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Trends in ultra-processed food availability and its association with diet-related non-communicable disease health indicators in the Portuguese population

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Abstract

Broad variations in dietary and physical activity patterns are part of nutritional transition concept. An additional nutritional transition has as main characteristic the change of consumption of processed foods for ultra-processed foods (UPF). This study aims to evaluate trends of UPF availability in Portuguese population and its association with diet-related non-communicable diseases (NCD) health indicators. This ecological study used data from the Household Budget Surveys conducted by the National Statistics Institute each 5 years within a national representative sample of households. The percentage of UPF was calculated based on the total daily amount of food and beverages available per capita (in grams). Data from the years 1990, 1995, 2000 and 2005 were used, which were retrieved from DAFNE-Anemos Software. NCD age-standardised mortality, prevalence and incidence were obtained from the Global Burden of Disease database, for the years 2000, 2005, 2010 and 2015. Between 1990 and 2005, the UPF availability increased from 3·9 % to 13·8 %. Over the years, almost all food and beverages categories increased the UPF availability contribution, mainly noticeable for milk, sugar, cereal and meat products. Positive correlations were observed between UPF availability and digestive diseases both in prevalence ($r = 0{\cdot}062$; $P = 0{\cdot}037$) and incidence ($r = 0{\cdot}005$; $P = 0{\cdot}010$) measures. Neoplasms incidence also showed positive correlation with UPF availability ($r = 0{\cdot}002$; $P = 0{\cdot}012$). Trends in UPF availability in Portugal increased exponentially. At the same time, there is a trend towards a decrease in unprocessed and processed food availability. The Portuguese population should be made aware of the health risks resulting from excessive consumption of UPF.

Keywords: **Ultra-processed food: Non-communicable diseases: Ecological study: Food processing: Food consumption trends**

Non-communicable diseases (NCD), as CVD, cancer, diabetes and chronic respiratory diseases, are an invisible epidemic and the leading cause of mortality in the world, killing 41 million people each year, equivalent to 71 % of all deaths globally. This epidemic situation hinders the economic development of many countries. Each year, more than 15 million people die from a NCD between the ages of 30 and 69 years; 85 % of these premature deaths occur in low- and middle-income countries. CVD account for most NCD deaths, or 17·9 million deaths annually, followed by cancer (9·3 million), respiratory diseases (4·1 million) and diabetes (1·5 million). These four groups of diseases account for over 80 % of all premature NCD deaths[1]. Unhealthy diet is one of the modifiable risk factors for the major NCD. Other NCD risk factors, such as overweight/obesity, higher blood pressure, blood sugar and cholesterol, are also linked to unhealthy diet[1].

Broad changes in dietary and physical activity patterns, obesity trends, and diet-related NCD are part of the concept of nutritional transition defined by Popkins (1993)[2]. An additional nutritional transition stage, so named by Fardet and Rock (2018)[3], is mainly characterised by the transition from 'normally processed' to ultra-processed foods (UPF).

The nutrition transition in Portugal is marked by a decrease in the adherence to the Mediterranean diet, intangible cultural heritage of humanity[4] and its replacement by a westernised diet characterised by excessive salt, sugar and fat[5–8].

Recent studies about UPF consumption in Portugal mainly focused on the last national dietary survey (2015–2016) and on specific age groups[9–13]. From these studies, it was evident that UPF consumption is a relevant issue in the Portuguese population. According to Magalhães et al.[14], UPF accounts

Abbreviations: HBS, Household Budget Surveys; INE, National Statistics Institute; NCD, non-communicable diseases; UPF, ultra-processed foods.

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for 24 % of total energetic value, which is an average value, when compared with other countries (UK: 54·3 %; Australia: 42 %)[15,16]. However, to our best knowledge, no information on UPF consumption evolution is available, as there are no studies on UPF consumption trends in Portugal.

To date, only two national dietary surveys have been performed in Portugal, a first one in 1980 and another in 2015/16 (IAN-AF)[7]. Nevertheless, they are not comparable due to the use of different methodologies. The lack of information on individual food consumption studies makes indirect assessment data, namely dietary data from the Household Budget Surveys (HBS), a possible and pertinent way to study time trends in UPF consumption among the Portuguese population. Previous studies showed the effectiveness of using these household food acquisitions data to estimate consumption trends, once HBS are periodically collected and present good correlation with individual food consumption values[17–19]. However, only two studies have analysed Portuguese HBS data to assess UPF consumption, both using the 2000 database[20,21].

A previous systematic review showed that studies on UPF food trends are still scarce and mainly focused on assessing the association with trends of overweight and obesity[22]. However, HBS data allow to monitor the variations in the share of UPF in diet over time and test how it correlates with the evolution of dietary quality and other epidemiological outcomes.

The aim of this study was to analyse trends of the UPF availability in the Portuguese population and its association with health indicators, such as mortality, prevalence and incidence of NCD.

Methods

Dietary data

This ecological study was based on Portuguese household food availability data, collected by the National Statistics Institute (INE) through the HBS that are performed every 5 years within a national representative sample of households (INE 2017)[19]. The Portuguese HBS data used in this study were obtained from the DAFNE-Anemos Software (available free of charge at http://www.hhf-greece.gr/DafnesoftWebV2/)[23]. All the existing datasets were used: years 1990, 1995, 2000 and 2005.

Dietary data retrieved from DAFNE-Anemos Software were available in eleven food categories: cereals and cereal products; meat, meat products and dishes; fish, seafood and dishes; eggs, milk and milk products; potatoes and other starchy roots, pulses and nuts; fruits; vegetables; added lipids; sugar and sugar products; non-alcoholic beverages; alcoholic beverages.

First, these data were classified according to the Nova System[24,25]. The classification was carried out by two different researchers, and disagreements were checked by a senior specialist. Foods were classified by the list of ingredients of the products. After this, the per capita total, UPF and percentual UPF household food availability was calculated, both overall and within each of the eleven DAFNE food subgroups. To better account for low or no-calorie foods[14], quantities (in grams for foods and in millilitres for beverages) rather than calories were used. Procedures were repeated separately for each one of the studied years. The mean total per capita household food availability in the years 1990, 1995, 2000 and 2005 was, respectively, 1799 g 1659 g, 1620 g and 1518 g.

Classification according to the degree of food processing

Despite the existence of other classification systems, the Nova System (Monteiro et al. 2019)[24] was chosen, as it is the most used worldwide[26] and also the most conservative in terms of classification for highly processed foods and UPF[21,27].

The Nova classification is based on the extent and purpose of the industrial processing applied to foods (Monteiro et al., 2019; Monteiro et al, 2016)[24,25]. This classification categorises foods into four groups. Group 1 includes unprocessed or minimally processed foods, which are those consumed as they were obtained in nature or that underwent industrial process with no addition of any ingredients, only to extend their shelf life or to make their preparation easier, such as drying, boiling, freezing or others. Group 2 includes processed culinary ingredients, such as sugar, oils, fats, salt and other substances extracted from foods or nature, used to cook unprocessed or minimally processed foods and to make meals or snacks. Group 3 includes processed foods, which are industrially manufactured by adding processed culinary ingredients to unprocessed or minimally processed foods, in order to increase their durability. Group 4 includes UPF. This food group is composed by industrial formulations manufactured mostly or entirely from sugar, salt, oils and fats, starches and many substances derived from foods but not normally used to cook, and additives including those used to imitate the sensory qualities of natural foods or to disguise undesirable qualities of the final product.

Health indicators

Trends in UPF availability were associated with dietary-related health indicators which are important causes of disability and premature death in Portugal, namely, neoplasm, diabetes mellitus, CVD, chronic respiratory diseases, digestive diseases and NCD in general. National data on prevalence, incidence and mortality of these diseases were used. Once the time lag between exposure to high UPF consumption and the occurrence of NCD is unknown, the arbitrary, but often applied, 10 years' period between exposure and outcome was used[28,29]. The Portuguese health indicators from 2000, 2005, 2010 and 2015 (the most recent available data considering an interval period of 5 years, as data from year 2020 were not yet available) were retrieved from the Institute for Health Metrics and Evaluation (IHME) website[30].

Comparing rates between two time periods is usually more representative when considering differences in the age structure of the two populations[31]. This is particularly important if the characteristic being observed varies by age, which is the case of NCD prevalence, incidence and mortality rates, that affect considerably more people in their later years of life than those in their younger years. It is only by removing the effect of the differing age distributions that make possible to better analyse the relative over time decreases or increases (https://www.statcan.gc.ca/en/dai/btd/asr)[32]. Age-standardised health indicators were thus used in this study.

The used mortality rates reflect the probability of dying between 15 and 60 years per 1000 population[33]. In this study, the incidence rates are expressed as the number of new cases in a year divided by the mid-year population size[30]. The prevalence used is the proportion of people in a population who are a case of a disease, in a specific period of time[30]. Overall and cause-specific NCD premature mortality, incidence and prevalence rates were obtained to correlate with UPF availability.

The values for the chosen variables were collected from the Global Burden of Disease (GBD) study[30]. The GBD is the most comprehensive global study that analyses 286 causes of death, 369 diseases and injuries, and 87 risk factors in 204 countries and territories, including data from Portugal. Led by the IHME, the GBD provides a tool to quantify health loss from diseases, injuries and risk factors. This tool can be used at the global, national and local levels to understand health trends over time. The IHME is an independent global health research centre at the University of Washington, USA, and the data are made available for download by non-commercial users[30].

Statistical analysis

Descriptive statistics were calculated for all variables. To study time trends, Spearman's correlation coefficients were computed between the age-standardised NCD mortality, prevalence and incidence rates in the years 2000, 2005, 2010 and 2015, and UPF availability in years 1990, 1995, 2000 and 2005. Spearman's correlation coefficients (r) were obtained for the global values of UPF availability with each one of the health indicators included, to assess the association between the availability of UPF and each one of the NCD indicators (dependent variables). Linear regression adjustments were used (R^2, coefficient of determination). The coefficient of determination is a statistical measure of how close the data are to the adjusted regression line. P-values were considered statistically significant at the 0·05 level. The statistical analysis was performed in IBM SPSS Statistics version 27.

Results

Time trends in ultra-processed foods

The HBS data indicated an increase trend in UPF availability in the Portuguese population. As shown in Table 1, UPF availability monotonically increased, nearly quadrupling between 1990 and 2005. Conversely, a monotonic decrease in unprocessed/minimally processed and specially processed food availability was observed during the same time period. The availability of processed culinary ingredients remained fairly constant.

Table 2 presents the percentual contribution of UPF for each food and beverages category total availability. The non-alcoholic beverages category presents the highest percentages of UPF availability. It is observed that the UPF availability of this food category increases until the year 2000 and then shows a decrease in 2005. With the exception of the vegetables and added lipids, all other food categories increased in UPF availability over the years. In 2005, the second food category with highest UPF availability were eggs, milk and milk products, as well as in 2000. In 1995 and 1990, the second food groups with the most UPF availability were added lipids and meat, meat products and dishes. Despite a still low percentage of contribution to the availability of UPF, it is important to highlight the categories of potatoes and other roots rich in starch, pulses and nuts, fish, seafood and dishes, fruits, and alcoholic beverages. There is an exponent increase in the UPF contribution in the categories of potatoes (0·14 % to 3·56 %) and fruits (1·03 % to 8·82 %).

Table 3 presents the percentual contribution of each food and beverages category for total UPF availability. It is noticeable that along time the highest contributions remain from the same categories: non-alcoholic beverages, eggs, milk and milk products, meat, meat products and dishes, and cereals and cereal products.

Table 1. Trends in food availability in Portugal, using HBS data (23) and Nova Classification System (24)

Year	Unprocessed or minimally processed food (%)	Processed culinary ingredients (%)	Processed food (%)	Ultra-processed food (%)
1990	68·0	4·1	24·0	3·9
1995	67·8	5·2	20·5	6·4
2000	66·0	4·7	19·1	10·2
2005	65·4	4·0	16·8	13·8

HBS, Household Budget Surveys.
$P < 0·001$. Percentages calculated from total per capita daily amounts of food and beverages availability (1990–1799 g, 1995–1659 g, 2000–1620 g and 2015–1518 g).

Table 2. Trends in the contribution of UPF for each food and beverages category total availability in Portugal, using HBS data (23) and Nova Classification System (24)

Food and beverages categories	Contribution of UPF for each category total availability (%), per year			
	1990	1995	2000	2005
Non-alcoholic beverages	36·92	47·81	48·65	35·85
Eggs, milk and milk products	4·30	7·09	15·31	20·75
Sugar and sugar products	1·67	7·13	8·73	17·62
Cereals and cereal products	3·39	6·82	7·14	14·70
Meat, meat products and dishes	9·79	10·06	12·34	12·95
Fruits	1·03	0·87	5·12	8·82
Added lipids	18·53	9·97	9·78	8·59
Potatoes and other starchy roots, pulses and nuts	0·14	0·89	2·08	3·56
Fish, seafood and dishes	1·74	1·76	1·09	2·81
Alcoholic beverages	1·18	1·98	2·58	2·78
Vegetables	0·03	0·08	0·04	0·00

UPF, ultra-processed foods; HBS, Household Budget Surveys.
Percentages calculated from each year total per capita daily availability amounts of each food and beverages category and thus not summing 100 %.

Trends in non-communicable diseases (mortality, prevalence and incidence)

Figure 1 shows the age-standardised NCD mortality rates trends in Portugal[30]. It is observed that over the years, the mortality rate

Table 3. Trends in the contribution of each food and beverages category for total UPF availability in Portugal, using HBS data (23) and Nova Classification System (24)

Food and beverages categories	Contribution of each category for total UPF availability (%), per year			
	1990	1995	2000	2005
Cereals and cereal products	14·32	16·35	10·00	14·49
Meat, meat products and dishes	20·09	15·42	11·90	8·86
Fish, seafood and dishes	1·87	1·40	0·54	1·00
Eggs, milk and milk products	16·10	18·12	25·87	27·23
Added lipids	10·74	5·75	3·26	1·83
Potatoes and other starchy roots, pulses and nuts	0·69	2·02	2·41	2·31
Vegetables	0·06	0·11	0·03	0·00
Fruits	3·17	1·45	6·43	8·19
Sugar and sugar products	1·04	2·29	1·59	2·06
Non-alcoholic beverages	28·69	34·51	36·04	32·86
Alcoholic beverages	3·23	2·57	1·93	1·16

UPF, ultra-processed foods; HBS, Household Budget Surveys.
Percentages calculated from total per capita daily amounts of UPF availability (1990–69·43 g, 1995–106·97 g, 2000–165·42 g and 2015–209·25 g).

for each of the NCD and NCD in general has steadily decreased until 2015. In contrast, the UPF availability constantly increases, considering a 10-year time lag between exposure (UPF availability) and outcome (NCD mortality).

Regarding to prevalence, NCD in general, diabetes, digestive diseases and neoplasms increased over the years. The prevalence of CVD has been steadily decreasing since 2000 (Fig. 2). Figure 2 shows the prevalence of NCD from the year 2000 to 2015 and compares it with trends in UPF availability in Portugal from the year 1990 to 2005.

The incidence of neoplasms and digestive diseases have increased continuously over the years. Diabetes and chronic respiratory diseases incidence maintained almost stable in the period from 2010 to 2015. The incidence of CVD has been decreasing since 2000. Incidence from NCD in general decreased until 2010, but in 2015 increased again (Fig. 3).

Table 4 summarises the information by presenting the correlations based on NCD in the years 2000, 2005, 2010 and 2015 and UPF availability in the years 1990, 1995, 2000 and 2005. A significant positive very weak correlation was observed between UPF availability and digestive diseases, both in the prevalence ($r = 0{\cdot}062$; $P = 0{\cdot}037$) and the incidence ($r = 0{\cdot}005$; $P = 0{\cdot}010$). Incidence of neoplasm also showed significant positive very weak correlation with UPF availability ($r = 0{\cdot}002$; $P = 0{\cdot}012$), while a significant negative correlation with CVD prevalence ($r = -0{\cdot}100$; $P = 0{\cdot}005$) and incidence ($r = -0{\cdot}002$; $P = 0{\cdot}042$) was observed. For mortality, all correlations were statistically significant but negative.

Discussion

The first finding of this study was the trend towards increased availability of UPF. In a space time of 15 years, UPF availability has nearly quadrupled in the Portuguese population. In agreement with this, a global study that analysed worldwide trends and patterns in the UPF consumption using per capita market sales data found a substantial expansion in the types and quantities of UPF and beverages available in the world's food supply. This evidences that a transition towards a more highly processed global diet is quickly underway[34]. Another trend study evaluating UPF consumption in the USA highlighted the high consumption of UPF in all parts of the US population, demonstrating that intake has continuously increased over the last two decades[35].

At the same time that trends in UPF availability increase in Portugal, the availability of unprocessed or minimally processed and processed foods decreases. Similar results were found in a trend study in Canada. Using HBS dietary data, they verified that the most important change in Canadian dietary patterns between 1938 and 2011 was the replacement of unprocessed or minimally processed foods and culinary ingredients used in the preparation of meals by UPF[36]. Another study using HBS data from Argentina observed trends consistent with those of the present study. They found an increase over time in the proportion of energy and critical nutrients coming from UPF, along with a decrease in unprocessed or minimally processed foods, culinary ingredients and processed foods[37].

Although the contribution for the total UPF availability remains coming mainly from the same categories (non-alcoholic beverages, eggs, milk and milk products, meat, meat products and dishes, and cereals and cereal products) along time, increased trends in the contribution of UPF within most categories were observed. Analysing each food category separately, there was a strong increasing trend in the availability of UPF within egg and milk products, sugar products, cereal products, and meat products. Following these same trends, a recent study using individual dietary intake data from Portuguese population (IAN-AF 2015/16) verified that the most common consumption from UPF among adults were yogurts and milk-based drinks, sausage and other reconstituted meat products, industrial cakes and desserts and industrial breads and toasts. These products added to packaged sweet snacks and soft drinks and sugar-sweetened beverages accounted for approximately 70 % of dietary energy originated from UPF in Portuguese adults and old people[11]. Another study, using Portuguese individual dietary data, associated factors with UPF consumption and showed yogurts were the main source of UPF in individuals of higher education levels. In the lower level of education, cold meats and sausages and soft drinks were highlighted[14].

The so-called double burden of disease, the growth of NCD simultaneously with the increase in malnutrition due to micronutrient deficiencies, is often associated with nutrition transition, a change from the local traditional diet towards a higher availability of UPF[38]. This study uses NCD mortality, incidence and prevalence data available from GBD to analyse the correlation between UPF availability and health outcomes. The findings reported an increasing trend in the prevalence of NCD in general, and in the prevalence and incidence of diseases such as cancer, digestive diseases, and diabetes, accompanying trends in UPF availability. On the other hand, this study shows mortality from CVD, and all NCD have decreased over time[39,40]. The decrease trend in mortality from CVD is shown in a recent WHO report, from 2000 to 2019. In the same period, deaths from diabetes increased slightly[41].

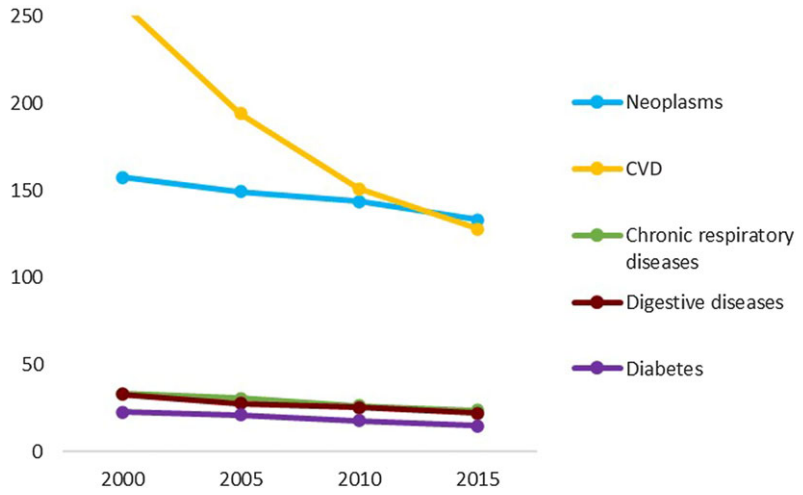

Fig. 1. NCD mortality rates (probability of dying per 1000 population) in Portugal, from 2000 to 2015. NCD, non-communicable diseases.

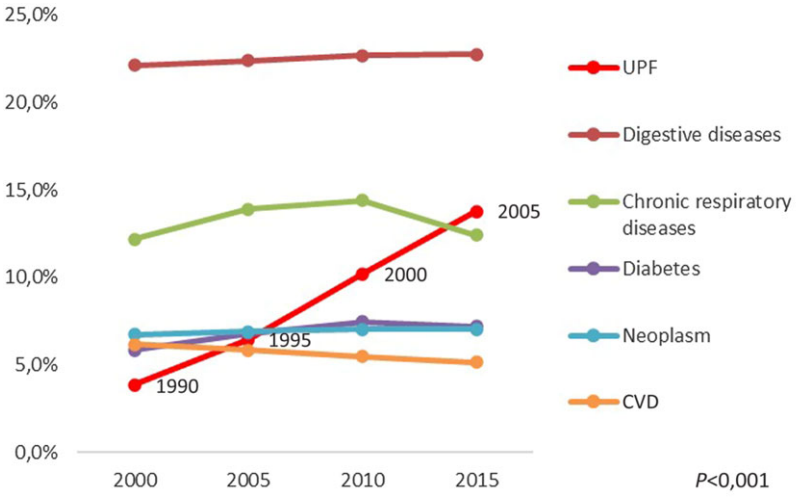

Fig. 2. NCD prevalence (age-standardised) in Portugal, from 2000 to 2015, and UPF availability increase in Portugal from 1990 to 2005. NCD, non-communicable diseases; UPF, ultra-processed foods.

Several studies have investigated the association between the consumption of UPF and health status[42]. A cohort study of 44 551 French adults verified that a 10 % increase in the proportion of UPF consumption was significantly associated with a 14 % higher risk of all-cause mortality[43]. A study of Spanish workers concluded that those who consumed the highest amount of UPF were twice as likely to have coronary atherosclerosis, regardless of blood lipids, hypertension, BMI and other cardiovascular risk factor[44]. Another study found a positive association between globally increasing per capita volume sales of UPF and adult BMI trajectories[45].

In the present study, negative correlations were found between the increase in the availability of UPF and mortality from all NCD, as well as for the prevalence and incidence of CVD. A prospective study with a representative sample of US adults observed no association with CVD mortality[46]. Despite the studies tending towards a similar result, this is an ecological study in which inferences should not be made at the individual level[47].

Furthermore, the negative impact of UPF is not only associated with NCD but has recently been associated on diet water footprint[48]. Dietary patterns worldwide are becoming potentially harmful to human and planetary health. A recent time-series study using data from Brazilian HBS verified that the environmental effects of the Brazilian diet have increased over the past three decades along with increased effects from UPF[49]. Once 'Food is the single strongest lever to optimise human health and environmental sustainability on Earth', it is also of utmost relevance to emphasise that the reduction of highly processed foods is among the measures pointed out to promote sustainable food systems[50].

The limitations and strengths of the present study should be considered.

Because the data available in DAFNE-Anemos Software only include information from 1990 to 2005, and the INE does not allow the use of detailed food and beverages information, the most recent HBS surveys (2010, 2015 and 2020) could not be used, and thus only four points in time were included in this

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Table 4. Correlations between prevalence, incidence and mortality rate of NCD and UPF availability in Portugal

	Prevalence			Incidence			Mortality		
NCD correlation with UPF availability	r	p	R^2	r	p	R^2	r	p	R^2
NCD in general	0·023	0·069	0·866	–0·022	0·322	0·459	**–1·000**	**0·022**	0·956
Neoplasms	0·030	0·103	0·804	**0·002**	**0·012**	0·976	**–1·000**	**0·010**	0·979
CVD	**–0·100**	**0·005**	0·990	**–0·002**	**0·042**	0·918	**–1·000**	**0·039**	0·924
Diabetes mellitus	0·137	0·116	0·696	0·001	0·175	0·680	**–1·000**	**< 0·001**	0·999
Chronic respiratory diseases	0·018	0·928	0·005	0·001	0·643	0·127	**–1·000**	**0·004**	0·992
Digestive diseases	**0·062**	**0·037**	0·928	**0·005**	**0·010**	0·980	**–1·000**	**0·029**	0·942

NCD, non-communicable diseases; UPF, ultra-processed foods.
r, Spearman's correlation coefficient; p, significance; R^2, coefficient of determination.
The use of boldface was to highlight values with statistical significance.

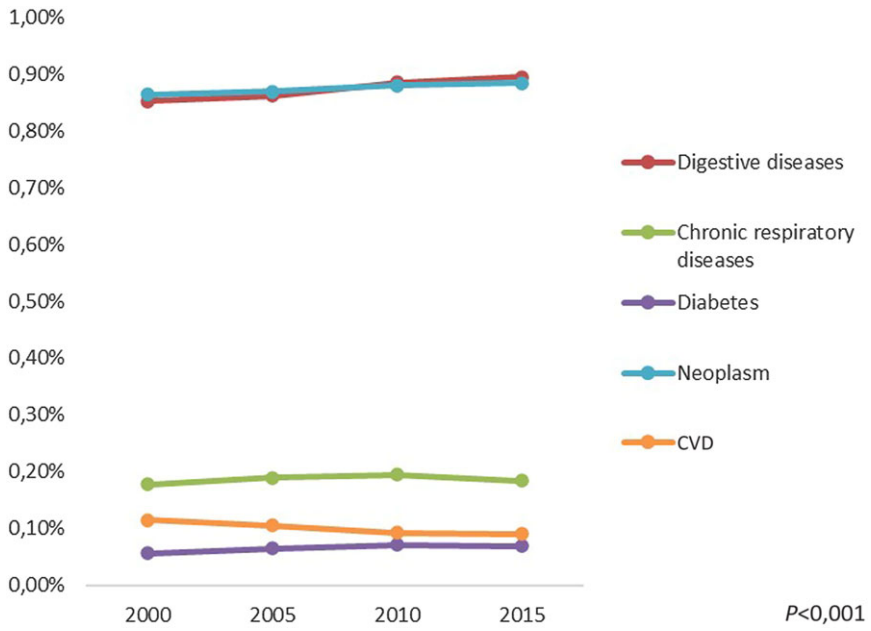

Fig. 3. NCD incidence (age-standardised) in Portugal, from 2000 to 2015. NCD, non-communicable diseases; UPF, ultra-processed foods.

study. However, even if included, the most recent data would not be possible to analyse with NCD outcomes, once so much recent data are not yet available and the 10 years' time interval used was not possible to achieve. In addition, as being an indirect measure, HBS captures only food acquired for consumption at home but not food consumption itself, which might underestimate or overestimate food consumption. Despite of that, in Portugal, HBS are the only periodically collected data that would allow for over time dietary monitoring. Not accounting for other factors, such as household income or health expenditures, for example, that might influence health indicators and thus the association with UPF availability, is also another limitation. As an ecological study, results have to be cautiously interpreted due to the possibility of ecological fallacy. For this reason, associations identified at group level data should not be assumed to be true for individuals[47,51,52]. Even tough, results have the capacity to highlight for the relevance of the subject and might pose hypothesis for further analysis.

The correlations do not account for potential confounding, and this may be a limitation of the study. Despite this, the results showed the alarm trends in UPF availability in Portugal.

Yet, it should be noted that the dietary information used was data collected by INE and national representative. As far as we know, this is the first study on trends in UPF consumption in the Portuguese population. Few studies compared UPF trends with NCD, and even fewer performed the analysis of UPF trends in food and beverages categories[22]. Finally, although UPF trends in Portugal are still low compared with other countries[15,16], the trend over the years is worrying, which emphasises the need for monitoring diet quality and should be taken into account by health educators and policymakers[53,54].

Conclusions

Trends in UPF availability in Portugal grow exponentially. At the same time, there is a trend towards a decrease in unprocessed and home-prepared foods. The trends in prevalence and

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incidence from neoplasms and digestive diseases, although presenting very week correlations, followed trends in UPF availability.

To monitor diet quality, and UPF in particular, is of utmost relevance in Portugal. Public policies should consider this fact and promote action in order to mitigate the increase in the availability and consumption of UPF and to alert the population about the harm to health arising from its excessive consumption.

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The authors declare that there are no conflicts of interest.

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