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Research article

Sustainability and nutritional composition of food offer and choices in three hospital canteens in Italy

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A R T I C L E I N F O

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A B S T R A C T

Diet is considered one of the most important determinants of health and at the same time a cause of climate change. We conducted a cross-sectional study in three Italian hospital canteens on five consecutive working days to investigate food offer availability and user choices in terms of nutritional intake and environmental impact. Photos of lunch trays were collected by the researchers and food offer and choices were analysed using the Italian Food Composition Database for Epidemiological Studies and the SU-EATABLE LIFE dataset. A total of 1227 lunch meals were analysed. The median energy intake ranged from 646 to 900 kcal/tray. The median energy content from lipids ranged from 32 to 40 % of energy and exceeded that from carbohydrates in one canteen. The median carbon and water footprint ranged from 773 to 1338 g CO_2 eq./tray and from 847 to 1229 L H_2O/tray, respectively. Differences occurred depending on sex and typology of work. In conclusion, regardless of the differences in the number of food options offered in the three canteens, the choices tended to be suboptimal from a nutritional perspective. The most sustainable choices were made in the canteen without beef on offer. Measures should be taken to increase the variety of vegan and vegetarian options on offer and to improve food choices in terms of nutritional composition and environmental sustainability. This could be done through educational programmes focused on increasing awareness on their diet, and practical indications on how to compose a complete and low impact meal.

1. Introduction

Dietary habits are widely recognised as one of the most important determinants of health, as they are associated with malnutrition and obesity. In 2020, between 720 and 811 million people worldwide were undernourished [1]. On the other hand, overconsumption of food, especially highly processed, energy-dense foods and sweets, has led to 1.9 billion people being overweight and 650 million

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people being obese in 2016, which in turn are major risk factors for cardiovascular disease, type 2 diabetes and cancer [2]. Overall, the health consequences of unhealthy diets and/or overconsumption are responsible for 40 % of the global burden of disease [3]. Furthermore, diet is considered to be one of the main causes of climate change. The food chain is responsible for 26 % of global CO_2 emissions, 32 % of global soil acidification, 78 % of eutrophication [4], and food production is responsible for about 40 % of land use and 70 % of freshwater withdrawals and is a threat to biodiversity [5]. However, the contribution of the food system to total anthropogenic greenhouse gas emissions varies from country to country, with percentages ranging from 14 % to 92 % [6]. Almost a third of these food system-related emissions are generated by flooded rice, by ruminants and by concentrated feed for pigs and poultry [7]. The coexistence in time and space of the three pandemics - obesity, malnutrition and climate change – is referred to as a "global syndemic". This definition illustrates not only the mere coexistence of these events, but also the synergy of the negative effects on our society [8]. This scenario will be exacerbated as the world population is estimated to grow to 9.7 billion people by 2050, which will require a 50 % increase in food production in agriculture, livestock feed and biofuels compared to 2012 [9]. For this reason, the concept of sustainable diets has been placed on the international political agenda.

A shift to sustainable diets is necessary to reduce the burden of disease associated with obesity and nutritional deficiencies and to mitigate the environmental impact of the food consumed by the population [10]. Such an objective is also pursued through the convergence of some of the Sustainable Development Goals, in particular No. 12 - Responsible consumption and production, No. 13 - Climate action, No. 2 - Zero hunger, and No. 3 - Good health and well-being [11]. The multidimensional nature of sustainable diets was already made clear in the 2010 definition of the Food and Agriculture Organization of the United Nations (FAO), which states that a sustainable diet has a low environmental impact and contributes to food and nutrition security and a healthy life for present and future generations. In addition, a sustainable diet protects and respects biodiversity and ecosystems, is culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, and optimizes natural and human resources [12]. However, a nutritionally balanced diet is not necessarily sustainable from an environmental perspective. For example, sugar and most sweets have a low environmental impact [13]. For this reason, and with the aim of helping the population to make more informed choices, Van Dooren et al. have attempted to combine the nutritional aspect and climate impact of food to create an index that could help consumers to choose products [14]. Evidence for the pursuit of both nutrition and environmental goals is provided, for example, by the Mediterranean Diet [15]. In particular, foods that should be consumed more frequently from a nutritional point of view have a lower environmental impact than foods that should be consumed less frequently [16]. Indeed, dairy, eggs, meat and fish produce greenhouse-gas emissions and require land use that are 100 % to 10,000 % higher than those of plant-based food per kcal of food produced [3]. Consequently, a global switch to healthy plant-based diets would simultaneously improve health and environmental outcomes. Specifically, a shift to a vegetarian diet would reduce the diet-related environmental impacts by up to 60 % [3].

Two of the most commonly used indicators to assess the environmental impact of the diet are the carbon footprint (CF) and water footprint (WF) . These parameters are calculated using life cycle assessment, an analytical method for evaluating the environmental footprint of a product or service throughout its life cycle, including the extraction of raw materials, production, consumption of the product, and waste disposal [17]. According to Petersson et al., the CF comprises the total greenhouse gasses emitted in all stages of production and distribution of a food product [18], and the WF is defined as the total amount of water consumed and polluted in all stages of production [18].

Some studies have been conducted to assess the sustainability of diets [16,19–21] and the food offered in school canteens [10,22, 23]. Few studies have assessed both the nutritional and environmental aspects of the food offered in a university canteen [24] or the choices of users in a workplace canteen [25]. To our knowledge, no evaluation of the sustainability of the food choices in a hospital canteen has yet been conducted. The aim of this study was to evaluate the food offerings of three hospital canteens and to assess user choices from the perspective of nutritional and environmental sustainability.

2. Materials and methods

The project began with a collaboration between the Department of Medicine at the University of Udine, the Friuli Centrale Healthcare University Trust, which is responsible for catering and hospital management, and the local Health Promoting Hospitals and Health Services (HPH&HS) network. We selected three workplace hospital canteens in the province of Udine (Italy) with different characteristics. In detail: 1) the canteen of the hospital of Udine (canteen 1, C1), which is managed by an external catering service and should have 450–480 users/day during the study period; 2) the canteen of the hospital of Palmanova (canteen 2, C2), which is managed by the same external catering service as the previous canteen but has 100–120 users/day; and 3) the canteen of the hospital of San Daniele del Friuli (canteen 3, C3), which is managed internally and has about 90 users/day. For each canteen, we contacted the managers to form an alliance, discuss the methodology for data collection and define the week for data collection. The composition of the tray for each canteen user followed the traditional structure of an Italian meal, as follows: 1 first course (generally cereal-based), 1 second course (cold or hot, generally a dish with a high protein content), 1 side dish (fresh or cooked vegetables, potatoes, but also pulses), a dessert or fruit, a portion of bread or 2 packets of crackers. Alternatively, it is possible to choose a second side dish instead of the first or second course. Only in C1 sugary drinks can be chosen instead of water. A fixed price applies to the lunch meal in all three canteens, regardless of the composition of the lunch tray. Users can choose whether they want to eat the meal in the canteen or take it away.

2.1. Data collection

Data collection was carried out in the three hospitals between August and September 2022 on five consecutive working days, from

Monday to Friday at lunchtime. On the observation days, two to four researchers (depending on the size of the canteen) were present in the canteen to introduce the study, ask all users to participate, and collect the data. Participants gave their written consent to take part, provided some personal details in a questionnaire (the full version of the questionnaire can be found in the Supplementary Material) and allowed the researchers to take photos of their tray before lunch to assess their food choices. The consent form, questionnaire and photos of the canteen tray were linked together by assigning each participant a unique code. Participants whose questionnaire was not fully completed or for whom a consent form was missing were excluded from the analysis. Individuals who opted for the take-away option were not included in the study. Personal data collected in the questionnaire included sex (set of biological attributes that are associated with physical and physiological features), age, professional role, typology of work (shift work/non-shift work), presence of specific dietary restrictions that may have influenced dietary choices (e.g., celiac disease, food allergy or intolerance, inflammatory bowel disease, bowel resection, or gastric banding). All data were pseudo-anonymised and kept in aggregate form so that the identity of individual participants could not be traced. The study was approved by the Institutional Review Board of the University of Udine, Italy (date of approval 06/07/2022). All study procedures complied with the ethical standards of the Declaration of Helsinki. Hypotheses were defined prior to data collection.

2.2. Analysis of the food offer

The Italian Food Composition Database for Epidemiological Studies (version 2022) [26] was used for the nutritional assessment, which is considered representative of foods available at national level. To assess sustainability, the SU-EATABLE LIFE (SEL) dataset [18] was used, which is the result of the revision of literature data on CF and WF of foods until January 2020. To analyse the food offerings, we obtained the ingredient list with portion sizes for each meal served during the week of analysis from the canteen staff. We then divided the dishes into five categories: vegan, vegetarian non-vegan, fish, meat non-beef and beef. Finally, we created a recipe dataset that included the energy content, nutrient composition, CF and WF for each ingredient. This allowed us to estimate the nutritional profile and environmental impact for each recipe in its standard portion using the standard recipe approach [27]. We performed a descriptive analysis of the offer. We plotted the relationship between each sustainability indicator and energy content for each recipe. We calculated the frequency with which the first and second course categories were offered in each canteen during the week of analysis.

2.3. Analysis of food choices

For the food choices of users, we considered all the dishes included in each tray. We visually estimated users' choices by a blind analysis of photographs carried out by two researchers to identify recipes and estimate portions compared to the standard portion (e.g., 50 %, 100 %, 150 %). Discrepancies were resolved by discussion between the two researchers. By combining the data extracted from the photos with the recipe database, we then estimated the nutritional profile and environmental impact for each individual tray before the meal was consumed. We calculated the frequency with which the categories (vegan, vegetarian non-vegan, fish, meat non-beef, beef) of the first and second course were chosen during the week of observation in each canteen, adding the option “no choice” if users did not choose either the first or second course. In addition, we compared the energy content, nutrient profile, CF and WF of the trays by sex, typology of work (shift work/non-shift work) and age group (<34 years; 35–54 years; >55 years) in C1, C2 and C3. Finally, we examined the regular users of each canteen, considering only those who participated in the study on all days of the observation week. For this subset of users, we calculated how often their meals comply with the range of reference (CF: 800–1000 g CO_2 equivalents/meal, WF: 700–1000 L H_2O/meal) of the SU-EATABLE life project [28].

2.4. Data analysis

We conducted a descriptive analysis of participants' characteristics linked to each tray and a further descriptive analysis of food offer and user choices. The categorical variables were presented as absolute numbers and percentages. In the food choices analysis, the nutritional and environmental variables were not normally distributed according to the Shapiro-Wilk test and were therefore presented as median and 25th-75th percentiles. The Kruskal-Wallis test was applied to determine whether the median values of each nutritional and environmental variable differed by canteen (C1, C2 and C3). If the Kruskal-Wallis test was significant, the Dunn test with Bonferroni adjustment was performed as a post-hoc analysis to determine which canteens differed significantly. In addition, for each canteen, we compared the nutritional and environmental variables between females and males, shift workers and non-shift workers using the Wilcoxon rank sum test, and between age groups (<34 years, age group I; 35–54 years, age group II; >55 years, age group III) using the Kruskal-Wallis test, followed by the Dunn test with Bonferroni adjustment. P-values <0.05 were considered statistically significant. Data were analysed with STATA (StataCorp. 2021. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC). The analytic plan was pre-specified and any data-driven analyses are clearly identified and discussed appropriately.

3. Results

3.1. Characteristics of the study participants

A total of 1227 lunch meals were analysed (798 from C1, 228 from C2, 201 from C3) (Fig. 1). The full description of the participants' characteristics can be found in Table 1. In C2 and C3, participants were predominantly female (66 % and 70 %, respectively);

the mean age of participants was higher in C3 (49 ± 11 years) than in C2 (44 ± 12 years) and C1 (43 ± 12 years). In terms of professional profile, nurses slightly dominated over other professional profiles in both C3 (23 %) and C2 (27 %), while the technicians were the most represented in C1 (26 %). The majority were non-shift workers and less than 10 % of participants in each canteen had dietary restrictions.

3.2. Food offer

Fig. 2A shows the CF values of the dishes (first courses, second courses and side dishes) in relation to their energy content per portion. The scatter plot shows that all individual portions containing beef are above 2000 g CO_2 equivalents (CO_2 eq.). Fig. 2B shows the WF values of the dishes in relation to their energy content per portion. We observe that the dishes with the highest WF are also those with the highest CF: beef meatballs, beef meatballs with tomato sauce, roast beef with tuna sauce and boiled beef. Dishes containing fish present values of CF ranging from 155 g CO_2 eq. (mackerel in oil) to 969 g CO_2 eq. and values of WF from 185 L H_2O (canned tuna) to 736 L H_2O (salad with mozzarella cheese, tuna, and eggs). Among the dishes containing non-beef meat, peas with ham is the one with the highest CF (1291 g CO_2 eq.) and WF (1094 L H_2O) due to the large amount of ham per portion (150 g). Finally, among vegetarian dishes, those containing cheese have the highest CF and WF.

The wider range of vegan options as first courses (Supplementary Fig. 1A) in C1 and C2 compared to C3 was due to the daily offering of soups and rice and pasta with oil or vegetable sauces. In C3, however, the vegan options of the first courses were mainly represented by soups (vegetables or pulses). Beef was offered daily as a first course in both C1 and C2 (pasta with *bolognese* sauce). In terms of second course offerings (Supplementary Fig. 1B), a wide range of vegetarian dishes were found in all canteens, mainly due to the many cheese options. However, a vegan option of second course was offered on a daily basis only in C2 and never offered in C3. Beef was offered as a second course three times a week in C2 and four times a week in C1. In C3, beef was never offered and poultry or pork was offered as a second course on four out of five days in the week of analysis. Fish was offered as a second course in fresh or canned form almost every day in every canteen.

3.3. Food choices

When analysing the first courses (Supplementary Table 1A), we found that vegan dishes accounted for 50 % of choices in C3, compared to 32 % in C1 and 31 % in C2. Almost a third (29 %) of users did not choose a first course in C2, while this percentage dropped to 24 % in C1 and 8 % in C3. Twenty-five percent of choices in C1 included fish, while this category accounted for 11 % in C2 and 8 % in C3. First courses with non-beef meat (represented only by pork meat in first courses), were underrepresented in C2 (3 %) and C1 (4 %) compared to C3 (24 %). For the second courses (Supplementary Table 1B), we found that in C3, where beef was never offered, other meats accounted for 59 % of choices. Even in C2, where a pulse-based burger was offered as a vegan option, meat was chosen in 56 % of trays (13 % contained beef and 43 % non-beef meat). In C1, 44 % of choices contained meat, in this case in equal parts of beef and non-beef meat (22 %). Fish was chosen in 28 % of trays in C1 and 8 % of trays in C2 and C3.

Table 2 shows the median and 25th-75th percentiles of energy (kcal/tray) and nutrients (expressed as a percentage of energy intake or in grams) of the canteen trays before eating the meal (i.e., food choices) for each canteen. The data show that the energy and nutrient content as well as the environmental impact of the trays differed between the three canteens ($p < 0.05$). The results of the Dunn test post-hoc analysis, to determine which canteens differed significantly, are shown in Supplementary Table 2. Specifically, the energy content of the trays was higher in C1 (854 kcal/tray) and C2 (900 kcal/tray) than in C3 (646 kcal/tray). The highest protein content

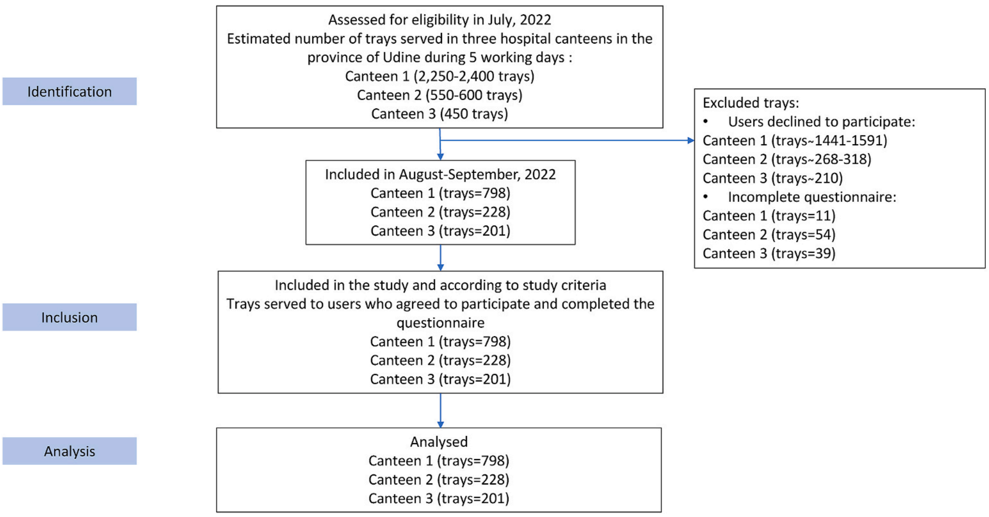

Fig. 1. STROBE flow chart. STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.

Table 1
Characteristics of participants associated to the analysed trays, grouped by canteen.

Category	Variables	C1 (n = 798)	C2 (n = 228)	C3 (n = 201)
Age, mean ± SD*		43 ± 12	44 ± 12	49 ± 11
Sex, n (%)	Female	402 (50)	150 (66)	140 (70)
	Male	396 (50)	78 (34)	61 (30)
Professional profile, n (%)	Doctor	187 (23)	18 (8)	30 (15)
	Nurse	96 (12)	62 (27)	47 (23)
	Health Care Assistant	24 (3)	24 (11)	15 (7)
	Administrative staff	174 (22)	44 (19)	43 (21)
	Technician	209 (26)	46 (20)	21 (10)
	Others	102 (13)	34 (15)	45 (22)
	Missing	6 (1)	0	0
Tipology of work, n (%)	Shift worker	202 (25)	49 (21)	36 (18)
	Non-shift worker	552 (69)	163 (71)	161 (80)
	Missing	44 (5)	16 (7)	4 (2)
Dietary restrictions, n (%)	Celiac disease	0	0	0
	Allergies/Intollerances	54 (7)	12 (5)	18 (9)
	Bowel resection, or gastric banding	1 (0)	1 (0)	0
	Inflammatory bowel disease	9 (1)	0	0

Notes: C1, canteen 1; C2, canteen 2; C3, canteen 3. *The age of the participants, was normally distributed and therefore presented as mean and standard deviation.

was in C1 and the highest lipid content was in C2 ($p < 0.0001$). Table 2 also shows the median values [25th −75th percentiles] for CF and WF of the choices in the three canteens. The lunch meals in C1 had the highest CF ($p < 0.0001$). C3 had the lowest CF ($p < 0.03$) and WF ($p < 0.004$).

Supplementary Table 3 shows the comparison of energy, nutrient profile, CF, and WF of the trays by sex, typology of work and age group in C1, C2 and C3. Sex differences were evident for most variables in C1 and C3. Males showed the highest values for energy (kcal/tray), protein (g), CF (g CO_2 eq./tray) and WF (L H_2O/tray). The lunchtime meals of shift workers in all canteens had a significantly higher energy content than those of non-shift workers ($p < 0.05$). In both C1 and C3, shift workers chose a meal with a higher median content of proteins (g/tray) and polyunsaturated fatty acids (g/tray) than non-shift workers. In C2, the non-shift workers chose a lunch meal with a higher fibre content in grams, while the opposite was true in C3. In C3, the shift workers had a higher lipid content in grams than the non-shift workers. As for the differences between age groups, the trays of the youngest (age group I) in C3 contained more available carbohydrates than the trays of the oldest (age group III). In C2, age group III opted for dishes with more sugar and fibre ($p < 0.05$) in grams and contribution to energy intake than age group I. In C1, the sugar content (g; %E) was also lowest in age group I. Finally, the protein content (g; %E) of the trays in C1 was significantly higher in age group I than in age group III.

3.4. Regular users of the three canteens

The regular users of the canteens were only three in C3, eight in C2 and 34 in C1. This subgroup (C1) consisted of 14 women and 20 men with an average age of 41 years old. The majority (n = 25) were non-shift workers. Of the 170 canteen trays associated to 34 users, 20 trays were vegetarian or vegan. Twenty regular users exceeded the upper limit of the meal reference range for CF and WF [28] on four or five days during the week of analysis. Among those who exceeded both reference ranges on three or less than three out of five days (n = 14), the other meals within the reference range could not compensate for the excess of CF and WF on the days outside the range, except in two cases. Indeed, the mean CF and WF calculated over the week of analysis was above the reference range [28] in 32 out of 34 regular users. The two regular users whose mean values were in the reference range had in common that they chose only some components of the full menu (1 first course, 1 second course, 1 side dish, a dessert or fruit, a portion of bread/crackers) and that the energy value of the meal was lower than that of the other regular users: one regular user ate only a salad and crackers every day, the other regular user ate either only the first course without the second course (never beef) or vice versa. Thirteen regular users had a mean CF of over 2000 CO_2 eq./meal, one regular user exceeded 3000 CO_2 eq./meal. The majority chose beef either once in a larger portion than the standard one or at least twice a week.

4. Discussion

This study gave us the opportunity to evaluate the choices of canteen users from a nutritional and sustainability perspective in relation to the food offered in three different hospitals in Friuli-Venezia Giulia (Italy).

4.1. Food offer

When analysing the CF and WF of the dishes offered in the canteens during the week of analysis, it was found that all dishes that exceeded the value of 2000 g CO_2 eq./meal contained beef. The high levels of CF from beef are due to the greenhouse gasses produced during the feeding and care of the animal, as well as the large amount of methane (CH_4) produced in the animal's rumen [28].

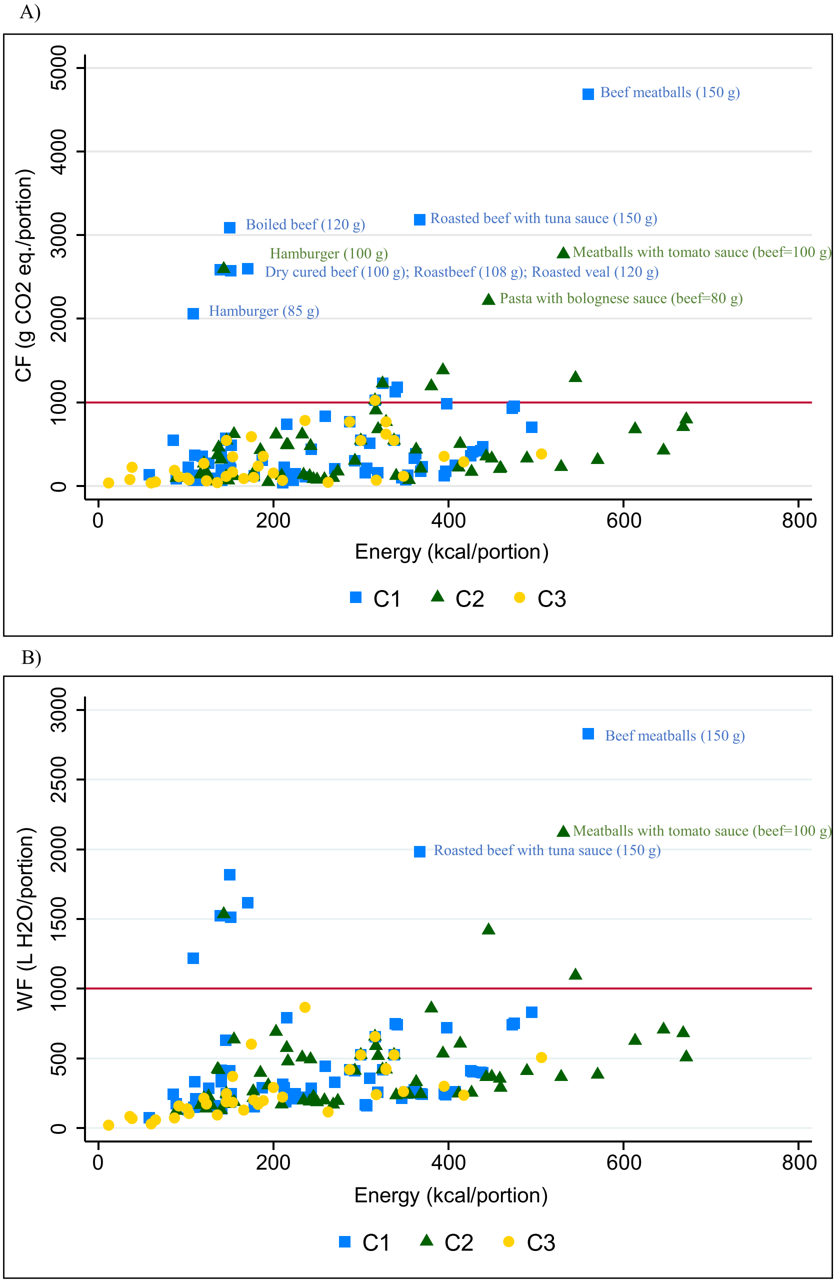

Fig. 2. Scatterplot showing the distribution of food portions according to their carbon footprint and energy content (A), and water footprint and energy content (B) by canteen (C1, canteen 1; C2, canteen 2; C3, canteen 3). Red line indicates the upper limit suggested by the SU-EATABLE guidelines for a complete meal.

Similarly, dairy products have a significant impact on climate and water resources [29]. Overall, the studies seem to indicate that poultry is more sustainable than pork, which in turn is more sustainable than lamb and beef [30]. First, we found that one of the canteens (C3) offered less variety than the others. In all canteens, the most common food category was vegan for first courses and vegetarian for second courses. We found that it was not possible to put together a full vegan tray in the C3 canteen and that the offered options were very limited in the other two canteens. In C1, however, it was possible to replace a second course with a protein rich vegan side dish (e.g., pulses). Although there were more options to create a vegetarian meal, it is important to remember that the vegetarian category was mainly represented by cheese, especially in C3. However, as these options were not exposed on the service counter, they did not have the same visibility as the other second courses. We would also like to point out that pulses were more represented in C1 and C2 than in C3, especially as a first course and as a side dish (data not shown).

Table 2
Medians [25th −75th percentiles] of energy, nutrients intakes and sustainability variables of the choices in C1 (n = 798), C2 (n = 228) and C3 (n = 201).

Variables	C1	C2	C3	p value*
	Median [25th −75th percentiles]			
Energy (kcal/tray)	854 [687–1017]	900 [712–1076]	646 [506–856]	0.0001
Protein (g)	45.7 [34.8–56.4]	37.5 [29.7–48.0]	32.4 [24.0–40.8]	0.0001
Protein (%E)	21 [18–25]	17 [13–21]	19 [16–24]	0.0001
Lipids (g)	29.9 [22.1–41.3]	37.7 [27.9–49.9]	25.4 [17.2–35.5]	0.0001
Lipids (%E)	32 [26–40]	40 [32–47]	34 [28–40]	0.0001
Carbohydrates (g)	103.0 [79.5–125.6]	93.1 [69.7–121.6]	78.0 [57.6–102.5]	0.0001
Carbohydrates (%E)	44 [38–52]	39 [32–47]	44 [38–50]	0.0001
Sugars (g)	26.7 [20.2–36.4]	25.1 [18.3–34.9]	22.3 [15.2–29.9]	0.0001
Sugars (%E)	12 [9–16]	11 [8–13]	12 [8–17]	0.0001
Fibre (g)	9.9 [7.3–13.1]	10.1 [7.9–13.4]	8.5 [6.8–11.3]	0.0002
Fibre (%E)	2 [2-3]	2 [2-3]	3 [2–4]	0.0001
SFA (g)	7.5 [5.2–12.2]	8.3 [6.2–14.0]	6.6 [4.6–8.8]	0.0001
SFA (%E)	8 [6–11]	9 [7–12]	10 [7–11]	0.0001
MUFA (g)	13.7 [10.1–17.6]	17.9 [13.4–23.3]	13.4 [6.8–17.8]	0.0001
MUFA (%E)	15 [11–18]	19 [16–24]	17 [12–21]	0.0001
PUFA (g)	4.7 [2.9–7.1]	6.3 [3.9–8.9]	3.3 [2.2–4.9]	0.0001
PUFA (%E)	5 [3–7]	6 [4–8]	4 [3–6]	0.0001
EPA + DHA (mg)	102 [20–246]	13 [0–116]	9 [0–16]	0.0001
CF (g CO_2 eq./tray)	1338 [958–2270]	1094 [744–2139]	773 [604–1075]	0.0001
WF (L H_2O/tray)	1229 [923–1792]	1220 [925–1773]	847 [633–1143]	0.0001

Notes: C1, canteen 1; C2, canteen 2; C3, canteen 3; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; CF, carbon footprint; WF, water footprint. * The Kruskal-Wallis test was used to determine whether the median values of the individual nutritional and environmental variables differed depending on the canteen. $p < 0.05$ was considered significant.

4.2. Food choices

4.2.1. Nutritional analysis

According to the larger range of vegan options offered as first courses compared to the other categories, these were the most frequently chosen. Second course choices consisted of meat (of any kind) to a similar extent in C2 and C3 and to a slightly lesser extent in the largest canteen (C1), with the main difference being that users of the internally managed canteen (C3) could not choose beef. From this it can be deduced that although users in the externally managed canteens (C1 and C2) had second course offerings that cover all dish categories (vegan, vegetarian non-vegan, fish, meat non-beef and beef), they still preferred meat as a second course. The lower percentage of meat choices in C1 was due to the greater availability of fish in this canteen.

From a nutritional point of view, the users' choices were compared with the national guidelines [31,32] and the results presented by Rosi et al. [25], which is the most similar Italian study in terms of population and methods. The mean value of energy in the externally managed canteens (C1 and C2) was higher than the mean value reported in the study by Rosi et al. at their baseline (649 ± 194 kcal/meal) [25], while the latter was comparable to the median value of C3. This could be partly due to the fact that 50 % of users in C3 chose a vegan option as their first course, which consisted mainly of vegetable and pulses soups. In addition, 22 % of the trays in C3 did not include a second course, which is the highest percentage among the three canteens. In all canteens, meals tended to be high in lipids: while in C1 and C3 the lipid contribution to energy intake was high but within the reference range (20–35%E) [31], in C2 the lipid contribution to energy intake was higher than the upper limit of the range and exceeded that of the carbohydrates. The values reported by Rosi et al. at their baseline [25] were very different: lipids had a mean value of about 27 ± 11%E and carbohydrates 50 ± 14%E, which are both within the limits of the reference ranges [31]. Rosi et al. observed that their users chose dishes with a macronutrient distribution closer to the Italian reference values, probably because the data collection followed a nutrition education course. In contrast, our results in terms of carbohydrates, proteins, lipids, and saturated fatty acids contribution to energy intake are similar to those of a Danish study that analysed the lunch of 240 employees in 15 worksite canteens [33]. The tendency towards a high-energy (in C1 and C2) and high-lipids (C1, C2 and C3) meal observed in our canteens should not be surprising, considering that a recent meta-analysis confirms the link between eating away from home, obesity, and the risk of non-communicable diseases [34]. To support this data, those who frequently eat in worksite canteens in Norway are more likely to be obese [35]. However, on the other hand, some studies found that eating at worksite canteens increases compliance with recommended dietary habits [36] and that the worksite canteen environment could be crucial in promoting health by positively modulating dietary habits of users [37].

As for sugar content, in our study it was higher in C1 than in C2 and C3. This is probably related to the different types of sugary products offered. Although yogurt and fruit were offered in all canteens, pudding and cake were also offered every other day in C2, and pudding and sugary drinks were also offered every day in C1. The intake of dietary fibre was low in all canteens. In C1 and C2, the fibre intake per 1000 kcal was below the reference range (12.6–16.7 g/1000 kcal) [31]. Comparable values for fibre per tray were reported by Rosi et al. [25], with the exception of C3, which had a lower fibre content per tray. Indeed, the consumption of at least one portion of pulses was much lower in C3 (4 %) than in Rosi et al. (17 %) [25]. Even a higher consumption of at least one portion of vegetables (C3:

83 %; Rosi et al., 66 %) and fruit (C3: 88 %; Rosi et al., 68 %) was not sufficient to balance the very low pulses consumption in C3 (data not shown). It should be considered that due to COVID-19 precautions during the study, users did not have autonomy in taking fruit and vegetables, which may have influenced their choices.

Males chose meals with a higher energy and protein content in grams than females in two out of three canteens (C1 and C3). This could be related to the fact that females were more likely than males to eat only one course (the first or second) in both canteens (data not shown). In general, our results regarding differences in energy and protein in grams by sex are consistent with data from the third Italian National Food Consumption Survey (INRAN-SCAI 2005-06) [38]. However, it should be noted that the national data refer to values collected over the whole day and not for the individual meal. Taking into account the differences related to the typology of work, we found that shift workers had a higher energy intake than non-shift workers in all three canteens, while we could not draw any conclusions about other nutritional differences. However, data in the literature are conflicting on this topic. Overall, it seems that energy intake did not differ between shift workers and non-shift workers [39,40]. On the other hand, it appears that shift workers are a category at risk for several conditions such as obesity, cardiovascular disease, metabolic syndrome, which are all conditions associated with excessive energy intake [41]. This suggest that not exclusively energy intake but other factors may lead to higher obesity rates in shift workers [40]. Regarding the comparison between age groups, although there were some significant differences in our three canteens, we considered them negligible, as none of these differences were found in all three canteens. This interpretation seems to be supported by Italian national data [38], which show similar values in adults (18–64 years) and the elderly (65 years and older).

4.2.2. Sustainability assessment

The CF and WF values in C3 are closer to the reference values (CF: 800–1000 g CO_2 eq./meal, WF: 700–1000 L H_2O/meal) of the SU-EATABLE life project [28]. The values that deviate the most from the reference values are those of C1 (CF: 1338 gCO_2 eq./tray, WF: 1229 L/tray). The CF of the trays analysed by Rosi et al. [25] (1061 $\pm$ 823 g CO_2 eq./tray) was similar to those in C2, lower than those in C1 and higher than those in C3. The lower values in C3 can easily be explained by the fact that beef was not offered in either the first or second course. Despite the higher percentage of meat choices (beef and non-beef) in C2 than in C1, the higher CF values in C1 than in C2 can be explained by the fact that the users of C1 chose a higher percentage of second courses with beef. Indeed, Hallstrom et al. [19] indicated that simply replacing ruminant meat with meat from monogastric animals can reduce greenhouse gas emissions by up to 35 %.

Significant differences in CF and WF by sex were found in C1 and C3, with higher values for males than for females. This could be due to the fact that females chose less energy-dense meals than males in both C1 and C3. In addition, beef was more frequently chosen by males than females in both the first and second courses in C1 (data not shown). Accordingly, some studies also show that men choose meat more often than women [42,43]. These data are also supported by the fact that most vegetarians in both the USA [44] and in an Italian study [45] are women. However, we need to consider that these choices are not necessarily related to awareness of food sustainability [46].

4.3. Strengths and limitations

This study provides descriptive data on both the nutritional and sustainability profile of food choices made in three Italian hospital canteens. In addition, we were able to stratify our data based on sociodemographic information collected through a questionnaire. The assessment of the trays through photographs allowed us to identify the presence of non-standardized portions in order to obtain a more reliable estimate of nutritional and environmental variables. In addition, we did not use literature recipes; the portion sizes and recipes were directly provided by each canteen staff.

However, some potential information biases should be noted. Users choices changed depending on the time window in which they visited the canteen, as certain dishes ran out earlier than others. As the evaluation was based on a visual assessment, we could only estimate the nutritional and sustainability profile of each tray. In addition, for the salads, it was not possible to calculate the amount of dressing added by users, so we assumed a default value based on national standards. Another similar limitation arises from the fact that we could not quantify the refilling of sugary drinks in C1. For the assessment of CF and WF, we used an environmental database, which is the result of a literature review and therefore needs to be constantly updated. We must also take into account that we only studied the lunch meals of a limited sample of users during one week, which limits the interpretation and generalization of the results. Finally, generalization is also limited by the distinct food offer of the food service in different workplace canteens, which guide the choices of users. Moreover, the food offered in Italian canteens is not easily generalizable to an international context because each country has its peculiarities in terms of traditional meal composition.

5. Conclusions

As far as we know, this is the first study to investigate the environmental impact and nutritional profile of users of worksite canteen in Italian hospitals. We found that the vegan and vegetarian offer was limited in all canteens, so that in one canteen it was not possible to compose a complete vegan tray. In terms of sustainability, the biggest difference was found between canteens that served beef and those not offering beef. It would be useful to nudge healthier and more sustainable behaviors by offering more alternatives to beef and the possibility to put together a tasty vegetarian or vegan meal that comes closer to the dietary recommendations. Regardless of the different number of offered food options in the three canteens, the dishes chosen by users tended to be high in lipids and low in carbohydrates in terms of contribution to energy intake compared to the Italian dietary reference values. Measures should be taken to improve dietary choices in terms of nutritional composition and environmental sustainability of the diet. This could be done through educational programmes focused on increasing awareness on the impact on health and on the environment of the diet (e.g., specific courses offered to employees, posters and/or leaflets, norm messages, newsletters). Another option could be to introduce practical indications *in loco* on how to compose a complete and low impact meal based on the offered menu (e.g., by adding an index to the menu items that summarize the nutritional and environmental rating of each dish or by highlighting the suggested tray composition that combine sustainability and nutritional aspects). In order to optimise nutritional and environmental strategies, further studies assessing the nutritional literacy of hospital workers and their attitudes towards these issues could be helpful for planetary health.

CRediT authorship contribution statement

Diana Menis: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Federica Fiori:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **Peter Cautero:** Writing – review & editing, Methodology, Investigation, Data curation. **Daniela Zago:** Writing – review & editing, Methodology, Investigation, Data curation. **Yvonne Beorchia:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Lorenzo Dallan:** Writing – review & editing, Data curation. **Pietro Vettorazzo:** Writing – review & editing, Data curation. **Lucia Lesa:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Alessandro Conte:** Writing – review & editing, Supervision. **Enrico Scarpis:** Writing – review & editing, Supervision. **Laura Brunelli:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Maria Parpinel:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Ethical statement

The study was approved by the Institutional Review Board of the University of Udine, Italy (date of approval 06/07/2022). All subjects gave their informed consent for participation. All study procedures complied with the ethical standards of the Declaration of Helsinki and with relevant guidelines and regulations.

Data and code availability statement

The data that has been used is confidential.

Preference for colour

Online only.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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