and consumption. Waste in food production and consumption also exacerbates greenhouse gas emissions, land degradation and biodiversity loss. Hospitals are microcosms of larger global food systems and offer a unique opportunity to analyse and mitigate these environmental impacts by implementing sustainable strategies. This involves understanding the full lifecycle of hospital food, from sourcing to disposal, and integrating data on FW, water use and operational inefficiencies into actionable strategies.

Integrating waste management strategies with life cycle thinking approach can provide actionable insights to optimise resource use while meeting the nutritional and personal needs of patients. By quantifying waste streams and analysing their environmental impact, healthcare facilities can identify opportunities to improve foodservice sustainability and reduce waste and the associated environmental costs without compromising the quality of care. To this purpose, the water footprint (WF) evaluation can be a useful indicator to evaluate how sustainable or "unsustainable" are the hospital meals. This research evaluates the WF associated firstly with the different menu served, and secondly to the FW produced. The study is based on the life cycle approach, a cradle-to-grave one, and the mass-balance principle is used to estimate food and water flows. WF will be calculated with the volumetric-oriented methodology. The results achieved are useful to highlight if and how it is possible to manage menus improving FW minimization. Moreover, the role of artificial intelligence (AI), not widely applied to hospital food service management, will be introduced.

2. Literature review

Even if the environmental challenges and the potential solutions related to hospital food services are highlighted in a growing body of literature, few of them focus their attention on the combination of patient satisfaction, FW reduction and environmental food service performance (Bux et al., 2023).

By assessing the nutritional, carbon and water footprints of one-month hospital menus in Turkey and comparing them to the Mediterranean diet, a

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study found that hospital menus did not meet Turkish dietary guidelines and had varying environmental impacts. Switching to a Mediterranean diet could reduce the carbon footprint by up to 23.4% and the water footprint by up to 58.6%. The study suggests that small adjustments could improve both the nutritional quality and environmental sustainability of hospital food services (Aytekin-Sahin et al., 2023). Other strategies to reduce the water footprint were evaluated in a study conducted in Southern Brazil, which assessed the FW and WF of hospital meals over the course of four seasons. The study confirmed that animal products contribute most to the WF, with beef having a particularly large impact, especially in winter. It also showed that fruit waste was higher in summer, highlighting the importance of considering factors such as seasonality and food selection in the sustainable management of food services (Strasburg et al., 2021; Guimarães et al., 2024). In New York, a study focused on waste generated in a hospital kitchen, revealing that daily waste amounted to 1.7 t, or 0.23 kg per meal. Extrapolated to a full year, the hospital produced 487 t of waste and emitted 294,466 kg of CO_2eq. By implementing strategies such as increased recycling and composting, landfill waste was reduced by 55% and greenhouse gas emissions by 64% (Thiel et al., 2021). Other solutions have been found with some innovative hospital food service strategies, such as room service and bedside meal ordering systems (BMOS), which significantly improve energy and protein intake while reducing FW by tailoring meals to patient preferences and allowing flexible, on-demand ordering. Improved meal presentation and texture modifications also increase satisfaction and reduce waste, especially when accessibility issues are addressed. Protected mealtimes (PM) and personalised nutritional support from dietitians further improve nutritional intake, quality of life and waste reduction by optimising portion sizes and patient-specific needs (Rinninella et al., 2023).

3. Methodology

The WF is a well-known indicator developed by Arjen Hoekstra in 2002 based on the concept of virtual water. According to the Water Footprint Network (WFN, 2024), “the water footprint is a measure of humanity’s appropriation of fresh water in volumes of water consumed and/or polluted”. It is also defined as a multidimensional indicator due to its ability to include

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source, time and space of water utilization. Differentiating three different typologies of water (green, blue, and grey), this indicator evaluates water utilization and pollution associated with human activities (production, consumption and disposal activities) at the micro, meso and macro level. Particularly, the green water refers to rainwater stored in the soil useful for plants grow; the blue water is surface and groundwater freshwater, and the grey water indicates the volume of water needed to dilute pollutants to restore water quality standards (Hoekstra et al., 2011a; 2011b). This analysis aims to evaluate the WF associated with one week's menu, considered as functional unit, distributed among nine hospitals in the Apulian region. The menus are related to seven lunches and dinners composed of first course, second course and side dish respectively; no fruit and beverage are considered, as well as ingredients whose weight is less than 10 g per meal. System boundaries, based on a cradle-to-grave approach, refers to:

- raw material production, intending livestock and fish farming activities, crop production and other agricultural processing;
- raw material transformation, intending meal preparation based on cook-chill method (i.e., blast freezing, 24-hours storage, storage, on-site service);
- meals distribution utilizing trucks, covering an average distance from cooking center to hospital of 190 km, with a load capacity of 180 meals/trip;
- landfill assumed as the unique FW disposal system.

As concern data collection, Vivenda SPA made available primary data related to 3408 patient interviews useful to measure customers' satisfaction. The questionnaire was managed for one week over three years: 2021, 2022 and 2023. This data, elaborated with an excel sheet and in line with Bux et al. (2023), allowed the evaluation of FW associated with single meals. Moreover, data concerning the different recipes for each dish were directly collected at Vivenda SPA. To evaluate WF, secondary data is derived from international database SU-EATABLE LIFE (Petersson et al., 2021), peer-reviewed articles and international reports (Hoekstra, 2011a; Lares-Michel et al., 2021; Sarker, 2017; Maimoun, 2015). The total week's menu WF, expressed in L/kg, was calculated by evaluating the WF for each input during its lifecycle adding the WF associated to the amount of FW landfilled.

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4. Results and Discussions

Based on Bux et al. (2023) and their analysis of patient satisfaction surveys in terms of leftovers, it was possible to evaluate which meals were the most and least appreciated, with the possibility to identify the best and the worst lunch and dinner menus. Subsequently, for each of these menus, it was evaluated the amount (in weight, expressed in g) of FW produced and the total WF.

Results achieved, summarized in tables 1 and 2, show that, during a week, each patient at lunch receives 3220 g of food and wastes approximately 290 g in the case of the best lunch menu and 430 g in the case of the worst lunch. The most wasted foods at lunch are dairy (12-15%), rice (10-13%) and pasta (10-19%). Regarding dinners, during a week each patient receives from 2430 to 2530 g of food and wastes more than 200 - 440 g in the case of best and worst dinner respectively. The most wasted foods are vegetables (12-15%) and pasta (17-19%).

Table 1. Lunch menus - food served, food waste, total WF and WF associated with food waste

	Lunch				
	FS (g)	**FW (g)**	**WF_{tot} (L)**		**WF_{FW} (L)**
Best	3220	290	6939	of which	17
Worst	3080	431	6502		25

Note: FS=food served; FW= food waste; WF_{tot}= total water footprint; WF_{FW}= water footprint associated to FW

Source: personal elaboration by the authors.

Table 2. Dinner menus - food served, food waste, WF_{tot} and WF associated with food waste

	Dinner				
	FS (g)	**FW (g)**	**WF_{tot} (L)**		**WF_{FW} (L)**
Best	2530	202	6571	of which	12

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Worst	2430	443	6082		26

Note: FS=food served; FW= food waste; WFtot= total water footprint; WFFW= water footprint associated to FW

Source: personal elaboration by the authors.

The total WF evaluation considering the best lunch menu indicates that approximately 6940 L of water, of which approximately 75% is green water, 13% blue and 12% grey water, are used to manage the life cycle of this menu. Associated with the worst lunch menu, the total WF is equal to 6502 L of which approximately 71% is green water, 15% is blue and 14% is grey water. These results point out that, comparing the worst lunch menu with the best one, the latter offers 5% more food, produces approximately half of FW and requires 6% more water, particularly green water. As for best dinner menu, the total WF is equal to 6571 L of which approximately 69% is green water, 17% is blue and 14% is grey water. The worst dinner menu served 2420 g of food of which 443 g are leftover (double amount compared to best dinner menu) and present a global WF equal to 6081 L (-7.5% compared to the best dinner menu) of which approximately 76% is green water, 10 is blue and 14% is grey water. A sort of paradox is evident: as the food waste rate increases, the water footprint decreases. The higher the level of patient satisfaction, the lower the amount of waste produced, and this relationship also influences performance in terms of WF. Indeed, the best lunch menu needs 2.15 L of water for each g of FS but wastes only an average of 9% while the worst lunch menu requests 1.93 L of water per g of food served producing an average of 13% of FW. In the case of best and worst dinner menus, the trend is almost the same except for the same value of WF/g of FS equal to 2.5 - 2.6 L of water. This contradiction is more evident considering the single dish composing all the menus. It was observed that vegetables are one of the most wasted foods during the worst lunch menu. Considering fennels, for instance, they present a very high WF (8280 L/kg) and are wasted on average for 20% of the served weight. However, there are foods that are both sustainable and "loved" by patients such as veal meat (13,678 L/kg) or pork meat (6092 L/kg), that although their high WF are wasted on average for 9.5% and 7% respectively.

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6. Conclusions

The results achieved are useful to improve hospital food service sustainability. From the environmental performance standpoint, it is possible to reduce the WF of different menus by proposing meals that are more appreciated by patients. This could also reduce, at the same time, FW production. By increasing patient satisfaction, the therapeutic function of food is also made more effective. By the side of food service companies, they can improve their competitiveness, composing and serving menus including dishes more appreciated and more environmentally friendly in terms of WF.

One of the main limits of the present research is the lack of data, intending specific local data to calculate WF and those to estimate FW. With regards to WF, AI could improve local data collection and management to make WF really a multidimensional local indicator. By the side of FW, AI, not widely applied to hospital food service, can help to analyze patients' nutritional needs, measure leftovers, analyse patient preferences and identify dishes that are less popular. The possible applications of AI in this field are the future aim of this research.

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