ORIGINAL ARTICLE

ENVIRONMENTAL IMPACTS OF DIET PATTERNS OF A UNIVERSITY HOSPITAL IN URUGUAY

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Highlights: (1) The Public University Hospital is of great capacity and complexity. (2) Food types and dietarypatterns caused different environmental impacts. (3) Of the 24 oral diet options, 13 types accounted for more than 93% of the total.

PRE-PROOF

(as accepted)

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ENVIRONMENTAL IMPACTS OF DIET PATTERNS OF A UNIVERSITY HOSPITAL IN URUGUAY

ABSTRACT

Introduction: in hospital care, the provision of meals integrates the recovery process of patients. The foods that are used can affect the environment. **Objective:** to identify the characteristics of the different diet patterns, as well as the environmental impacts of the foods used in the menus of a Public University Hospital (PUH) in Uruguay. **Methods:** retrospective study using secondary data. The period investigated was 2021 and the first half of 2022. The prescriptions of total oral diets (OD) and supplemental diets (SD) were evaluated. The following variables were analyzed: a) energy value in kilocalories (kcal), b) water footprint (WF) - for OD; and for the inputs used in SD: c) energy value, and d) generation of greenhouse gases (GHG). **Results:** The PUH served 317,380 meals during the three semesters. Of the 24 options for prescribing OD, 13 types represented more than 93% of the total number of consultations. As for the 21 types of foods used in dietary prescriptions, 6 were of animal origin. In the environmental impact assessment, a difference of up to 51% in WF was identified between the types of OD. In SD, the group of enteral formulas for adults represented 88.37% of total consumption. The group of infant formulas had the greatest impact on GHG emissions. **Conclusions:** in addition to attention to dietary care, hospital food services should consider the environmental impacts in the provision of their meals.

Keywords: hospital feeding; greenhouse gases; water footprint; nutrition.

INTRODUCTION

The distribution of hospital meals is usually carried out by the Nutrition and Dietetics Services, which is one of the denominations of the Food and Nutrition Service (FNS). According to Abreu et al. [1], FNS is an establishment that produces and distributes meals for all types of communities.

In the hospital context, food supply plays a key role in the recovery and maintenance of health, with a view to meeting the nutritional needs of patients and contributing to their clinical recovery[2]. In the exercise of its function, the objective of a hospital FNS, and under the responsibility of a registered dietitian, is to provide safe food from a hygienic-sanitary point of view, and that can guarantee the main nutrients necessary for the maintenance or recovery of the health of all those who need this service[3].

The duties of a hospital FNS are the preparation and provision of nutrient-balanced meals, according to the patient's profile[4]. For this reason, food planning should be done individually, considering factors such as pathology, clinical condition, age, sex, dentition, functionality of the gastrointestinal tract, among others[5]. The provision of food for hospitalized patients can cover a number of services, from breakfast to dinner.

In dietary preparations for patients, foods may present modifications to meet dietary characteristics such as consistency, volume, temperature, and others[6]. Factors such as nutrient content or chemical composition and special conditions can also be considered[5]. Examples of different consistencies include normal, bland, pasty, and semi-liquid diets[7].

Currently, there is a great concern with the sustainability of the planet. The concept of sustainability is directed to strategies that aim to improve the long-term quality of life of society and the maintenance of environmental resources in a quantitative and qualitative way[8].

Human food consumption, whether domestic, commercial, or institutional, has an important environmental impact, including food production and meal preparation[9]. The following footprints are some examples of impacts on the environment: ecological (EF), carbon (CF) and water (WF) footprints. WF is an indicator used to quantify, in liters, the use of fresh water that is used directly and indirectly during the production process of a given product[10].

Another environmental impact that is usually evaluated is the emission of greenhouse gases (GHG). According to the Kuioto Protocol, the six GHGs are: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfurhexafluoride[11]. The emissions of these six GHGs are converted and accounted for in the form of carbon dioxide equivalents (CO_2e)[12]. It is estimated that agriculture and livestock are responsible for approximately 70% of total freshwater consumption in the world and that 26% of global GHG emissions are due to foodproduction[13].

Uruguay (UY) is a country in the southern end of Latin America. This country has an estimated population of approximately 3.5 million people, of whom almost 50% live in its capital, Montevideo[14]. A general public university hospital (PUH), of high complexity (coronary, renal, gastric, liver diseases, among others), is located in Montevideo. It is a national reference and serves the adult population[15]. The PUH is considered large and has 500 beds.

The PUH is part of the Brazilian Health Care Network and serves people regardless of their social status, contributing to raising the quality of public services and improving the equity and social efficiency of the national health system[15]. Considering the importance of hospital nutrition in the treatment of patients, this study aims to identify the distribution and characteristics of the different diet patterns, as well as the environmental impacts of the inputs used in the Montevideo PUH.

MATERIAL AND METHODS

Type and characteristics of the study site

This research was conducted at the Hospital de Clínicas Dr. Manuel Quintela, which is the PUH of the *Universidade da República* (Udelar), in Montevideo, Uruguay. This study considered two different evaluations, namely: dietary prescriptions by oral feeding (OD) and by supplemental feeding (SD). This is a case study, with quantitative evaluation, and using secondary data[16] referring to the periods of 2021 and the first half of 2022.

Use of data and inclusion criteria

For this research, the total number of hospitalized patients was quantified according to the type of dietary prescription. To evaluate the research, the selection criterion was used through the ABC curve, according to the model proposed by Strasburg and Jahno[17].

Thus, in the evaluation of OD, dietary prescriptions were included up to a limit equal to or greater than 90% of the total. The same concept was applied to SD prescriptions, however, in this case, the number of different types of inputs used in patient care was considered.

Investigated variables and inclusion criteria

For the pattern of OD, the following variables were verified:

a) Caloric value (kcal). The information was collected from the food label of the industrialized products available in the PUH stock. For unprocessed or minimally processed products, such as meat, fruits and vegetables, the Brazilian Food Composition Table (TACO)[18] was considered as a reference.

b) Water footprint (WF) – To calculate the WF of plant foods, the data of Mekonnen and Hoekstra et al.[19] were used, using average values according to the type of classification in terms of percentage of carbohydrates (see Table 2 in the Results section). For animal foods such as meat, eggs, and dairy products, the references used were those of Mekonnen and Hoekstra[20]. And the value of the study by Pahlow et al.[21] was used to calculate the WF of the fish.

For SD we considered:

c) Caloric value (kcal). The information was collected from the food label of the industrialized formulas used in the PUH in the period investigated.

d) Greenhouse Gases (GHG) – the information available on the food label of each product were verified to identify its place of origin. For this calculation, we considered the distance in kilometers (km) from the city and country of origin to the city of Montevideo. This information was obtained from the website "Distância entre cidades" (Distance between cities)[22]. The data obtained considered the shortest distance between the two points by land when the product came from Latin America, and the shortest distance in a straight line when it came from other continents. The GHG emission values were obtained from the table in the "GHG Report: conversion factors 2020 - Full set"[23] using as a vehicle parameter a diesel-powered truck that emits 0.53912 kgCO2e per km traveled.

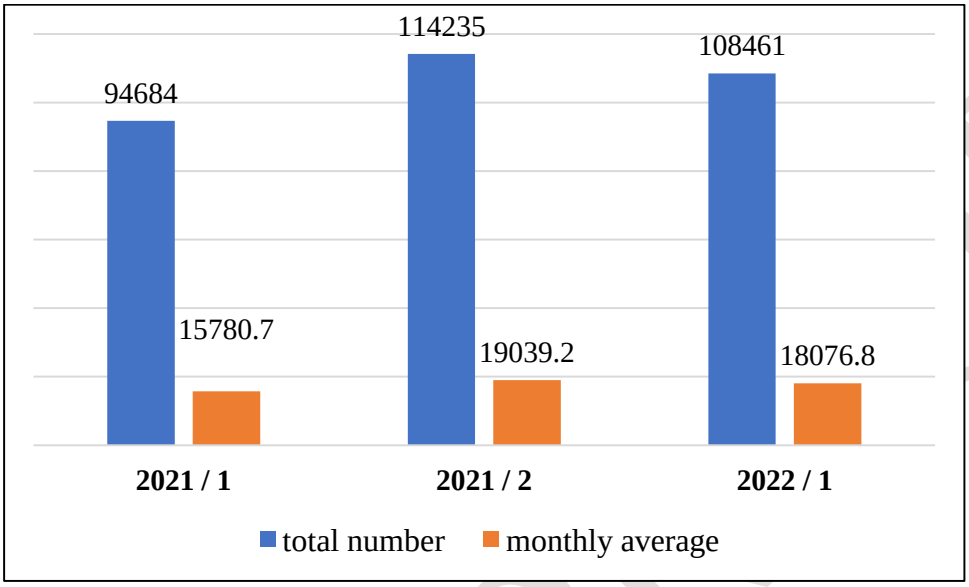
The results of the data found were calculated in absolute and percentage frequencies in the Microsoft Excel© 2010 software.

Ethical issues

In this study, there was no direct intervention with human beings, thus an Informed Consent Form was not required. The project is part of a postdoctoral research and was approved by the College of Sciences of the *Universidade da República* (Udelar) in 2021.

RESULTS

Number of Hospitalizations (month)



Graph 1. Number of hospitalizations per semester in a Public University Hospital. Montevideo, Uruguay.

The PUH's patients were provided with at least four meals daily: breakfast, lunch, snack, and dinner. In graph 1, the comparative evaluations were carried out per semester, and in the first of 2021 it represented 45.3% of the total annual hospitalizations. It is worth mentioning that in a 365-day year, the first semester has 181 days. The average daily attendance per semester was 523.1 (2021/1), 620.8 (2021/2) and 599.2 (2022/1). In the comparison between the first two semesters, there was an increase of 14.5% in the number of patients in 2022. The percentage distribution by diet type is presented in table 1.

Table 1. Percentage distribution of the main types of diets in the Public University Hospital. Montevideo, Uruguay.

Diet type	% 2021	% 2022
N1 (normal)	37.21	36.92
Patient companion	11.29	10.33
Cafeteria (normal)	7.34	7.09
N3 (hypercaloric)	5.81	5.99
N4 (renal)	5.74	6.34
Bland (special)	5.45	5.37
I2 (intestinal)	5,24	5.01
D2 (diabetes)	5.00	4.43
Special	4.29	4.46
Gastric	2.13	2.61
H2 (hypocaloric)	1.91	2.18
H1 (transition)	1.73	1.6
N5 (renal diabetic)	1.51	1.43
Total %	**94.65**	**93.76**
Total year diets	208919	108461(*)
Daily average	572.4	599.2

% = percentage distribution; (*) first semester.

The PUH has a registry with 24 options of dietary prescriptions. In 2021, 13 types of diets reached a total of 197,742 supplies (94.65%). In the first half of 2022, this amount was 101,693 of the total of all services (93.76%). Regarding the descriptions presented in Table 1, those of "companion" and "cafeteria" are services without therapeutic purpose. And, in the “special” modality, the dietary pattern is quite particular and specific for some patients.

Diet patterns

Lunch and dinner patterns are similar, with a menu structure that includes some preparation with one type of meat (animal protein) and another that can be a side dish (vegetables, cereals, or a combination of both) or salad, depending on the season. And for dessert fruits and milk-based creams are used. The PUH works with a standard system of monthly menus, which repeat every four weeks. There is a pattern for the coldest period (April

to September) and another for the warmest (October to March). Table 2, where we present the standard structure of food for each dietary prescription, did not include the "special" modality.

Table 2. Daily list of foods and quantity (in grams) according to the Diet Manual at the Public University Hospital. Montevideo, Uruguay.

Food (g)	**N 1**	**N 3**	**N 4**	**B**	**I 2**	**D 2**	**G**	**H 2**	**H 1**	**N 5**
Meat (1)	180	300	120	300	180	180	180	120	300	120
Egg	25	25	50	25	25	25	25	25	25	50
Whole milk	400	500	250	700	300	-	500	-	-	-
Skim milk	-	-	-	-	-	400	-	300	250	300
Cheese	-	20	-	-	-	20	-	-	-	-
Butter	-	-	10	-	-	-	-	-	-	-
animal origin (g)	605	845	430	1025	505	625	705	445	575	470
Veg 1*	300	300	300	200	450	450	300	450	200	300
Veg 2*	150	150	150	-	150	150	100	150	100	150
Veg 3*	200	200	200	200	200	200	200	200	100	200
Pulses (2)	15	15	-	-		15	-	-	-	-
Fruit B*	150	300	70	300	400	400	100	450	300	450
Fruit C* (3)	60	100	80	100	60	100	50	-	-	-
Cereals	70	70	70	70	-	70	70	70	70	70
Cornstarch	15	25	5	45	5	10	25	5	-	10
Bread	240	240	-	-	240	120	240	120	-	-
Cookies	-	-	80	-	-	-	-	-	160	80
Pasta	-	-		-	70	-	-	-	-	-
Oil	40	40	40	40	40	40	40	40	40	40
Sugar	30	40	20	60	20	-	40	-	20	-
Fruit jam	80	80	80	-	-	-	-	-	-	-
Maltodextrin	-	80	80	-	-	-	-	-	-	10
vegetable origin (g)	1350	1640	1175	1015	1635	1555	1165	1485	990	1310
Total (g)	**1955**	**2485**	**1605**	**2040**	**2140**	**2180**	**1870**	**1930**	**1565**	**1780**
% animal	30.9	34.0	26.8	50.2	23.6	28.7	37.7	23.1	36.7	26.4
% vegetable	69.1	66.0	73.2	49.8	76.4	71.3	62.3	76.9	63.3	73.6

Note: (*) Veg 1 - ex: chard, lettuce, tomato; Veg 2 – ex: beet, carrot, pumpkin; Veg 3 – potato, sweet potato; Fruit B – ex: peach, apple, orange, pear; Fruit C – banana. (1) Meat: chicken - 150 g (1x week); fish - 200 g (2x week); other days - beef; (2) Pulses (2x week); (3) Fruit C (4 x week)

Among the 10 types of diets, an average of 31.8% of animal products were offered. However, this average was especially influenced by the individual value of the pasty diet. It is worth mentioning that some of the foods presented in table 2 are specific to certain types of

meals. Milk is one of these examples, being more used for breakfast and lunch. Bread, for example, can be a complement to meals such as lunch and dinner.

Environmental impact

Table 3. Energy and water footprint assessment according to the type of diet. Public University Hospital. Montevideo, Uruguay.

Tipo de Dieta	kcal	HH	HH / kcal
N1 (normal)	2565.6	3822.5	**1.90**
N3 (hypercaloric)	**3023.8**	**5389.0**	1.782
N4 (renal)	1862.1	2850.4	1.531
Bland (special)	2086.1	4771.1	**2.287**
I2 (intestinal)	2114.1	3605.3	1.705
D2 (diabetes)	1833.0	3701.9	2.020
Gastric	2405.1	3626.3	1.508
H2 (hypocaloric)	**1712.6**	2760.4	1.612
H1 (transition)	2217.9	4403.8	1.986
N5 (renal diabetic)	1807.2	**2751.4**	1.522
Average	**2162.8**	**3768.2**	**1.744**
Standard deviation	**408.5**	**880.8**	**0.272**

Bold numbers are author's highlights for lowest and highest values.

The data of the variables in Table 3 were prepared from the list of foods presented in Table 2. From the latter, the percentage differences between the highest and lowest values of each item evaluated stand out. In kcal, this difference is 56.6% between the H2 (minor) and N3 (major) diets. For WF, this value is 51% among the N5 diet in relation to N3. This difference was related to the amount of animal products used.

Supplementary food

Table 4. General evaluation of the consumption of inputs for supplementary food at the Public University Hospital. Montevideo, Uruguay.

Supplementary Feeding	2021/1	2021/2	2022/1
Quantity kg	1004	1327	1129
Monthly average	167.3	221.2	188.17
Daily average	5.55	7.21	6.24

In Table 4 the consumption of supplementary foods in each semester investigated is presented. As in the evaluation of OD, in 2021 the first semester represented 43.07% in relation to annual consumption, while in the comparison between the first semesters of each year it was 12.45% in relation to 2022.

As for the types of products used, this study categorized them as follows: a) Supplements: three products – thickener, maltodextrin and caseinate; b) Adult enteral diets - 13 products, two of them with the same purpose, but different brands for each year; and c) Baby formulas – five products, two of them with the same purpose, but used in different periods (2021 and 2022).

Table 5. Distribution of variables according to the group of inputs used for supplementary feeding at the Public University Hospital. Montevideo, Uruguay.

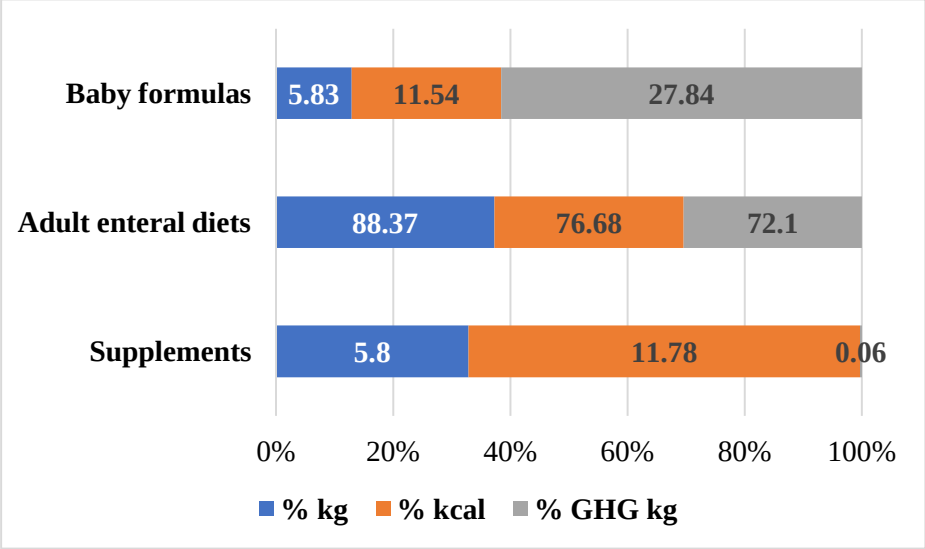
Supplements	**2021/1**	**2021/2**	**2022/1**	**Total**
kg	271.75	196.25	275.35	743.35
kcal	1013067	722408.3	1019213	2754687.5
GHG	44.197	44.197	44.197	44.197
Adult enteral diets	**2021/1**	**2021/2**	**2022/1**	**Total**
kg	2473.69	4661.9	4186.28	11321.87
kcal	4176892	6965307	6788588	17930786
GHG	47797.28	47797.8	55737.98	50444.18
Baby formulas	**2021/1**	**2021/2**	**2022/1**	**Total**
kg	314.66	220.71	211.31	746.68
kcal	905751	755440.5	1036019	2697210
GHG	19478.23	19478.23	19478.23	19478.23

Note: GHG - the values are constant, independent of the quantity of product purchased, as it refers to the distance from the origin of the input.

The data in Table 5 highlights the GHG emission variable for each product group. The supplementary items come from Uruguay or Argentina and, therefore, have the lowest percentage of GHG emissions. The products used in enteral diets for adults and infant formulas come from countries outside South America.

While in Table 5 the variables are evaluated according to each semester, in Graph 2 is the consolidated result according to the three categories investigated. In the evaluation of each

of the three product groups in each semester, supplements had their highest consumption in 2021/1 (58.1%).



Graph 2. Percentage distribution of items evaluated for enteral diets at the Public University Hospital. Montevideo, Uruguay.

The products used in the enteral diets for adults had the lowest consumption (34.7%) in 2021/1 and in the first half of 2022 there was an increase of 69.2% compared to the same period of the previous year. Regarding baby formulas, the first half of 2021 was the period of highest consumption (58.8%), also identifying a reduction of 32.8% in 2022 compared to the same period in 2021. In total, kg of the three periods, the distribution was as follows: 2021/1: 23.9%; 2021/2: 39.6%; and 2022/1: 36.5%. In relation to GHGs, in the consolidated comparative evaluation of graph 2, this is quite evident, especially in the evaluation of the group of infant formulas that proportionally has the greatest impact in terms of emissions, due to the distances of origin from Europe (11149 and 12965 km). This happens with some products that also pass through other Latin American cities before their final destination in Montevideo.

DISCUSSION

Number of Hospitalizations (month)

In the results presented, it is possible to identify a gradual increase in the number of hospitalizations from the first to the second half of 2021, as well as in the comparison between the first half of each year. An increase in the average number of hospitalizations from one year

to another was identified. This was probably due to the return of care from other medical specialties, which were more restricted in the period directly impacted by the number of COVID-19 cases.

With the COVID-19 pandemic, there was a change in hospital care standards, where many types of pathologies and surgical procedures ceased to occur. Reductions in the number of hospitalizations were highlighted in studies that describe specific pathologies or periods[24,25,26,27]. Recommendations for social distancing prior to vaccine development and the emergence of new mutational variants of the virus also contributed to this reduction.

We also highlight the impact of the ABC curve to show the representativeness of the data, since the 13 types of diets verified represented more than 93% of the overall total of all consultations. A study carried out in a Brazilian hospital, using the same criteria, identified that 86% of the inputs used were restricted to 49 items[28].

Diet patterns

The structure and pattern of the inputs used in the menus generally take into account the eating habits of the population and the availability of different types of food. Hospital diets are generally subdivided into: routine diets, diets with modified composition, special diets, and exam preparation diets[1]. The prescription of the diet and the number of meals a patient can receive will be related to their health and nutritional status. Regarding the types of food, it is possible to identify the presence of the same products, which are used for all types of diets, but with different amounts. And other very specific items, and therefore used for various purposes, such as cookies, pasta and maltodextrin.

A study by Rigo et al.[29] described the components of the lunch menu offered to diabetic patients in a Brazilian hospital. The repetition of several foods was noted in the evaluation of the fortnightly menu. Also in this same study, a difference can be seen in relation to the structure of the menu standard in relation to the PUH of Uruguay. In the Brazilian hospital, the standard structure of the patients' menu usually consists of a type of salad, rice, a pulse (usually beans), a type of meat, a side dish (usually vegetables), and a dessert that can be fruit or some type of sweet cream preparation.

It is noteworthy that the different types of diets take into account the clinical needs of patients. However, issues such as modifying the consistency of foods, or even restricting some

nutrients, such as sodium, for example, are considered therapeutic diets[30]. In the Montevideo PUH, the diet with the highest number of prescriptions was the normal type, which does not require specific restriction in terms of nutrients or consistency.

As for the use of different types of food, those of vegetable origin are more offered and also have a greater energy contribution in general, especially with the use of cereals and fruits. In turn, vegetables are part of the preparation of menus in dish such as salads and side dishes[31]. At the same time, the vegetable group also tends to have greater refusals of consumption[32]. However, the issue of acceptance in the consumption of patients was not evaluated in this study.

The standardization of menus and types of food is also an important tool in the service management process, simplifying processes, since food preparation involves aspects such as infrastructure, number of workers, financial resources and time[30]. Therefore, it is important to standardize the types of diets offered to ensure a better standard of care.

Environmental impact

Among the various possibilities to evaluate the environmental impacts of the oral diet, only the water footprint was considered in this study. The WF assessment is a good indicator to verify the environmental impacts on collective food services.

Regarding WF, it is worth mentioning that the three worst (highest) values were especially related to the per capita amount of meat (in the N3, B and H1 diets) and dairy products (N3 and B diets). However, in the relationship between the variables WF and kcal, pasty and diabetic diets had the worst results.

In the PUH, it was identified that the frequency of beef is higher than that of other types of meat. In an evaluation of the menus of a university restaurant in Brazil, it was identified that 77.9% of the WF came from 34.5% of the animal items used[33]. A similar result was found in the evaluation of the foods offered in a university cafeteria in Montevideo, where animal products represented 26.52% per capita in grams, but 69.78% of WF[34].

A similar result was obtained when comparing two menu patterns also in another Brazilian university restaurant where the vegetarian option had a WF 59.5% lower compared to the conventional standard[35]. In another study, this time evaluating the standard menu of hospital workers, in the total value of WF, 64.2% was due to inputs of animal origin[28].

Menus based on the predominance of plant elements have the potential to reduce environmental impacts that can vary between 20 and 30% in relation to diets classified as omnivorous[36]. There are still results from other studies that point to a direct relationship between the consumption of animal foods and various environmental impacts, especially with water use and GHG emissions[37,38].

In the PUH, chicken meat is offered only once a week, which is an option for significant reduction of WF, since 1 kg of beef has WF greater than 15 thousand liters, while chicken is 3.9 thousand liters per kg[20]. González-Garcia et al.[38] also point to chicken as a protein replacement option to reduce WF in menus.

Supplementary food

When evaluating these elements, it should be born in mind that the PUH primarily serves adult patients. In this case, the use of infant formula was due to patients with high-risk pregnancies who needed nutritional supplementation for their children. This explains the overall distribution of less than 6% of total intake in the SD group. As for the general evaluation between the variables kilograms, calories, and GHG, it should be noted that each product group has different characteristics and purposes. However, a relationship was especially identified between GHG emissions according to the origin of the products of each group, especially those that came from Europe.

The relationship between GHG emissions and the distance of origin of the products was also presented in the study by Ribeiro et al.[39], which identified that the use of enteral dietary products for adults and for pediatric use in a hospital came from countries such as Germany, the Netherlands, England, China, and the United States. A study in the UK found that locally sourced products had much lower GHG emission levels compared to imports[40].

Many products used in enteral nutrition or infant formulas have water as their main component. In a study that evaluated 74 products available in Brazil, it was identified that 87.8% were marketed in liquid form[41]. Thus, a large part of the emissions is due to the transport of the main constituent: water. In addition, many of the ingredients that make up the diets and enteral formulas are available in local markets. Thus, if there were incentives for the production of these products by national laboratories, the environmental impact would be lower. Nogueira

et al.[42] highlight that the purchase of local products reduces distances, which translates into less GHG emissions, in addition to offering opportunities to strengthen the regional economy.

As limitations of this study, we highlight that the databases used to evaluate caloric values (kcal), WF and GHG were obtained from reference tables in the literature for scientific articles, and therefore represent the evaluation of the characteristics and specificities of a given period. Due to the sample size, it was not possible to apply statistical test.

CONCLUSIONS

In this study, we presented data from the evaluations of three semesters at the food and nutrition service of a public university hospital in the city of Montevideo, Uruguay. An increase in the number of hospitalizations in each of the semesters could be observed. In relation to the various types of dietary compositions prescribed, it was identified that 10 diet types concentrated the main meal supplies. Foods used by PUHs are generally classified as unprocessed or minimally processed. This study analyzed the water footprint of each type of diet. It was observed that the greater use of beef and cow's milk generated the greatest impacts of WF in some oral diets.

In the products used as supplementary diet, the group of enteral diets for adults presented the highest total consumption, justified by the characteristics of the hospital that attends this type of patient. The environmental impact of GHG emissions was directly related to the origin of the products purchased.

It is noteworthy that hospital food services, in addition to providing care with nutritional aspects, can also consider the environmental impacts of the foods and supplements used in the preparation of menus and dietary prescriptions, in order to contribute to the sustainability of the planet. New studies of this nature are suggested to understand and propose changes in the food supply of hospitalized patients.

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