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Changes in UK price disparities between healthy and less healthy foods over 10 years: An updated analysis with insights in the context of inflationary increases in the cost-of-living from 2021

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A R T I C L E I N F O

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Price increase

A B S T R A C T

Food prices and affordability play an important role in influencing dietary choices, which in turn have implications for public health. With inflationary increases in the cost-of-living in the UK since 2021, understanding the dynamics of food prices becomes increasingly important. In this longitudinal study, we aimed to examine changes in food prices from 2013 to 2023 by food group and by food healthiness. We established a dataset spanning the years 2013–2023 by combining price data from the UK Consumer Price Index for food and beverage items with nutrient and food data from the UK nutrient databank and UK Department of Health & Social Care's National Diet and Nutrition Survey data. We calculated the price (£/100 kcal) for each food item by year as well as before and during the period of inflationary pressure, and classified items into food groups according to the UK Eatwell Guide and as either "more healthy" or "less healthy" using the UK nutrient profiling score model. In 2023, *bread, rice, potatoes and pasta* was cheapest (£0.12/100 kcal) and *fruit and vegetables* most expensive (£1.01/100 kcal). Less healthy food was cheaper than more healthy food (£0.33/100 kcal versus £0.81/100 kcal). Before the inflationary pressure period (from 2013 to late 2021), the price of foods decreased by 3%. After this period, the price of food increased by 22%: relative increases were highest in the food group *milk and dairy food* (31%) and less healthy category (26%). While healthier foods saw smaller relative price increases since 2021, they remain more expensive, potentially exacerbating dietary inequalities. Policy responses should ensure food affordability and mitigate price disparities via, for example, healthy food subsidies.

1. Introduction

Overall dietary quality is constrained by the range, affordability, and acceptability of foods available for purchasing (Lee et al., 2011). Food environments where healthy foods such as fruits and vegetables are hard to access, more expensive and have a lower quality contribute to higher rates of diet-related non-communicable diseases such as type 2 diabetes (Afshin et al., 2019; Russell et al., 2022). The United Kingdom (UK) Eatwell Guide is a representation of dietary recommendations provided by the UK Department of Health & Social Care, and is designed to help people make healthier food choices and achieve a balanced diet (Buttriss, 2016). The majority of adults from the UK do not adhere to the recommended dietary guidelines for healthy eating (Public Health England). For instance, while the Eatwell Guide recommends that adults consume at least 5 portions of fruit and vegetables per day (Buttriss, 2016), data from 2018 suggests that only 28% of the UK population achieved this (NHS Digital).

The price of food and beverages (hereafter referred to as food) plays an important role in shaping dietary choices (Glanz et al., 1998), and the

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Abbreviations

CPI	Consumer price index
F&V	Fruit and vegetables
HFS	High in fat and/or sugar
NDNS	National Diet and Nutrition Survey
Q	Quarter

price of healthier foods can limit the adoption of healthier eating habits (Pechey & Monsivais, 2016). A systematic review has shed light on a universal trend, revealing that healthier dietary patterns can cost up to £1.20/day (US$1.50) more than less healthy dietary patterns (Rao et al., 2013). Similar findings have also been reported in the UK (Jones et al., 2014, 2018). In 2014, a study linked UK Consumer Price Index (CPI) and nutrition surveillance data to investigate changes in food prices between 2002 and 2012 (Jones et al., 2014). This study found that the mean price of food high in fat and/or sugar (as defined by the UK Eatwell Guide) was £0.31/100 kcal in 2012, while the price of fruits and vegetables was £0.91/100 kcal (Jones et al., 2014). It also reported that all prices had risen between 2002 and 2012, but some Eatwell Guide food groups (e.g. protein foods) experienced a higher price increase compared to others (e.g. grains); and prices of more healthy foods grew faster than those of less healthy foods based on nutrient profiles (Jones et al., 2014).

Since the publication of this aforementioned study (Jones et al., 2014), several developments have occurred in the UK that may have differentially impacted the price of foods. The introduction of the Soft Drinks Industry Levy (SDIL) in 2018 led to a slight increase in the price of sugary drinks (Scarborough et al., 2020). The withdrawal of the UK from the European Union (Brexit) and, perhaps most importantly, increases in the cost-of-living beginning in late 2021 (often referred to as the 'cost of living crisis' characterised by a decrease in real disposable income as a result of high inflation rates) have also been reported as impacting food prices. Indeed, a recent report found that between December 2019 and March 2023, food prices rose by almost 25 percentage points, with Brexit contributing an estimated 8 percentage points to this rise (Bakker et al., 2023). It is currently unknown if the recent increases in the price of food have differentially affected different food groups as well as more healthy and less healthy food.

The rising cost of food may lead to increased levels of food insecurity by limiting access to healthy and nutritious foods. In 2014, approximately 8.4 million people, representing 13% of the UK population, reported experiencing food insecurity in the past year (Taylor & Loopstra, 2016). This increased to 24% in January 2023, amid the UK's inflationary pressure period (Food Foundation). Such an increase in households reporting food insecurity is alarming given that food insecurity is associated with a range of negative health outcomes such as obesity, cardiovascular disease and stress (Eskandari et al., 2022; Liu & Eicher-Miller, 2021; Pourmotabbed et al., 2020).

In this longitudinal study, our aim was to build upon and update previous research in the UK (Jones et al., 2014) by examining changes in food prices between 2013 and 2023 overall, by Eatwell Guide food groups (Buttriss, 2016) and by healthiness category as determined by the UK government's nutrient profiling model (Rayner et al., 2009). Additionally, we aimed to assess the impact exerted by the UK's period of inflationary pressure on food prices.

2. Methods

This longitudinal study is an updated analysis using the same methodology described previously (Jones et al., 2014). We sourced and linked food price and nutrition data from two separate and publicly available databases. We converted prices to a price per unit of energy metric (£/100 kcal) and categorised food items using the nutrient profiling model used by the UK government to identify and restrict marketing of less healthy foods and also by the five Eatwell food groups. Finally, we compared the prices of these food groups in the first quarter of 2023 and examined the change in price since the first quarter of 2013. We used the price per unit of energy metric over other metrics (i.e. per portion or mass), as it has been argued that price per unit energy best addresses questions of public health and nutrition in terms of the sustenance that foods can contribute (Jones & Monsivais, 2016). Fig. 1 describes the process by which we calculated the price per unit of energy for CPI food items. We relied on publicly available data that was not collected from human or animal participants, and therefore did not require ethics approval.

2.1. Food item list

In the UK, the government uses CPI to measure inflation. The CPI is based on a basket of goods representative of the population's spending patterns (e.g. 'windscreen wiper blades', 'car tyre' and 'tea bags'), whose prices are measured nationwide from various locations on a monthly basis. The content of the basket is updated annually to represent the latest consumer spending patterns determined by market research data. Data on the content and price of the basket items can be found on the Office for National Statistics website (Office for National Statistics, 2023a). For the current study, we included all food items from the CPI basket and excluded those that involved any service element (e.g., a beer in a pub) as it was not possible to separate the cost of the service from that of the food. We also excluded food items from the basket that were not plausible sources of dietary energy (e.g., ground coffee, tea bags and bottled water). In 2023, a total of n = 190 food items remained after these inclusions. In the main analyses, we only considered food items that remained in the CPI basket during the entire study period (2013–2023) to enable a meaningful comparison of price development over time (n = 114). In sensitivity analyses, we also considered food items specific to the annual CPI baskets. For example, the CPI food item 'fresh veg-cauliflower-each' was included in main analyses as this food item could be found in CPI baskets from 2013 to 2023, while the CPI item 'melon each e.g. honeydew' was only included in 2023 and therefore was not included in main analyses but was included in sensitivity analyses.

2.2. Food price data

We calculated the median per unit price for each food item in each quarter between 2013 and 2023. If in any given quarter, no price data were collected but price data were available in subsequent quarters, the prices of the last quarter were carried forward for a maximum of two consecutive missing quarters. This was the case for all food items the first two quarters of 2019 and one food item in the first quarter of 2021.

2.3. Data sources used to calculate the price per unit energy

Similar to the previous study (Jones et al., 2014), we used the price metric £/kcal to calculate the price of food. However, we expressed it as £/100 kcal (rather than £/1000 kcal) for comparability with other price metrics used in sensitivity analyses (details in section 2.5.1). In order to calculate £/100 kcal, we linked price information to newly collected information from four sources on 1) food item weight, 2) yield factor, 3) energy content, and 4) nutrient content, as described below. While nutrient information was not directly used for the calculation of the price per unit energy metric, this information was included as it was necessary for the categorisation of food items as 'more healthy' and 'less healthy' described below.

2.3.1. Food item weight

To calculate £/100 kcal, we first calculated the price per 100 g (£/100 g). We first identified extracted information on the weight of

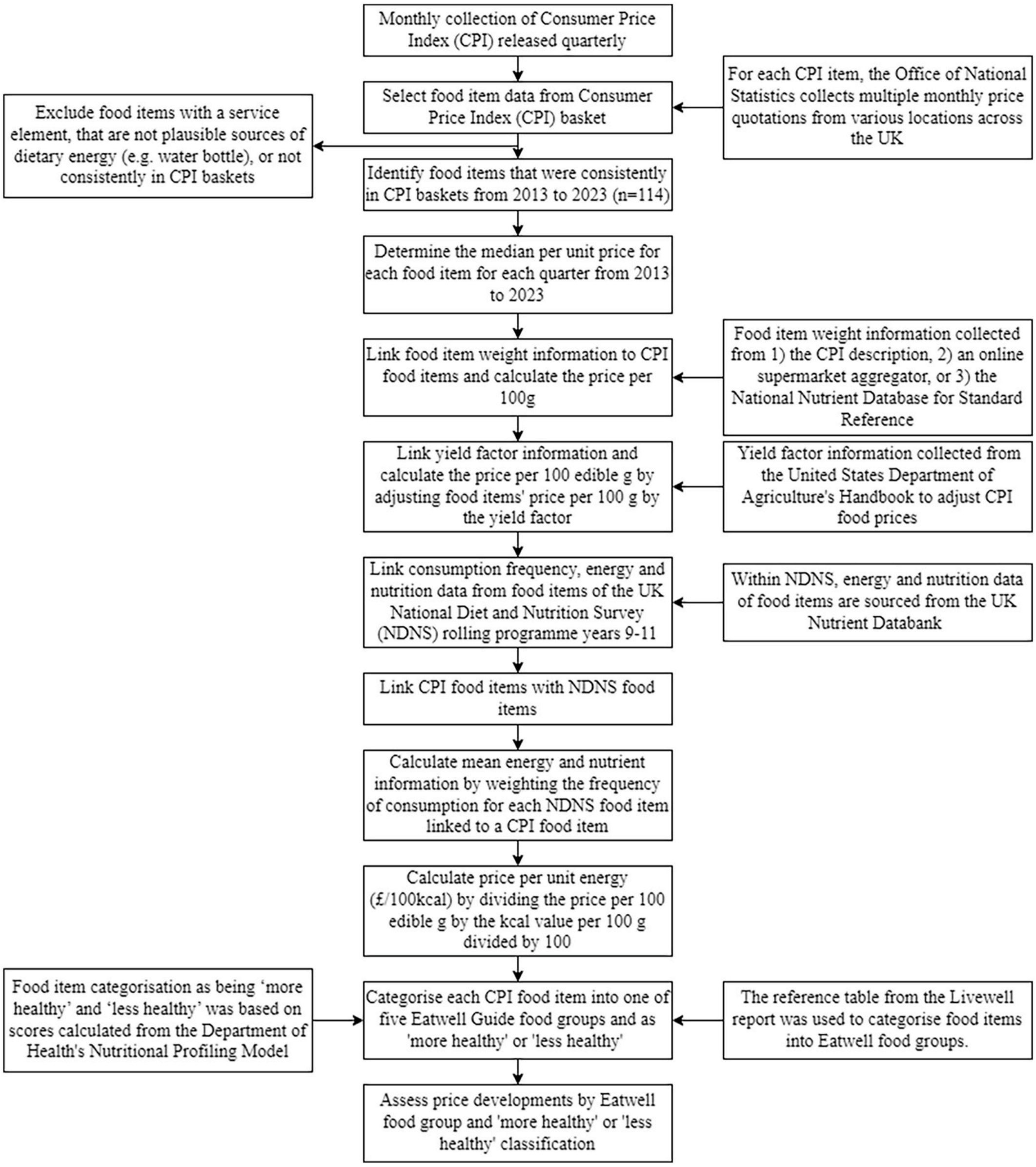

Fig. 1. Flow of steps used to calculate the price per unit of energy for CPI food items.

each food item from the CPI dataset. Price data corresponding to the food-based CPI items were per unit prices (e.g. the price of one pineapple as purchased from a supermarket). If the purchase weight (e.g. 'grapes per kg') was not available from the CPI food name description, two approaches were considered. For packaged products, we inferred food item weight by searching an online supermarket aggregator (Trolley) and selecting relevant items with prices closest to the 2023 food price data. For fresh foods with variable weights (e.g. pineapples), we used the National Nutrient Database for Standard Reference (a source of food composition data in the United States (US Department of Agriculture)) to collect food item weight information as, as far as we are aware, no UK data was available.

2.3.2. Adjustment for yield factor

As the prices included in CPI represent data on foods as purchased and the database used for calorie information list this for foods as consumed, all CPI food prices were adjusted for a yield factor (i.e. adjusted for preparation and waste) to account for the disparity between the two datasets. For example, while the purchased weight of pineapple is 900 g, approximately half of a pineapple is wasted in preparation resulting in a yield factor of 0.5. Cooking may also mean the purchased and consumed weights differ. Given the absence of UK-specific sources, the yield factor for each CPI food item was sourced from the United States Department of Agriculture's Handbook (United States Department of Agriculture, 1975). If the yield factor could not be identified from this Handbook, the Dutch 'Maten Gewichten en Codenummers 2003' was used (Donders-Engelen et al., 2003). The edible mass of CPI food items was calculated by multiplying the yield factor by food item weight. Then, the price per 100 edible g (£/100 edible g) was calculated by dividing the median price of the CPI food item by its edible mass.

2.3.3. Energy and nutrition information

We obtained energy information to transform the price per 100 edible g to price per unit energy (£/kcal). We sourced energy and nutrition information data from the UK National Diet and Nutrition Survey (NDNS) rolling programme for years 9–11 (2016–2019) (UK Data Service). These years were selected because they were collected during the midpoint of the analysis period (2013–2023), and more recent data were not available. NDNS years 9–11 data comprised a list of 5927 food items, consumption frequency, and linked nutrient information collected from the UK Nutrient Databank (Amoutzopoulos et al., 2022). The following information was extracted: consumption frequency, kilocalorie, saturated fat, total sugar, sodium, fruit content, vegetable content, nut content, fibre and protein per 100 g/100 ml. As explained below, consumption frequency and kilocalorie information was used to calculate £/100 kcal, and all other information was used to categorise food items as 'more healthy' and 'less healthy'.

2.3.4. Linking process

We determined the most appropriate NDNS food items for each CPI food item. In the majority of cases, multiple NDNS food items could be matched to one CPI food item due to the broad description of CPI food items and range of food preparation methods used in NDNS food item descriptions. To account for this, we calculated the weighted mean energy and nutrient content of each CPI food item based on frequency of consumption of all NDNS food items that could plausibly be linked. For example, the NDNS food items 'garlic (& herb) bread' and 'garlic bread lower fat' were both linked to the CPI item 'chilled garlic bread'. As 'garlic (& herb) bread' was consumed more often than 'garlic bread lower fat' (102 versus 6 times), the energy and nutrient information for the CPI item 'chilled garlic bread' was more similar to that of 'garlic (& herb) bread' than 'garlic bread lower fat' from the NDNS dataset.

2.3.5. Calculation of price per unit energy

After calculating £/100 edible g, the £/100 kcal of CPI food items was calculated as: £/100 edible g divided by kcal/100 edible g divided by 100.

2.4. Food group classification

In order to assess price development by food group, we classified all food items into one of the five Eatwell categories. The 'healthiness' of food items was also categorised as "more healthy" or "less healthy" using the Nutrient Profiling Model.

2.4.1. Eatwell Guide food group classification

We categorised each food item into one of five groups defined by the Eatwell Guide (Buttriss, 2016). The five groups included bread, rice, potatoes and pasta (grains); fruit and vegetables (F&V); milk and dairy foods (dairy); meat, fish, eggs, beans and other sources of protein (proteins); and food and drinks high in fat and/or sugar (high in fat and/or sugar; HFS). We relied on a reference table from the Livewell report (Macdiarmid et al., 2011) to match CPI food items to Eatwell Guide food groups (hereafter referred to as Eatwell food groups).

2.4.2. Classification of food healthiness

We also categorised each food item as 'more healthy' and 'less healthy' based on scores calculated from Department of Health & Social Care's Nutrient Profiling Model (hereafter referred to as healthiness categories) (Rayner et al., 2009). This model assigns a score based on levels of energy, saturated fat, total sugar, sodium, fibre, protein, and fruit, vegetable, and nut content per 100 g. Points from 0 to 10 were assigned for energy, saturated fat, total sugar, and sodium (i.e. less healthy nutrients), with higher levels receiving more points. Conversely, 0 to 5 points were awarded for the presence of fibre, protein, and the percentage of fruits, vegetables, and nuts (i.e. more healthy nutrients and food groups). The final nutrient profile score was calculated by subtracting the points for healthier nutrients from those for less healthy nutrients. As per the guidance, higher scores represent less healthiness and *food* was classified as 'less healthy' if the overall score was 4 points or more, while *beverages* were classified as 'less healthy' if the score was 1 point or more (Department of Health, 2011). These cut-offs are used in policy settings to determine for example what foods can be advertised on television to children.

2.5. Statistical analyses

We used descriptive statistics to characterise the price of food and its variation over time by quarter (absolute and relative change), overall, by Eatwell food group and by healthiness category. We report these descriptive statistics for the entire study period (2013–2023) and for the period before and during the inflationary pressure period (starting in the fourth quarter of 2021 (Hourston, 2022; Office for National Statistics, 2023b)).

We employed Analysis of Variance (ANOVA) models to evaluate differences in food item prices for the first quarter of 2023 by Eatwell food groups or healthiness category. Food item prices (£/100 kcal) served as our dependent variable, and the independent variable was the Eatwell food group or healthiness category. Subsequently, we used repeated measures ANOVA to investigate the presence of significant price fluctuations over a decade (2013–2023), both across the entire spectrum of food items and within each specific Eatwell food group and healthiness category. Here, time functioned as the independent variable, while food item price was the dependent measure.

Further, to explore whether the development of food prices (dependent variable) over time differed across Eatwell food groups or healthiness categories (independent variables), we implemented linear mixed-effects models with a random intercept for food items. We integrated interaction terms between time and Eatwell food groups (varying the reference group to be able to assess differences between all food groups), as well as between time and healthiness category. This analysis was further stratified into the pre-inflationary period (quarter 1 of 2013 to quarter 3 of 2021) and the inflationary period (quarter 4 of 2021 to quarter 1 of 2023).

After inspection, outliers based on the median price in the first quarter of 2023 ± 3SD were excluded (i.e. chewing gum and mushrooms), leading to a total of $n = 112$ food items that have been in the CPI basket throughout the study period. All analyses were conducted in R (version 4.1.2 for Windows) (Panter & Ogilvie, 2015) and statistical significance was set at an alpha level of 0.05.

2.5.1. Sensitivity analyses

Sensitivity analyses were conducted not excluding outliers based on the median price in the first quarter of 2023, as well as including all CPI food items (i.e. not just those continuously in the CPI basket throughout the study period). Furthermore, given discussions surrounding which price metric to use (Jones & Monsivais, 2016), we included two other commonly used price metrics; £/100 edible g and price per portion size (£/portion). £/100 edible g was calculated as above. As elsewhere (Donders-Engelen et al., 2003), the £/portion was calculated by multiplying the edible g of the average portion of CPI food items (in 100 g) by £/100 edible g. The average portion of CPI food items was calculated using NDNS food consumption data.

3. Results

3.1. Overall food price trends over time

In the first quarter (Q1) of 2023, the average price of all foods included in the CPI basket was £0.63/100 kcal (Table 1 and Fig. 2). Throughout the study period (from Q1 2013 to Q1 2023), there was an overall increase of 20% (£0.07/100 kcal) in the mean price of all foods within our sample (Table 1). However, this increase was not uniform across time (Table 1 and Fig. 2). From Q1 2013 to Q3 2021, there was a 3% decrease in the price of all foods. Conversely, from Q4 2021 to Q1 2023, the mean price of all foods increased by 22% (Table 1). Analysis revealed a statistically significant increase in price from Q1 2013 to Q1 2023 ($F (40,4520) = 7.8$, $p < 0.001$).

Table 1
Mean price of food (£/100 kcal) in 2013 and 2023 and the absolute and relative changes in price between 2013 and 2023 for n = 112 food items over the study period, by Eatwell food group and healthiness category.

	All foods	Bread, rice, potatoes and pasta (grains)	Fruit and vegetables (F&V)	Milk and dairy foods (dairy)	Meat, fish, eggs, beans and other sources of protein (protein)	Food & drinks high in fat and/or sugar (HFS)	Less healthy[a]	More healthy[a]
2013 Q1 mean price in £/100 kcal (SD)	0.56 (0.68)	0.12 (0.13)	0.99 (0.99)	0.45 (0.67)	0.64 (0.47)	0.31 (0.31)	0.26 (0.22)	0.74 (0.79)
2023 Q1 mean price in £/100 kcal (SD)	0.63 (0.70)	0.12 (0.12)	1.01 (0.90)	0.54 (0.77)	0.79 (0.64)	0.38 (0.40)	0.33 (0.30)	0.81 (0.81)
Mean relative change in price in %								
2013 Q1 – 2023 Q1	20	6	7	27	26	30	32	14
Before inflationary pressure	−3	−15	−11	−5	3	5	5	−7
During inflationary pressure	22	22	16	31	22	25	26	20
Mean absolute change in price in £/100 kcal								
2013 Q1 – 2023 Q1	0.07	0.00	0.02	0.09	0.16	0.07	0.07	0.07
Before inflationary pressure	−0.05	−0.02	−0.19	−0.04	0.02	0.01	0.01	−0.08
During inflationary pressure	0.10	0.02	0.16	0.10	0.13	0.06	0.07	0.13

Abbreviations: Q = Quarter.
Before inflationary pressure period is from Q1 of 2013 to Q3 of 2021, and during inflationary pressure period is from Q4 of 2021 to Q1 of 2023.
[a] Foods were classified as 'less healthy' if the overall score was ≥4 points, while beverages were classified as 'less healthy' if the score was ≥1 point.

3.2. Price differences by Eatwell food group

In Q1 of 2023, there was a statistically significant difference in mean prices by Eatwell food groups ($F(4,109) = 6.04$, $p < 0.001$). Grains had the lowest mean price at £0.12/100 kcal, while F&V had the highest mean price at £1.01/100 kcal (Table 1). The price of F&V increased the least in relative terms (7%), while the price of HFS foods increased the most (30%) between Q1 2013 and Q1 2023. In absolute terms, the price of grains increased the least (£0.00/100 kcal), while the price of proteins increased the most (£0.16/100 kcal).

When examining trends over the period before the start of the inflationary pressure, dairy, F&V, and grains showed a decrease in price. In this same period, proteins and HFS had a slight increase in price (Table 1). During the inflationary pressure period, all five food groups exhibited an increase in price. Dairy showed the highest mean increase in relative price at 31% and F&V the lowest at 16%. In absolute terms, the price of F&V increased the most (£0.16/100 kcal), while the price of grains increased the least (£0.02/100 kcal).

Fig. 3 illustrates a clear ordering of prices among the Eatwell food groups throughout the 11-year study period, with F&V consistently having the highest price and grains the lowest price per 100 kcal in every quarter of every year studied. Fig. 3 also provides insight into the price variations of the Eatwell food groups over time. The price of grains remained relatively constant throughout the study period, while the price of F&V exhibited the most volatility (Fig. 3). Indeed, all food groups showed statistically significant changes over time, except for grains. As the higher price of F&V may obscure some of the trends of cheaper and more stable food groups when displayed on the same scale, Supplementary Fig. S1 displays the price trends by Eatwell food group in separate panels. While the price variation of grains appear less stable than in Fig. 3, price variations only took place on a scale of £0.02/100 kcal (Supplementary Fig. S1).

Interaction terms in models comparing the price development over time during the 11-year study period by Eatwell food groups, showed that the price trend of HFS and protein was statistically significantly different from all other food groups (Supplementary Table S1). Differences between the food groups F&V, dairy and grains were not statistically significant as they all exhibited an initial decrease in price, with a subsequent increase during the inflationary pressure period (Fig. 3). Before the inflationary pressure period, F&V demonstrated the greatest decrease in price. Furthermore, the price trend of dairy differed statistically significantly from proteins and HFS. During the inflationary pressure period, there was a more pronounced price increase trend for F&V and proteins relative to grains. Moreover, the positive price trend for F&V and proteins exceeded that of HFS. No other statistically significant differences in price trends were found.

3.3. Price differences by healthiness category

In Q1 of 2023, the average price of 'less healthy' foods was £0.33/100 kcal compared to £0.81/100 kcal for 'more healthy' foods (Table 1). This difference was statistically significant ($F(1,112) = 14.48$, $p < 0.001$). The absolute price increase between Q1 of 2013 and Q1 of 2023 was the same for 'less healthy' and 'more healthy' food (i.e. £0.07/100 kcal). However, relative price increases of 'less healthy' food (32%) was more than twice that of 'more healthy' food (14%). Price trends differed over the study period: before the inflationary pressure period, the price of 'more healthy' food fell by 7% while that of 'less healthy' food increased by 5%. While the absolute price increase was larger for 'more healthy' food during the inflationary pressure period, the relative price increase of 'less healthy' food was larger than that of 'more healthy' food (26% versus 20%).

Fig. 4 shows that 'more healthy' foods consistently had a higher price than 'less healthy' foods throughout the study period. When the price trend of healthiness categories are displayed on separate panels (Supplementary Fig. S2), a clear U-shaped trend in price is seen for 'more

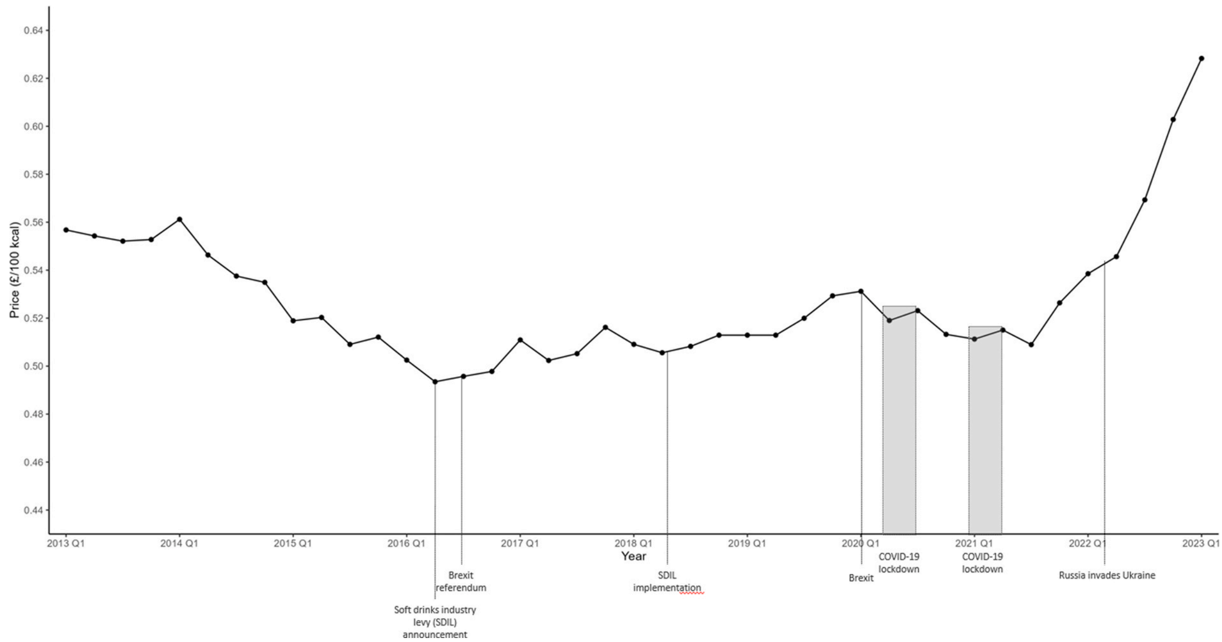

Fig. 2. Mean price of foods (£/100 kcal) from 2013 to 2023.

healthy' food, whereas the price of 'less healthy' food was more stable until the inflationary pressure period. The price trends of both 'more healthy' and 'less healthy' foods differed statistically significantly over time (Supplementary Table S2). During the entire study period, the price trend of 'less healthy' food showed a greater positive price trend than 'more healthy' food (Fig. 4). Furthermore, the price trend of 'less healthy' food showed a greater increase before, but a smaller increase during the inflationary pressure period compared to 'more healthy' food.

3.4. Sensitivity analyses

The sensitivity analyses where we did not exclude CPI food item outliers, revealed slightly higher mean prices over time for various food groups and healthiness categories, with trends largely mirroring primary analyses (Supplementary Figs. S3 and S4). Similarly, the trends in our sensitivity analyses including all food items from the CPI basket at any point in the study period yielded similar results to primary analyses (Supplementary Table S3), though with some noted discrepancies in the 2013–2016 pricing trends for the F&V food group (Supplementary Fig. S5) and price of 'less healthy' and 'more healthy' food categories (Supplementary Fig. S6).

Finally, we observed that the choice of price metric had some impact on the results. While grains remained one of the least expensive by mass (£0.34/100 edible g) and portion (£0.25/portion) compared to other food groups, the price of F&V was the second least expensive food group by mass and the least expensive by portion (Supplementary Table S4 and Supplementary Figs. S7 and S8). Furthermore, 'more healthy' foods

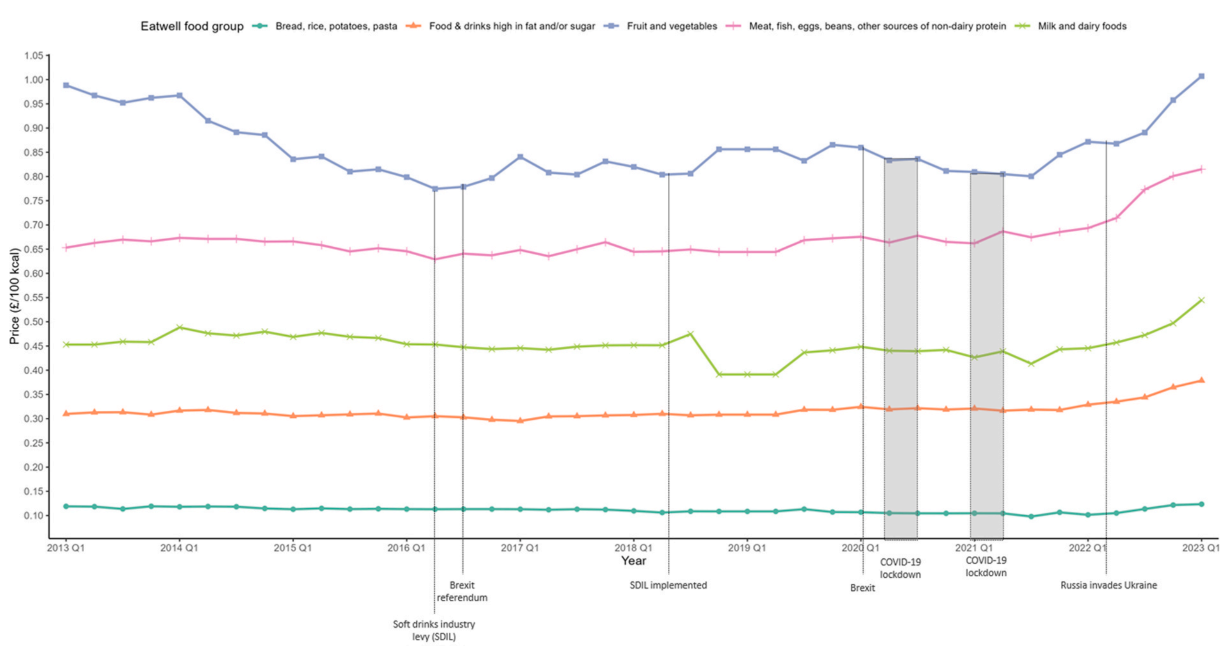

Fig. 3. Mean price of foods (£/100 kcal) by Eatwell food group per quarter from 2013 to 2023.

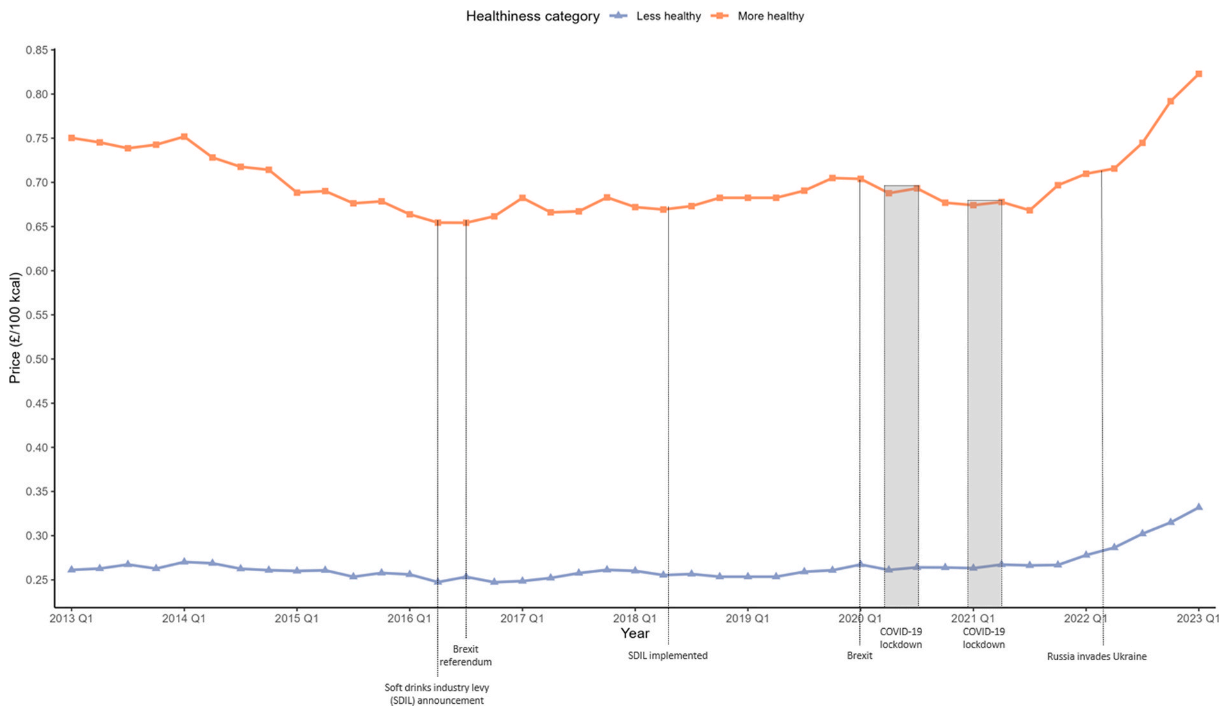

Fig. 4. Mean price of foods (£/100 kcal) by healthiness category per quarter from 2013 to 2023.

were more costly compared to 'less healthy' foods using the price metrics by energy and portion, but 'less healthy' foods were more expensive by mass (Supplementary Table S4 and Supplementary Figs. S9 and S10). The two alternative price metrics gave similar results for the price trends over time as the main analysis (Supplementary Figs. S9 and S10).

4. Discussion

The current longitudinal study is the first to assess food price developments by food group and healthiness category during the UK's inflationary pressure period. Our results demonstrated that the average price of food items from CPI baskets increased by 20% over the past 11 years (from 2013 to 2023), with significant differences in trends by time period, food group and healthiness category. Before the inflationary pressure period (from Q1 of 2013 to Q3 of 2021), there was a small decrease in food prices overall. Unsurprisingly, our study reveals a significant shift in food price trends during the inflationary pressure period: food prices increased by 22% over 18 months. This price increase was seen in all food groups, but the growth in price was different for different food groups. Notably, the largest relative price increase of 31% was seen in the price of dairy foods, while F&V increased the least by 16%. The price of 'more healthy' food was consistently higher than 'less healthy' food. During the inflationary pressure period, the price of 'less healthy' food increased by 26% compared to 20% for 'more healthy' food. Despite this greater relative price increase of 'less healthy' food, the price of 'more healthy' food increased more in absolute terms (£0.07/100 kcal versus £0.13/100 kcal). This pattern of results was true regardless of the price metric used (i.e. per unit energy, mass, or portion).

The observed 22% increase in the price of food during the inflationary pressure period corroborates a previous report using the same data source that showed prices per unit of food increased by almost 25% between December 2019 and March 2023 (Bakker et al., 2023). This same report found a significant impact of post-Brexit trade restrictions on food prices (one contributor of the UK's inflationary pressure period (Office for National Statistics, 2023b)); it suggested that, had these trade restrictions not been implemented, the increase in food prices would have been 17% instead of 25% indicating that Brexit made a substantial contribution to the inflationary pressure period in the UK (Bakker et al., 2023). The 3% difference in price increases between this study and the previous report may be due to different base years and this study's exclusion of food with no calories and a component of service. Reports of food insecurity also increased by almost 10% from December 2021 to June 2023 (Food Foundation). Compared to prior research on food prices between 2002 and 2012 (Jones et al., 2014), we found a smaller relative price increase from 2013 to 2023. Food prices increased by 26% from 2007 to 2012 (Jones et al., 2014), while we found that food prices were relatively stable from 2013 to 2021, with reductions in the prices of grains and F&V food groups, as well as in the 'more healthy' category, until the onset of the inflationary pressure period. Our findings for the protein and HFS food groups were also consistent with prior research (Jones et al., 2014). Prices of these food groups, and those of 'less healthy' foods, had some of the highest relative increases across the 11-year period. Given earlier evidence that HFS food predominantly comprise of less healthy foods (Jones et al., 2014), it is unsurprising that this nutrient-based category also had a relatively high increase in price. Despite the price increases in 'less healthy' food, 'more healthy' food remained significantly more expensive throughout the study period, aligning with prior studies (Lee et al., 2011; Palermo et al., 2016; Rao et al., 2013).

Research consistently underscores that the higher prices of nutritious foods can create barriers for lower-income households, leading to disparities in dietary quality (Hoenink et al., 2020; Monsivais et al., 2012; Pechey & Monsivais, 2016). The period of inflationary pressure in the UK further erodes food affordability and potentially exacerbates disparities in diet among different socioeconomic groups. Notably, a Food Foundation report revealed that the percentage of disposable income spent on food aligning with UK dietary guidelines increased by 7% for the lowest-income groups over the past three years, but only by 1% for the highest-income groups (Goudie, 2023). While it is true that the elevated prices of healthier foods compared to less healthy options may contribute to dietary inequalities, our research hints at a somewhat unexpected trend over the 11-year study period. During this time, the cost of less healthy foods increased at a faster rate than that of healthier alternatives, thereby decreasing relative price differences between 'more healthy' and 'less healthy' food. Despite the narrowing of relative price differences, absolute price differences between 'less healthy' and 'more healthy' food remained unchanged from 2013 to 2023 (i.e. £0.48/100 kcal). The consistently high cost of F&V and 'more healthy' food, combined with rising prices in energy and services and food in general (Harari et al., 2023) without increases in wages in line with inflation (Hourston, 2022), may pose challenges for certain populations to maintain a healthier diet.

The observed trends in food prices across different food groups and healthiness categories whereby some food groups (e.g. grains) remained relatively stable over time while others showed more volatility (e.g. F&V) reflect the interplay of a multitude of factors (differentially) impacting the food market. These factors encompass a range of elements, from global market dynamics and weather patterns affecting crop yields to significant occurrences like the COVID-19 pandemic, Brexit and the war in Ukraine (Stein & Santini, 2022). Each of these events has played a role in the inflationary pressures in the UK by directly or indirectly impacting food prices and availability (Office for National Statistics, 2023b). For example, the COVID-19 pandemic and the Ukraine war have led to disruptions in supply chains. Additionally, other UK-specific elements, such as the country's reliance on food imports, utility price regulations, labour shortages, Brexit, and strategic pricing decisions by supermarkets, may have further exacerbated the situation (Bakker et al., 2022; Office for National Statistics, 2023b). These combined effects have created unique market dynamics in the UK, suggesting that the results of this study might not be generalizable to other countries.

Ensuring food affordability and security, especially for those in lower socioeconomic positions (SEP), requires multifaceted strategies by policymakers. While the UK already does not add value added taxes to most food items sold at supermarkets, other strategies ensuring food affordability might include provision of or increase in healthy food subsidies (Blakely et al., 2020), guaranteed pricing on healthy foods, and expansion of existing incentive programs targeted at vulnerable groups (Thomas et al., 2023). For example, the Healthy Start programme aims to help pregnant low-income women and children <5 years of age purchase F&V and milk by offering Healthy Start cards with money to be used at some UK retail outlets. The income threshold for eligibility to this programme, the value on the Healthy Start cards as well as the range and locations of retail outlets registered for the programme could be increased (McFadden et al., 2014). Other fiscal strategies not directly aimed at food that could further support healthier eating as food prices rise may include energy bill discounts for households with a lower SEP and increased income tax credit for people with a low income (Amaglobeli et al., 2023).

In this study we focused on the price of specific food items and groups. More comprehensive approaches, such as costing whole diets, may provide a broader understanding of affordability in the context of nutritional health. Lee et al. (2013) developed a step-wise framework for the monitoring of the price and affordability of foods, meals and diets at country level. The current study falls under the 'minimal' approach (i.e. country-wide differential between the price of selected healthy foods and less healthy foods). Future studies in the UK could consider using the 'expanded' or 'optimal' approach which account for the price differential between diets rather than foods, given concerns about the affordability of dietary patterns. Implementing more comprehensive methodologies for monitoring food prices and affordability may necessitate the use of an alternative price database to CPI, as these approaches require data on a wider range of food items. Studies using more comprehensive methodologies stratifying by household socioeconomic position have recently been conducted in the Netherlands, Australia and Mexico (Batis et al., 2021; Hoenink et al., 2022; Lee et al., 2020). Unlike the current study, these aforementioned studies also weighed the inclusion of food items based on their consumption frequency. The affordability of healthy and less healthy diets by socioeconomic group is especially important during a period of inflationary pressure. Future studies may also use more advanced statistical analyses such as join point regression to reveal deeper insights into the dynamics of food pricing, offering a clearer picture of how macroeconomic and global factors such as the Ukraine war, Brexit and COVID-19 influence market trends.

Our sensitivity analyses considering different price metrics provided additional insights into the price of food. Unsurprisingly, and as previously, the choice of price metric altered the ranking of prices (Carlson & Frazão, 2012; Jones & Monsivais, 2016). For instance, all three price metrics ranked grains as one of the least expensive food groups. However, F&V was one of the least expensive food groups by mass and portion, but the most expensive food group per unit of energy (likely due to the generally low energy density of F&V). These variations in price metrics highlight the importance of carefully considering the metric used when assessing affordability and making policy recommendations (Foley et al., 2018). As previously noted, it has been argued that when addressing questions of public health and nutrition, pricing food on the basis of energy content may be the most appropriate as it enables comparison of the amount of sustenance different foods can contribute (Jones & Monsivais, 2016). While the Eatwell Guide specifies energy requirements by age and sex, it also provides guidance based on mass (e.g. fish and meat) and portion size (e.g. F&V) (Buttriss, 2016). Interestingly, the trajectory of price changes over time remained consistent regardless of the choice of price metrics, suggesting that longitudinal studies examining price shifts may be less influenced by the specific price metric selected. However, it is important to consider how relative and absolute changes in prices might affect consumers differently. While relative price changes can influence consumer choices and perceptions of affordability, absolute price changes may have a more direct impact on household budgets, particularly for lower-income groups. This distinction is important for understanding the broader implications of food pricing trends on consumer behaviour.

4.1. Strengths and limitations

By using nationally representative data on prices and food consumption our results are likely to be nationally representative. Reliability is further enhanced by the use of multiple sensitivity analyses demonstrating that the choice of price metric and inclusion criteria for foods did not change our interpretation of food price trends. While CPI baskets reflect foods commonly purchased by UK customers, a limitation of this study is the inclusion of a limited number of foods that solely reflect those encompassed by the CPI. Thus, this dataset does not allow for the monitoring of food prices using the aforementioned 'expanded' or 'optimal' approaches. Furthermore, the aggregated nature of the available data posed challenges in accurately determining the weight and nutrient composition of CPI items, which were necessary for calculating the price per unit energy. Due to data aggregation and "the need to protect the integrity of the CPI", the UK government has been unable to disclose more granular, product-level information (personal communication, UK Office for National Statistics, June 2023). Also, while impacts are likely minimal, the use of calorie information from only a few NDNS years does not account for potential product reformulation during the study period (e.g. a reduction of sugar in sugar sweetened beverages). Lastly, the start of the inflationary pressure period was determined using CPI data and hence partly driven by food price changes leading to some circularity in analyses.

4.2. Conclusion

An examination of the CPI food basket from 2013 to 2023 revealed a 20% increase in the average price of food, with notable variations across different time periods, food groups and healthiness category. While price changes were fairly limited in the period leading up to the inflationary pressure, the occurrence of the inflationary pressure period resulted in an increase in price of 22% and impacted all Eatwell food groups and both 'more healthy' and 'less healthy' food categories.

However, the scale of this impact varied between groups from 16% (F&V) to 31% (dairy). While 'more healthy' food saw smaller relative price increases compared to 'less healthy' food since 2021, 'more healthy' foods had a greater absolute price increase and remained more expensive, potentially exacerbating dietary inequalities. Collectively, our findings shed light on the dynamics of food pricing, offering data that can guide policy measures addressing the challenges of rising food costs.

Ethics approval and consent to participate

We relied on publicly available data and did therefore under UK law did not require ethics approval.

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Consent for publication

Not applicable.

Declaration of generative AI

During the preparation of this work, JCH used ChatGPT v4.0 in order to improve readability and language. After using this tool, JCH reviewed and edited the content as needed and takes full responsibility for the content of the publication.

CRediT authorship contribution statement

Jody C. Hoenink: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Kate Garrott:** Writing – review & editing, Methodology, Data curation. **Nicholas R.V. Jones:** Writing – review & editing, Methodology. **Annalijn I. Conklin:** Writing – review & editing, Methodology. **Pablo Monsivais:** Writing – review & editing, Methodology. **Jean Adams:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

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

Data availability

All data used in this study are publicly available

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107290.

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