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Evolution of school meal recommendations in Catalonia: environmental footprint, price and healthiness

RESEARCH

Final thesis proposal

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Contents

Abstract

Food systems and dietary choices have a relevant impact on the natural environment and human health. In children, an adequate diet is essential for a correct growth and development. School lunchroom can be an excellent educational tool that includes kitchen staff, teachers, monitors and children. In Catalunya, different versions of recommendations for the design of school menus have been published from 2012 to 2020, with the main changes being a replacement of animal products by plant-based products, mainly legumes as a source of protein. The environmental footprint (EF), price and healthiness of the 3 published versions have been evaluated. Lower recommended frequencies of meat and fish resulted in a 36% reduction in carbon footprint, 4% in water footprint and 14% in land use. Overall price for a weekly menu decreased from 3,65€ in 2012 to 2,98 in 2020. As the scientific knowledge about the healthiness and EF of different food groups increases, better recommendations can be elaborated. More data on the EF of fish is needed for a more realistic analysis, but the improvement is promising. Still, a further restriction in meat and especially beef could enhance the sustainability of recommended school menus in Catalunya.

Key words

School meals; Sustainable diet; Carbon footprint; Water footprint; Land use; Food price; Healthy diet; Dietary guidelines

1. Introduction

There is an increasing body of scientific evidence on the extent of the impact of food systems and dietary choices on the natural environment and human health. On one hand, food systems have an enormous environmental footprint (EF): they contribute to 20-30% of all anthropogenic greenhouse gas (GHG) emissions (GHGE) and 70% of all human water use, being also the leading cause of deforestation, land use change and biodiversity loss [1]. On the other hand, dietary factors are responsible for 22% of global deaths and 15% of global dissability-adjusted life years (DALYs) [2]. These facts depict a global issue that is related to the concept of "planetary health". Planetary health is defined by Whitmee et al [3] as "the health of human civilisation and the state of the natural systems on which it depends". Food plays a major role in planetary health, and the current situation is not favorable. However, the environmental preasure of the food system could be significantly reduced by dietary changes. For example, it was found by linear programming that food-related GHGE could be reduced by up to 30% without impairing nutritional adequacy if some food replacements were done [4]. Still, to achieve this reduction, big-scale changes are needed.

On a global level, the transition towards healthy and sustainable dietary patterns is considered a priority. It is actually aligned with many of the Sustainable Development Goals (SDG) stated by the UN [5], such as:

- **SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.**

A diet low in animal products and high in plant-based whole foods is nutritionally more adequate and reduces the risk of malnutrition (Target 2.2). Moreover, it has a lower EF. When also consuming local and seasonal products, there is a benefit for small producers and local economy and therefore an improvement in food security (Target 2.1, 2.3 and 2.4).

- **SDG 3: Ensure healthy lives and promote well-being for all at all ages.**

Some changes in diet would improve human health and prevent some non-communicable diseases such as cardiovascular disease, diabetes or cancer (Target 3.4).

- **SDG 12: Ensure sustainable consumption and production patterns**.

By promoting sustainable dietary habits, awareness is raised regarding sustainable lifestyles in harmony with nature (Target 12.8). Also, an environmentally-friendly diet is key to achieve sustainable management and efficient use of natural resources (Target 12.2).

In Spain, the most recent food-based dietary guidelines were released in 2020 [6]. Although the final report includes information on sustainable diets, the guidelines are mostly

based on nutritional criteria (dietary reference values and food composition). Indeed, it is mentioned in the report itself that further scientific data is necessary for the elaboration of "sustainable and healthy dietary guidelines". However, among all 17 autonomous communities in Spain, some of them have released their own dietary guidelines and recommendations that include sustainability aspects, such as Catalonia and Andalucia [7,8].

In Catalonia, the Strategic Food Plan 2021-2026 for the agrifood sector includes both sustainability and nutritional aspects, among others, being aligned with planetary health [9]. This Plan aims to embrace all sectors of the food systems: from agricultural and livestock producers to food industry, retail, education, public meals and consumer-oriented actions. One of the main strategic lines is to enhance food system transition towards a positive or neutral environmental impact. This includes some challenges. For instance, replacing 10% of animal protein with alternative protein, or increasing by 10% the consumption of local agroecological products. It is also intended to analyze the EF of the main agrifood products and to reduce food loss and food waste along the food chain. Another strategic line is to promote healthy dietary habits and raise awareness about the impacts of diet on human health and the environment. Several actions are proposed with that aim, such as including health, lifestyle and nutrition in educational programs.

School menus themselves, besides representing only 10% of the total meals of a child in a year, have an important role in children and teens health, contributing to an adequate nutritional status and a correct growth [7]. They are an excelent educational tool too [7]. In Catalonia, 42,5% of children have lunch in school canteens. School lunches should include all members of the educational environment: teachers, cooks, lunchroom monitors, children and teenagers, and their families [10].

After declaring the climate emergency in 2020 in Barcelona, and being in 2021 the World Sustainable Food Capital, the city Municipality and the Catalan Agency of Public Health (ASPCAT, Agència de Salut Pública de Catalunya) started a pilot plan in order to transform school menus into more sustainable and healthy options. Their specific action plan regarding public meals is to *"Implement and promote healthier diets that are low in carbon in 2021, in schools and all municipal dining rooms: seasonal, ecological, locally produced, reducing the consumption of animal protein (especially red meat) and highly processed foods."* [10]. It has been recently studied to which extent the EF of school menus of the city of Barcelona could be reduced by implementing such "low-carbon meals": there is a potential reduction of 60% of blue water footprint, 53% of GHGE and 48% of land use [11].

These measures are not being recommended in Barcelona only. In 2020, the ASPCAT published the third and newest version of the "Guidelines for healthy eating at school stage"

for schools and families so to make meals healthier and more sustainable [7]. Different menus for cold and warm seasons, consumption frequency of each food group, cooking techniques, cutlery and other aspects of school lunch environment are reviewed in the report. There are two previous guidelines, published in 2012 and 2017 [12,13]. Major changes between the first and the second versions of the guidelines were established based on health reasons, while modifications from the second to the third one where based not only on healthiness but also on sustainability. However, the assessment of the environmental impact of the recommendations and the variation over the versions has not been carried out. Additionally, healthier and more environmentally-friendly dietary patterns seem to be less affordable than unhealthy, non-sustainable ones such as the Western dietary pattern [14]. Having price an important impact on dietary choices and food consumption [15], it should be included in the analysis of the of diets, together with environmental impact and healthiness [14].

Therefore, the general aim of this study is to evaluate the environmental, economic and health aspects of recommended school menus in Catalonia and compare these dimensions across the 3 guidelines.

The specific aims are

- To quantify the difference in carbon footprint (CF), water footprint (WF), land use (LU) and price of the recommendations from the 2020, 2017 and 2012 guidelines.
- To evaluate the contribution of each food group and course into the total CF, WF, LU and price of the weekly menu for each of the 3 guidelines.
- To qualitatively evaluate the differences in the food groups recommendations among the three versions of the dietary guidelines in terms of healthiness.

By doing this, the aim is to answer the following research question:

How do the CF, WF, LU, price and healthiness of the Catalonia institutional recommendations for school menus evolve along the consecutive guideline versions?

2. Methods

Food frequency consumption recommendations

The basis of the study were food frequencies consumption recommended by the ASPCAT, which can be found in the series of publications “Healthy eating at school-age. Guidelines for families and schools” for years 2012, 2017 and 2020 [7,12,13] [Table 1].

	Food category		Recommended weekly frequency				
			2012	2017		2020	
First course	Rice		1	1		1	
	Pasta		1	1		1	
	Legumes		1-2	1-2		1-2	
	Vegetables		1-2	1-2		1-2	
Second course	Meat (all)	White meat	1-3 (all)	1-3 (all)	1-3	1-2 (all)	1-2
		Red and processed meat			0-1		0-1
	Fish		1-3	1-3		1	
	Eggs		1-2	1-2		1	
	Plant protein (legumes and derivates)		∄	0-5		1-2	
Sides	Salad		3-4	3-4		3-4	
	Others (potatoes, vegetables, legumes, pasta, rice, mushrooms...)		1-2	1-2		1-2	
Dessert	Fresh fruit		4-5	4-5		4-5	
	Yoghurt, nuts, cottage cheese, curd…		0-1	0-1		0-1	

Table 1. Food frequency consumption recommended by the Catalan Agency of Public Health in 2012, 2017 and 2020 guidelines, stated as a range of servings per week. ∄ = does not appear

Specific values for recommended servings of each food group were needed in order to do quantify the environmental footprint and price of the weekly menu. As the recommendations were stated as a range of servings per week, and a non-trivial number of possible combinations among groups could be derived, the mean value of the stated range was calculated [table 2]. For the results to be comparable across guidelines, it was necessary that the sum of all specific frequencies for each course was the same in all 3 guideline versions. f such sum was not equal when using the mean value of the recommended range, then the frequency in sample menus was obtained. This happened only with second courses, so the procedure for the calculation of their frequencies of consumption was the following:

Each guideline proposes two sample monthly menus of school lunches: one for the cold season (from mid-September to mid-March) and another one for the warm season (from mid-March to mid-June). First, frequency of consumption for each food category was calculated as the average number of times a specific food item belonging to such food category and course was suggested in a weekly menu. Following recommendations, when a second course contained both the food categories fish and meat, each counted as half a serving. This happened when having a complete dish such as mixed paella,which contains one serving of rice, and one serving of meat and shellfish together. The frequency of consumption was calculated separately for warm and cold menus in each guideline. As the school year includes 6 months of cold season (2/3 of school year) and 3 moths of warm season (1/3 of school year), the weighted average frequency was calculated as following [table 2, table S1]:

$$\text{Average menu freq} = (2*\text{freq cold season} + \text{warm menu freq})/3$$

Where:

- Average menu freq = average frequency of the given food category along the school year
- Freq cold season = average weekly freq given food category in the cold season menu
- Freq warm season = average weekly freq given food category in the warm season menu

	Food category		Sample menu frequency		
			2012	**2017**	**2020**
Second course	**Meat (all)**	**White meat**	2,21	1,25	1
		RP meat		0,5	0,5
	Fish		1,63	1,5	1
	Eggs		1	1	1
	Plant protein		∄	0,58	1,33

Table 2. Recommended food frequency consumption by the Catalan Agency of Public Health in 2012, 2017 and 2020 guidelines for second courses. "Sample menu freq" is the average food frequency for each food category in the sample menus. RP = Red and processed meat. ∄ = not included.

Food category description

To do the assessment of the environmental impact and price of the recommendations, each food category was broken down into specific food items. According to the composition of sample menus of each of the 3 guidelines, a count for every food item in the cold- and warm-season sample menus was obtained.Values for all 3 warm-season and cold-season menus were added separately, thereby obtaining a total count of each food item. Each food item's count was divided by the total count of all items in the same food category, both for warm-

and cold-season menus, and then the weighted average was calculated using the same procedure as in recommended frequency of consumption. This way, the composition of a given food category was determined in cold- and warm-season menus. All calculations and complete data can be found in supplementary material [table S2].

Garlic, spices and salt were also excluded because of their low relative weight and similarity among 3 guidelines is assumed. Bread, oil and water were also excluded because they lack specific recommendations.

Serving size

Serving sizes for each food category were retrieved from the "Orientative serving sizes for each age group" publication by the ASPCAT, which contains recommendations for different age groups [16]. Recommendations for age group 7-12-year-old children was chosen because it is more probable that the school lunch service works 5 days per week in primary school, which corresponds to that age, that in high-school (from 12 years on), where there is the possibility of serving school lunch only 3 days per week [7,12,13]. As servings are expressed in ranges of grams of raw product, the mean value of the given range, transformed to kg, was used as the specific serving size. E.g. being 50-60 g the recommended serving size, the final value would be 0,055 kg. In the case of eggs, average medium egg weight by the Spanish Institute of the Egg [17] was used to transform units to kg. Serving size for sides other than salad was determined as the average of the 4 types of sides [table 3, table S3].

Course	Food category	Recommended serving size, range *	Recommended serving size, mean ^
First course	**Rice, pasta**	60-80	0,070
First course	**Legumes**	50-60	0,055
First course	**Vegetables**	120-150	0,135
First course	**Potatoes**	200-250	0,225
Second course	**Meat (bone-free)**	60-80	0,070
Second course	**Chicken, rabbit, pork ribs, lamb... (gross weight)**	75-100	0,0875
Second course	**Fish (fillet)**	70-90	0,080
Second course	**Eggs**	1-2 units	0,075 *
Second course	**Legumes**	50-60	0,055
Side	**Vegetables**	60-100	0,080
Side	**Rice, pasta**	25-30	0,0275

Side	**Potatoes**	90-100	0,095
Side	**Legumes**	20-30	0,025
Dessert	**Fruit**	120-150	0,135
Dessert	**Yoghurt**	100	0,100

Table 3. Serving sizes for each food category and course. Adapted from the Catalan Agency of Public Health [16]
*Grams of raw product. ^Kg of raw product

Menu composition

The total weight of a weekly menu in each of the 3 guidelines is calculated by adding the weight of each food category and course, which is in turn calculated as the product of the serving size and the weekly frequency of consumption of the given food category. With these values, contribution of each food category to the overall menu composition, by weight, is obtained [table S7].

Environmental footprint

3 parameters of the EF were studied: carbon footprint, water footprint and land use. The functional unit of this analysis was a weekly meal for a 7 to 12 years-old child according to the recommendations of the ASPCAT. System boundaries included all stages from farm to regional distribution center.

Carbon footprint

Most CF values were obtained from a systematic review that calculates global average CF values for fresh products from many studies [18]. Mean value for each ingredient was inserted in the spreadsheet in kg of CO_2-equivalent units (kg CO_2-eq) per kg food from farm to regional distribution center. For sheep/goat and beef, the specific CF value for the EU was used, as it was available. The CF values for shellfish (used in dishes like paella or “arròs a la cassola”…) were calculated by a weighted arithmetic mean of the food groups “prawn/shrimp” and “mussels” and using the same serving size as fish. Because of lack of data, values from “All fish” were used as a proxy for Halibut.

The CF of a few ingredients were obtained from other sources as they did not appear in that review: pasta was obtained from the environmental product declaration of durum wheat semolina pasta [19], and the value for ice cream was determined as the average of the 4 analyzed ice-cream types in a product-specific life cycle analysis publication [20]. All CF data can be found in supplementary material [table S4].

Water footprint

Total WF values were obtained mainly from the work of Mekonnen and Hoekstra [21] from farm to farm gate or slaughterhouse gate. The report includes many national values, including Spain. When Spanish data is not available, the global average value was used. Data was expressed in m^3 of H_2O per ton (or L of H_2O per kg) of carcass weight. Carcass weight was transformed to bone-free meat using the same ratios reported by Clune for beef, sheep and goat, pork and chicken [18]. Turkey and rabbit do not appear in the WF report [21], so chicken was used as a proxy because they are part of the same food category (i.e.white meat). Similarly, milk was used as a proxi for yoghurt, while ice cream WF was obtained from the same source as its CF [20]. WF for mushrooms were obtained from a product-specific report [22]. For pasta, the average value between those in Mekonnen and Barilla reports [19,21] was calculated. All WF data can be found in supplementary material [table S5].

Land use

LU values for the different food items were retrieved from a publication by Poore and Nemecek [23] and expressed in m^2 per kg of product, 100 g of protein or 1000 kilocalories. Units were transformed to kg of product using FAO food composition tables [24]. Products that were not specified in the report were assigned a proxi food item. Ice cream and mushrooms LU were obtained from the same source as their WF [20,22]. All LU data can be found in supplementary material [table S6].

General assumptions

All crop products were assumed to be field-grown and not in a greenhouse, by conventional agriculture techniques

Marine water fish was assumed to come from wild capture and was assigned a WF and LU of 0 [25]. This assumption is based on all 3 guidelines stating that “fish should come preferably from sustainable fishing systems”.

Calculations

EF parameters of each food category were calculated by multiplying EF values per kg of specific food item by their relative frequency in the food category; the sum of all these values determined the EF of the given food category. Total WF, CF and LU for a weekly menu was the sum of the EF of each course: food category EF multiplied by its serving size and its weekly frequency of consumption. All calculations were done in Microsoft® Excel® for Microsoft 365 and can be found in supplementary material [tables S7, S8 and S9].

Price

The price for each food item was retrieved from the monthly report on household food consumption in Catalonia, expressed in € per kg of food [26]. The average price for every food item in each of the two seasons was calculated separately, so taking into account the seasonality of the price along the school year. Only the months that belong completely to each season were included, i.e., from October until February for cold season, and from April until June for warm season. September and March were excluded, as they are divided between two different seasons. Afterwards, the average price for a food category was obtained for each of the two seasons by multiplying and adding all food items' relative frequencies. Then, the weighted average between the two seasonal prices was calculated for each guideline version. All calculations can be found in supplementary material [tables S10 and S11].

Health

Changes in recommended food consumption frequencies across the 3 published guidelines were qualitatively assessed in terms of healthiness, together with a broad review of the overall dietary guidelines in each publication.

3. Results

Food frequency consumption recommendations

Food frequency consumption for each food category and course across the 3 guidelines is summarized in table 2. The main changes were implemented in the composition of second courses, which contain the protein portion of the meal. In 2012 guidelines, only animal products (meat, fish and eggs) were recommended as main ingredient for second courses. In 2017, pursuing health improvements, types of meat were differentiated, being white meat prefered over RP meat. Also, plant protein is included as an alternative. Finally, in 2020 guidelines, there is a substantial reduction in the recommended frequency of consumption of animal protein, specially fish, being it replaced by vegetable protein.

Menu composition

Total weight of weekly menus is almost equal in all 3 guidelines (1,77-1,79 kg/weekly menu). Contribution of each food category to weekly menu composition, by weight, is represented in table S7 and figure 1. Vegetables account for nearly 32% of the menu weight in all guidelines, fruit for 30-32% and animal products diminish from 26% in 2012 to 23% in 2017 and 19% in 2020.

Carbon footprint

Total CF for weekly menus is summarized in table 4. Explicit calculations can be found in tables S7 and S12. A negative trend for CF is maintained along guideline versions. In 2017 guidelines, CF is reduced by 25% in comparison with the 2012 guidelines, and in 2020 the reduction reaches 36% compared to 2012.

	Carbon footprint		Water footprint		Land use		Price	
	Weekly menu	Relative difference vs 2012	Weekly menu	Relative difference vs 2012	Weekly menu	Relative difference vs 2012	Weekly menu	Relative difference vs 2012
2012	3,37	1,00	3048,54	1,00	9,60	1,00	3,65	1,00
2017	2,51	0,75	2804,73	0,92	7,61	0,79	3,32	0,91
2020	2,16	0,64	2916,24	0,96	8,11	0,84	2,98	0,82

Table 4. Carbon footprint (kg of CO_2 equivalent units per weekly menu), water footprint (L H_2O/weekly menu), land use (m^2/weekly menu) and price (€/weekly menu) of weekly menus following recommendations in each of the 3 guidelines and their relative difference versus 2012 version

Contribution of each food category to the weekly meal CF is represented in figure 1. The main contributors are meat (28-42%) and fish (23-31%) in second course. First courses – except rice – and sides have the lowest contribution to the overall CF (<5% each).

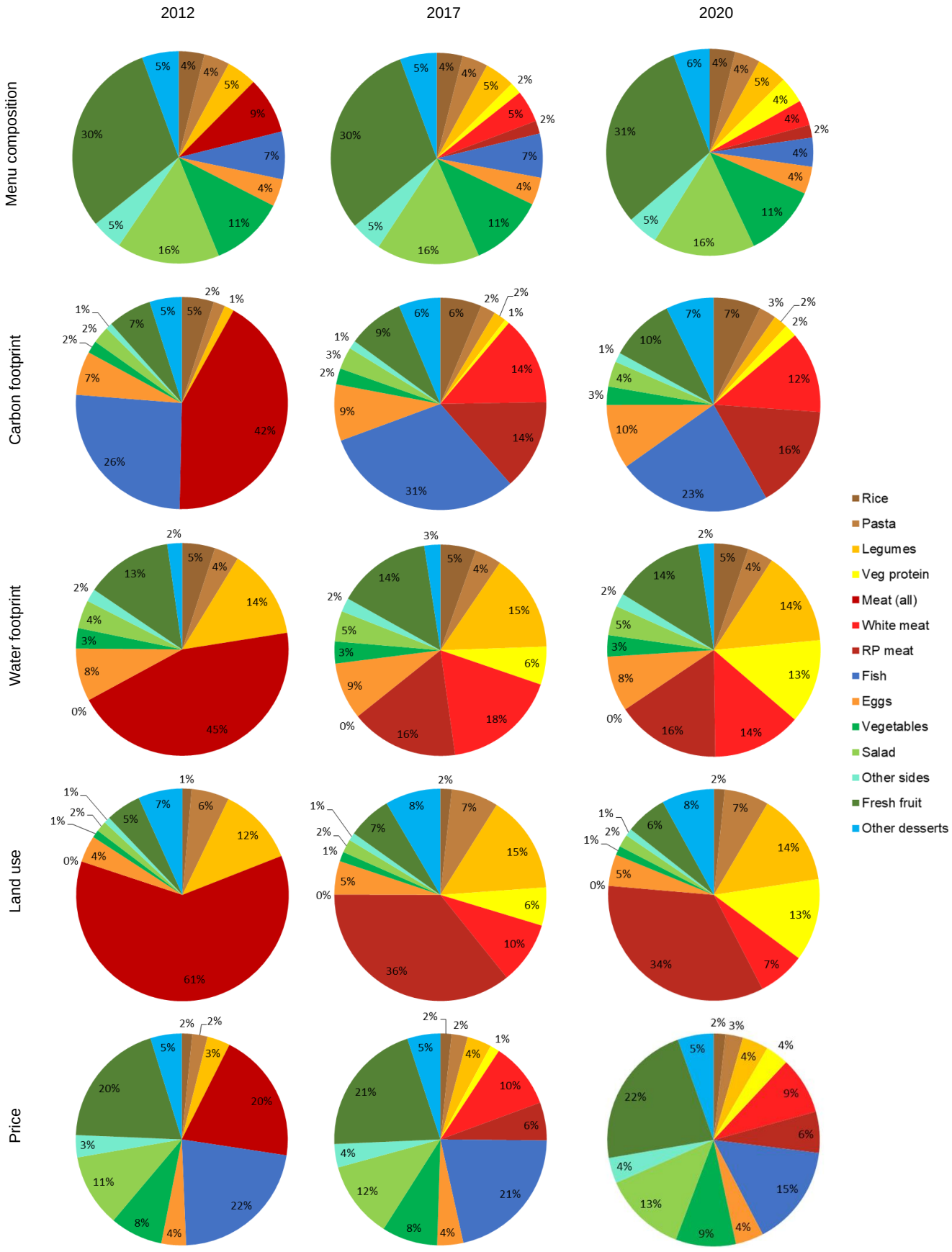

Figure 1. Contribution of each food category and course to weekly menu composition (kg food), carbon footprint (kg CO_2-eq), water footprint (L H_2O), land use (m^2) and price (€) in each of the three guideline versions (2012, 2017 and 2020) proposed by the Catalan Agency of Public Health. Veg = vegetable. RP meat = red and processed meat

Water footprint

Total WF for weekly menus are summarized in table 4. Explicit calculations can be found in tables S8 and S12. There is a WF reduction of 8% in 2017 guidelines followed by an increase in 2020: the difference versus 2012 WF decreases to 4%.

Contribution of each food category to the weekly meal WF is represented in figure 1. All second courses together (meat, fish, eggs and vegetable protein) always account for 49-53% of overall WF. The main contributor is meat, with a significant reduction from 45% in 2012 to 30% in 2020. The second largest WF is from legumes as a first course (14-15%) and as a second course (6-13%). Desserts other than fruit, sides, vegetables and pasta have the lowest contributions (<5%) after fish (0%).

Land use

Total LU for weekly menus are summarized in table 4. Explicit calculations can be found in tables S9 and S12. The trend is negative at first: in 2017 guidelines, there is a 21% reduction versus 2012, but in 2020, there is an increase in LU, and the difference compared to 2012 is 14%.

Contribution of each food category to the weekly meal LU is represented in figure 1. The course with the highest LU is meat, with a clear negative trend in contribution: from 61% in 2012 to 41% in 2020. Rice and vegetables as a first course and sides have 1-2% contribution in all guidelines, and legumes and vegetable protein increase from 12% to 27%.

Price

Total price per weekly menu is reported in table 4. Explicit calculations can be found in tables S11 and S12. There is a marked reduction of 9% and 18% in 2017 and 2020 guidelines, respectively: from 3,65 to 3,32 and 2,98€/weekly menu.

Contribution of each food category to the weekly meal price is represented in figure 1. Meat, fish and fresh fruit as a dessert are the most expensive courses in all guidelines (15-22% of the total price), followed by salad as a side and vegetables as a first course. Vegetable protein, legumes, sides other than salad, rice and pasta have the lowest contribution: <5% of total price, followed by desserts other than fresh fruit (4-5%).

Health

The same definition of a “healthy diet” is found in all 3 guidelines: “A healthy diet is a diet that is satisfactory, sufficient, complete, balanced, harmonious, safe, adapted to the individual and the environment, sustainable and affordable”. Also, all guidelines include a basic health justification for the need of dietary guidelines in terms of nutrition, physical and mental growth and development, and other justifications that in the long term will influence individual health: food behavior, pleasure, social relationships and religious identity.

A general description of the dietary habits of children and teenagers is described in each guideline, highlighting some food categories that can be related to the dietary recommendations. On one hand, it is remarked in all guidelines that there is a very low consumption of fruit, vegetables and legumes. A low intake of fish is mentioned in 2012 and 2017 guidelines, but not in 2020. A low intake of whole grains is highlighted only in 2020. This translates to low consumption of fiber, minerals and vitamins, which are essential for an adequate nutrition. On the other hand, 2012 and 2017 reports state that “this is often accompanied by an excessive consumption of candy, sweetened beverages and RP meat”. In 2020 publication, the term “ultraprocessed” food is introduced as undesirable due to its large content of sugar, salt and unhealthy fat.

Regarding dietary guidelines, all 3 guidelines want to point towards the Mediterranean diet, described as one of the healthiest worldwide. They promote the consumption of whole grains, fresh fruit, nuts, vegetables, legumes and olive oil. All these foods are considered healthy because of their high nutrient density. In 2020 guidelines, sweetened beverages are explicitly discouraged and it is also specified that dairy should be unsweetened, thereby trying to reduce the intake of sugar. Fish and eggs are also promoted over meat, and fresh whole products are recommended over processed and ultraprocessed foods, all of these resulting in a lower saturated fatty acid (SFA), salt and sugar consumption.

It is also remarkable the transition from nutrient-based dietary guidelines in 2012 to food-based dietary guidelines in 2020, which give more flexibility and quality information to consumer instead of being too numeric or technical.

There are recommended food frequency changes largely driven by health parameters. The increased recommendation on legumes in 2017 and the reduction of RP meat enhances fiber and plant protein consumption and attempts to curb SFA intake. In 2020 there is a notable reduction of fish. Whole grains are prefered in all guidelines, but the recommendation becomes more severe in 2020, where menus must be accompanied by whole grain bread and either pasta or rice should be whole-grain as well, so encouraging fiber intake and a lower glicemic index.

Last, cooking techniques are reviewed. Pre-cooked foods have lower recommended frequencies of consumption in 2020 compared to previous guidelines, in line with the avoidance of processed foods, but fried foods do not change over the 3 guidelines. Still, salad as a side is always preferred over fries or other alternatives, providing more nutrients.

4. Discussion

CF and price of the weekly menus recommended by the ASPCAT depict a negative trend along the 3 guideline versions, while LU and WF see a reduction from 2012 to 2017 followed by a small increase in 2020. The main driver for these fluctuations is the amount of animal products served in a weekly menu, namely meat and fish.

In 2012 recommendations, animal products together (meat, fish, eggs and dairy) contribute to 25% of total menu composition by weight, while representing 75% of the weekly menu CF. This is a consequence of the high environmental impact associated to their production, which is very resource-intensive compared to plant-based foods, both per weight and per nutritional unit [18,23,27,28]. In 2020, the contribution of animal products to the total weekly menu is reduced to 19% of total weight and 67% of total CF. Therefore, in 2020 recommendations, 1,26 less kg CO_2-eq are produced by weekly menu compared to 2012 thanks to meat and fish reduction replacement by vegetable protein. In all Catalunya there are 483.712 primary school students [29] and 42,5% of them have lunch at school [7]. Assuming all schools follow frequency of consumption recommendations regarding fish and meat (it is estimated that 96-98% of them do [30]), there would be a CF reduction of 259 tones of CO_2-eq per week of the school year thanks to the update in 2020 guidelines. This equals the annual CF associated to 1619 adults consuming the Spanish average diet [31]. However, it will be mentioned in limitations that the results of the present study are probably an underestimation.

Legumes have a 15-times-lower CF than meat and 11-times-lower CF than fish, by weight. When comparing by gram of protein, which is the main nutrient of interest in the second course, legumes have a very small CF: 0,25 g, while this impact ascends to 8,6 for fish, 10 for white and pork meat, and even 62 for ruminant meat: 250 times higher than legumes [28]. Thus, further improvements could be achieved if red and processed meat was represented by pork instead of beef. This same finding has already been suggested by other researchers [27,31].

Both WF and LU show a clear decrease in 2017 thanks to a lower red and processed meat recommended frequency of consumption, which accounts for 407 L H_2O and 2,8 m^2 less per weekly menu. In 2020, a reduction in white meat consumption results in a further decrease of 98 L H_2O and 0,17 m^2. However, they both suffer a small increase in 2020 compared to 2017. This is a consequence of a reduced frequency of consumption of fish, which has an associated WF and LU of 0, and their replacement by legumes. Nevertheless, the magnitude of the increase is very small compared to the improvement seen when meat recommendations are decreased. Also, this result might not be realistic. Note that this is calculated based on the general assumption that fish comes from wild capture and thus has a WF and LU of 0. This

can undermine the actual environmental footprint of fish, as fishing has an impact on marine ecosystems which is not reflected here. The lack of studies on the EF of fish, specially WF and LU, is a common limitation in other similar studies [27]. Even if fish was not from wild capture but from aquiculture, there would be a decrease in associated WF: when assigning all fish servings the average WF for aquiculture fish found by Pahlow et al [32], 1629 L H_2O/kg, the trend is maintained: 2017 recommendations entail a 8% reduction in WF, followed by an increase of 1,5% in 2020.

The weekly menu becomes less expensive as guidelines are updated, mainly because animal products are reduced – the most expensive foods per kg are fish and red meat, so their frequency of consumption has a high impact. Fruit also has a relatively large contribution to overall price but its frequency is maintained because of health and sustainability reasons.

When revising health recommendations and actual dietary patterns of children and adolescents, it is always highlighted how fruit and vegetables are essential for a healthy diet and how there is a too low consumption in children. Actually, low fruit and vegetable consumption are leading causes of death and DALYs worldwide [33], so schools should pursue such recommendations. Fish is also a nutrient-dense food whose consumption is beneficial from a health point of view, but in 2020 a higher consumption is not encouraged anymore, maybe because of sustainability issues. Such recommendations have an impact on the EF, as mentioned before. Another remarkable healthiness improvement is the introduction of the "ultraprocessed foods" concept, which did not have a technical definition until 2017 [34]. Snacks, candy, other products with added sugar, salt and fat and also pre-cooked foods such as fish sticks are more strongly disencouraged in 2020, although being mentioned from 2012, maybe because of the concern and scientific evidence raised over the last years: publications with "ultraprocessed food" as a query in PubMed have increase from less than 5 per year in 2014 until 50-60 per year nowadays.

With all the resulting information in this analysis, the recommendations for school lunches could still be improved and enhance their sustainability. For this purpose, suggestions for food frequency of consumption and some specific food items are shown in table 5. First, and most important, meat frequency of consumption should be reduced to once a week. Red and processed meat would be represented by a lean cut of pork once a month and white meat would be present in the other 3 weeks of the month. The corresponding courses should be replaced with legumes. Otherwise, instead of modifying frequency of consumption, serving sizes could be shrinked and thus have meat more frequently but in lower quantities, and this might increase acceptability while making space for more plant foods in the dish. These changes can entail an EF reduction of 4,5% of CF, 8% of WF and 17% of LU compared to 2020 values. Second, there are a few specific food items with specially large EF in the

respective food category, such as rice among grains, apricots, cherrys and plumbs among fruit, and lentils among legumes. It has been tested wether their frequency of consumption could have an effect on overall menu EF, and there can be improvements but they are not comparable to reducing meat consumption. The largest effect was with legumes: if chickpeas were prioritized over beans and lentils, a further 1% reduction in WF and LU would be possible, but lentils are a nutritionally-valuable food, so this should be evaluated by professional dietists. With other food groups, changes were insignificant. Regarding rice, it is an important gran in our diet so frequency of consumption in first courses should not be reduced to less than 1 per week, but its presence as a side can be constrained and replaced by potatoes and vegetables.

	Food category		Frequency of consumption	
First course	Rice		1	
	Pasta		1	
	Legumes		1-2	
	Vegetables		1-2	
Second course	Meat (all)	White meat	1	3/month
		Red meat (lean pork)		1/month
	Fish		1	
	Eggs		1	
	Plant protein (prioritize chickpeas)		2	
Sides	Salad		3-4	
	Others (potatoes, vegetables or mushrooms, not rice)		1-2	
Dessert	Fresh fruit		4-5	
	Yoghurt, nuts. Avoid cheese		0-1	

Table 5. Suggested recommendations for school menus. Stated as servings per week unless otherwise specified.

The price reduction in conjunction with sustainability and health improvements could encourage decision makers to implement these changes in the menus. Also, other factors should be considered for these recommendations to be effectively implemented in school lunches: cooking skills of the kitchen service, their motivation to learn and change recipes, the acceptability of the dishes and its general feasability.

In general, findings are in line with other similar studies [11,27]: animal products are the main drivers for the environmental impact of institutional meals, and beef is the food item with the highest associated values of CF, WF and LU. Legumes are the cheapest protein and the most environmentally-friendly. However, there is still research to do on the environmental

impact of school meals in Spain. Structured data on the origin of food (local or imported, organic or conventional) and the recipes in the actual menus served in schools instead of the official recommendations. Also, other institutional meals are to be analyzed: for instance, hospitals or nursery homes.

It is important to bear in mind the limitations of this analysis, as well as its strenghts. On one hand, the environmental impact assessment does not include transportation from wholesale market to kitchen, cooking nor waste, so, results don't represent the actual impact but the relative change along guidelines. Transport and retail represent a very low proportion of total EF, around 6% according to González-García et al [27], but processing of some foods like sausages or hamburgers can substantially increase their EF. Second, CF, WF and LU data are a global average – EU average in the case of meat CF – so a locally-adapted database should be created in order to obtain a more accurate evaluation of diet sustainability in Spain. Last, the food category description procedure used can introduce high variability when there is a change in one food item of a small food category. This is the case, for instance, of legumes and white and red and processed meat, which contain only 3 food items. When the frequency of one of the food items vary, the average value for the food category suffers a significant increase or decrease. On the other hand, there are some strengths to be highlighted in the present study. First, it analyzes 4 quantitative parameters (CF, WF, LU and price) and a qualitative one (health), which makes it very integrative. It firmly approves food frequency of consumption variations in ASPCAT recommendations for school lunchs, specially from an environmental point of view. Still, it is possible to include some improvements as aforesaid.

5. Conclusion

This study is an assessment of the environmental footprint (carbon footprint, water footprint and land use), price and healthiness evolution of recommendations for the design of school menus in the guidelines published by the Catalan Agency of Public Health. Environmental footprint and price results correspond to the production of a weekly menu for a 7-12-year-old child and do not include transport or retail phases. Healthiness instead is evaluated in a qualitative manner. For the quantitative analysis, food frequency of consumption and serving size are retrieved from the ASPCAT recommendations and environmental impact data are compiled from scientific reports. The main changes along guideline versions are in the frequency of consumption of food categories in second courses: meat, fish, eggs and plant-based protein – mainly legumes.

Animal products are the food category with the largest contribution to the total EF of the menu, so reducing their frequency of consumption conveys a significant improvement on its sustainability. In the case of water footprint and land use, the effect is smaller than in carboon footprint, maybe because of the replacement of fish, with associated water footprint and land use values of 0, by legumes. Although legumes have a relatively low EF, the overall EF of the weekly menu suffers a small increase. More research on the origin of fish and its impact on the environment is necessary in order to adequatly evaluate the sustainability of school menus and dietary patterns in general.

The changes included along guidelines are firmly approved from a sustainability and health viewpoint, but further improvements could be achieved with another modification. Meat is the less-environmentally-friendly food category, and, especially beef, has the highest EF by weight and by nutritional unit. So, by reducing the frequency of consumption of meat to once a week, red meat to once month or less, and replacing beef by pork, overall EF of the menu could still be improved.

Results of the study are aligned with other similar studies, but there is need for more research on the impact of school meals in Spain and Catalunya. The study has some limitations, such as the use of global average values instead of locally-adapted approximations, and the exclusion of some factors from the system boundaries, but it still evinces a positive trend towards a more sustainable, healthier and less expensive menu design for Catalan school menus.

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