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RESEARCH

Are gluten-free food staples accessible to all patients with coeliac disease?

Yvonne M Jeanes,[1] Ozan Hanci[2]

[1]Department of Life Sciences, Health Sciences Research Centre, University of Roehampton, London, UK
[2]Department of Paediatrics, Royal Surrey County Hospital, Guildford, UK

Correspondence to
Dr Yvonne M Jeanes, Department of Life Sciences, Health Sciences Research Centre, University of Roehampton, London SW15 4JD, UK; y.jeanes@roehampton.ac.uk

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ABSTRACT

Introduction Within England the removal of prescribed gluten-free (GF) foods from many Clinical Commissioning Groups has resulted in a greater reliance on commercially available GF food by adults and children with coeliac disease (CD). High cost and limited availability of GF foods are associated with poorer dietary adherence in people with CD.

Aim To assess if the rise in popularity of GF diets globally has improved the cost or availability of cereal-based GF foods over the past 6 years.

Design Observational study where data were collected on cereal-based GF foods from 50 stores and 10 internet retailers. The number of GF foods within each food category and the cost per 100 g of GF and gluten-containing (GC) foods were compared by store type.

Results GF food availability has increased in premium stores and online. The majority (82%) of GF food categories were significantly more expensive online compared with regular supermarkets. On average, GF breads were 400% more expensive compared with GC breads ($p<0.001$); no narrowing in cost difference over time observed. Convenience stores did not stock any GF bread nor GF pasta and only one of the budget supermarkets stocked them, similar to data reported 6 years ago.

Conclusions GF food availability has increased, predominately in premium markets. The GF food desert within convenience and budget stores will continue to disproportionately impact poor socioeconomic cohorts, the elderly and physically disabled. A lack of accessibility to GF foods impacts GF dietary adherence, increasing related comorbidities and healthcare costs.

INTRODUCTION

Coeliac disease is an autoimmune enteropathy caused by genetic and environmental factors, where the ingestion of gluten causes damage to intestinal mucosa with resultant impaired nutrient absorption, and increased risk of anaemia and osteoporosis.[1] Worldwide prevalence of coeliac disease is estimated at 1.4%.[2] Presently there is no cure and coeliac disease is managed by patients adhering to a lifelong, strict gluten-free (GF) diet. Gluten is a protein within wheat, barley and rye; thus a GF diet excludes many commonly consumed carbohydrate-based foods and includes alternatives such as manufactured GF bread, GF flour and GF pasta, as well as naturally occurring GF foods such as potatoes and rice. Adhering to a GF diet can be very challenging, it requires knowledge, skills and modified behaviours to undertake the substantial changes to dietary habits.[3] Studies have reported the proportion of people with coeliac disease who adhere to a GF diet ranges from 36% to 96% depending on the methodology used to determine dietary adherence and population recruited.[4] Improving GF dietary adherence is key to reducing morbidity associated with coeliac disease and associated healthcare costs.[5]

The increasing trend for grocery shopping online has enabled people with coeliac disease to access GF foods via internet food delivery services and global sales of GF foods have substantially increased in recent years.[6] Influencing this is the rise in popularity of consuming GF foods for gluten sensitivity and GF living as a lifestyle choice contributing to consumer demand for greater availability of GF foods.[7] It is reasonable to postulate that there has been a substantial improvement in the availability of manufactured GF foods within the UK, a viewpoint held by Clinical Commissioning Groups,[8] and costs may also be reducing.

Within the UK, GF foods have been available through prescriptions since the 1960s to promote adherence by improving access to GF foods and reduce

the financial burden to patients; this is still in line with today's national guidance.[9 10] However, in reality, access to prescribed GF foods is very variable across the UK, in several areas prescribed GF foods are not available to patients.[11]

The economic burden of the GF diet and the limited availability of GF foods[12 13] can impact on patients' quality of life[14 15] and GF dietary adherence.[16 17] The current study aims to assess if the rise in popularity of GF diets globally has improved the cost or availability of commercially available cereal-based GF foods over the past 6 years.

MATERIALS AND METHODS

A cross-sectional survey of manufactured GF foods was conducted in 2017. Data were collected from two areas within London with dipolar opposite deprivation indices, to reduce any bias this may cause.

Food retailers

Fifty physical stores were surveyed, inclusive of premium, regular and budget supermarkets, health food and convenience stores; stores were categorised as previously described.[12] Supermarkets, between each category, were selected to be of similar size to account for difference in stock availability between varying store size. An internet search identified physical food stores; the stores selected represented geographical spread for each region in order to account for differences in local population. Permission to collect data was obtained from the duty or store manager. Online retailers of manufactured GF foods were identified through extensive UK-based internet searches and information from Coeliac UK, 10 retailers were selected, 5 were affiliated with a physical supermarket surveyed and 5 were independent online retailers providing GF food delivery.

Food categories

Eleven cereal-based food categories were surveyed; white and brown bread loaves, white and brown bread rolls, flaked breakfast cereals, pasta, plain flour, crackers and crispbreads, cereal bars, sweet biscuits and whole sponge cake. In addition, sandwiches/wrap and GF oats were included. The selected food categories include those within the Coeliac UK's 'Gluten Free Guarantee' campaign.[18]

Procedure

Each store was systematically explored, the total number of GF and gluten-containing (GC) food products available for each food category was recorded per store. The GF foods were confirmed to be so, by having the Crossed Grain symbol on their packaging or when the symbol was not available the ingredients were examined, those which contained wheat, barley, rye, oats, spelt, Khorasan wheat/kamut were excluded. Labels which stated 'may contain traces of gluten', 'made on a line handling wheat', 'made in factory also handling wheat' and 'not suitable for people with coeliac disease/a wheat allergy due to manufacturing methods' were also excluded. Information on weight, pack size and price was recorded for the cheapest and most expensive GF and GC cereal-based food products in physical stores. The cost was recorded as pence sterling per 100 g. At the time of data collection, the exchange rate was £100=US$1.3=€1.18. The mean value from the cheapest and the most expensive GF food product for each food category listed and their GC counterparts was calculated for each store, where only one option was available this value was used, as published previously to allow for comparisons over time.[12] Costs recorded were exclusive of any delivery cost associated with purchase.

Statistical analysis

Continuous data were assessed for normality using Kolmogorov-Smirnov. Data are presented as median values (IQR) unless stated otherwise. Continuous non-parametric data analysis used the Kruskal-Wallis and Mann-Whitney U tests to examine differences in availability and cost of GF foods across all retailer categories. A p value of <0.05 was considered significant and all values were two sided. Data were analysed using SPSS, V.21 (IBM). There were no significant differences between the two regions surveyed (data not shown), data from the two regions are presented combined.

RESULTS

Availability of manufactured GF foods

None of the convenience stores and only one of budget supermarkets stocked any of the GF food categories surveyed (table 1). Food staples: GF breads, GF pasta and GF flour were available in all online stores, premium and regular supermarkets, however, none of the convenience stores stocked any GF food staples and only 10% of budget supermarkets stocked GF bread and GF pasta (table 1). An increase in the availability of GF bread loaves was observed within premium and regular supermarkets from an average of 3 and 5 loaves in 2011 to 12 and 7 loaves respectively in the current study.[12] Additionally, compared with data published in 2011 we report a greater availability of GF pasta and GF sweet biscuits and a similar availability of GF plain flour, GF bread rolls and GF whole sponge cakes in premium and regular supermarkets.[12] No increase in average availability of GF foods from budget nor convenience stores was observed; online data were not reported in 2011. GF sandwich/wrap availability was particularly poor with only two regular supermarkets stocking them (one option in each store), none of the other physical stores and online stores stocked any GF ready-made sandwiches/wraps (table 1).

Table 1 Percentage of stores stocking gluten-free (GF) foods and median number of GF products available in each store

	Supermarkets						Convenience		Health food		Online	
Gluten free food categories	Premium	%*	Regular	%*	Budget	%*	Stores[3]	%*	stores	%*	stores	%*
All bread loaves	12.0 (10.8–12.5)†‡	100	7.0 (5.5–8.3)†§¶	100	0.0 (0.0–0.0)**	10	0.0 (0.0-0.0)††	0	2.0 (0.0–2.0)‡§‡‡	60	13.5 (7.3–16.8)¶‡‡	100
White bread loaf	4.0 (3.8–4.0)‡	100	3.5 (3.0–4.0)§¶	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	1.0 (0.0–1.0)‡§‡‡	60	5.0 (3.8–8.3)¶‡‡	100
Brown bread loaf	8.0 (7.0–8.5)†‡	100	3.5 (2.5–4.5)†§¶	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	1.0 (0.0–1.0)‡§‡‡	60	7.5 (3.5–10.3)e f	100
White Bread rolls	1.0 (1.0–1.0)‡§§	100	1.0 (1.0–2.0)§¶	100	0.0 (0.0-0.0)**	0	0.0 (0.0-0.0)††	0	1.0 (0.0–1.0)‡§‡‡	60	3.0 (1.0–5.0)§§¶‡‡	100
Brown bread rolls	1.0 (1.0-1.0)§§	90	1.0 (1.0–1.0)§¶	100	0.0 (0.0-0.0)**	0	0.0 (0.0-0.0)††	0	1.0 (0.0–1.0)§‡‡	60	1.0 (1.0–3.0)§§¶‡‡	100
Flaked breakfast cereal	2.0 (0.8–3.0)‡§§	80	4.0 (1.0–5.5)§¶	100	0.0 (0.0–0.0)**	10	0.0 (0.0-0.0)††	0	1.0 (1.0–1.8)¶‡‡	100	8.0 (3.8-12.5)§§‡‡	100
Cereal bars	3.0 (0.0–6.0) †§§	50	7.5 (4.0–13.5)†§	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	7.5 (0.0–9.3)	70	14.5 (3.5-65.8)§§	90
Pasta	3.5 (2.0-4.0)§§	100	4.5 (3.0–6.0)¶	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	4.0 (3.8-8.0)‡‡	100	15.5 (12.0–68.0)§§¶‡‡	100
Plain flour	1.0 (1.0–1.0)†§§	100	2.0 (1.8–3.0)†	100	0.0 (0.0-0.0)**	0	0.0 (0.0-0.0)††	0	0.5 (0.0–2.8)	50	2.5 (2.0-3.3)§§	100
Crackers/crispbreads	8.5 (6.5–13.0)	100	11.5 (9.5–14.3)	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	11.5 (7.8–13.3)	100	27.0 (9.3–56.5)	100
Sweet biscuits	7.0 (4.0–13.0)†§§	100	16.0 (11.5–25.0)†	100	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	9.0 (0.0–10.3)§‡‡	70	26.5 (14.5-53.5)§§‡‡	100
Whole sponge cake	1.5 (0.0–4.0)‡	50	2.5 (2.0–4.0)§¶	100	0.0 (0.0–0.0)¶¶	0	0.0 (0.0–0.0)¶¶	0	0.0 (0.0–0.0)‡§‡‡	10	1.0 (0.0–2.0)¶‡‡	70
Sandwich/wrap	0.0 (0.0–0.0)	0	0.0 (0.0–0.3)	20	0.0 (0.0–0.0)	0	0.0 (0.0–0.0)	0	0.0 (0.0–0.0)	0	0.0 (0.0–0.0)	0
GF Oats	1.5 (1.0-2.0)§§	100	0.5 (0.0–2.0)¶	50	0.0 (0.0-0.0)**	10	0.0 (0.0-0.0)††	0	0.5 (0.0-2.3)‡‡	50	3.0 (2.5–14.3)§§¶‡‡	90

Values presented as median number of GF products available within each store type (and IQR),
*percentage of stores stocking the GF food item. Data is non-parametric; Kruskal-Wallis analysis undertaken to determine difference between store types; a significant difference between groups was observed for all food categories (P<0.05), except sandwich/wrap category. Mann Whitney tests were utilised to compare difference between store types. Significant difference (P<0.05) between
†premium and regular supermarkets,
‡premium and health food stores,
§regular supermarkets and health food stores,
¶regular supermarkets and online stores,
**Significant difference between budget supermarkets and health food stores, premium, regular supermarkets and online stores.
††Significant difference between convenience stores and health food stores, premium and regular supermarkets and online stores.
‡‡health food stores and online stores.
§§premium and online stores,
¶¶Significant difference between budget supermarkets and convenience stores with premium and regular supermarkets and online stores.

Table 2 Comparison of cost between gluten-free (GF) and gluten-containing (GC) foods

Product	n*	Gluten-free cost† (pence/100 g)	Gluten-containing cost† (pence/100 g)	P values	% Difference‡ 2017†	% Difference 2011[12]
All bread loaves	37	64 (55–68)	13 (10–23)	<0.001	400 (187–490)	360
White loaf	20	61 (55–67)	12 (9–29)	<0.001	467 (218–500)	–
Brown loaf	17	66 (55–72)	17 (11–23)	<0.001	324 (187–404)	–
All bread rolls	37	90 (70–96)	18 (13–27)	<0.001	379 (281–491)	155
White bread rolls	20	90 (67–92)	18 (13–27)	<0.001	384 (236–403)	–
Brown bread rolls	17	96 (78–103)	18 (12–27)	<0.001	386 (281–536)	–
Cereals—flaked	15	85 (67–92)	44 (33–44)	<0.001	109 (52–149)	96§
Cereal bars	20	176 (153–193)	132 (129–140)	0.001	30 (6–46)	–
Pasta	20	41 (34–59)	28.5 (21–66)	0.1	18 (–12 to 70)	175
Plain flour	20	18 (17–35)	9.5 (5–43)	0.006	85 (–5 to 269)	184
Crackers/crispbreads	20	160 (114–243)	85 (69–109)	<0.001	122 (79–124)	220
Sweet biscuits	15	130 (103–139)	63 (62–66)	<0.001	107 (77–130)	518
Whole sponge cake	15	83 (80–85)	60 (48–67)	<0.001	35 (24–46)	78

*Number of stores that stocked a GF and GC version of the food. Median (IQR) costs are presented for each food category from premium and regular supermarkets combined.
†Cost for each food category, for each individual supermarket, was calculated as a mean value between the cheapest and most expensive item; the median (IQR) was then calculated for all premium and regular supermarkets combined.
‡% Difference between cost of GF and GC food categories.
§Includes all GF breakfast cereals. 2011 data presented as mean values.

Cost of manufactured GF foods

GF foods were significantly more expensive than their GC counterparts in 91% of the food categories; in particular GF bread loaves were substantially more expensive (400%), similar to the 360% published in 2011[12] (table 2). GF bread rolls were 379% more expensive compared with just 155% in 2011[12] (table 2). However, the percentage difference does appear to have narrowed over time between GF and GC pasta, crackers, sweet biscuits and cake (table 2). The 85% higher cost of GF flour compared with GC flour is lower than the 184% reported in 2011.[12] Our data do include large variation between stores, as demonstrated by the large IQR values for percentage difference values in regular and premium supermarkets (table 3). Eighty-two per cent of GF food categories were more expensive online compared with regular supermarkets (table 3). Independent online food stores stocked significantly more expensive GF versions of all types of bread, flaked breakfast cereal and plain flour ($p<0.05$) when compared with supermarket-affiliated online food stores. The percentage difference in cost between GF and GC foods is greater in regular supermarkets compared with premium supermarkets in five food categories (table 3), in particular GF brown loaves are 400% more expensive in regular supermarkets compared with 255% in premium supermarkets ($p=0.014$, table 3).

DISCUSSION

The scarcity of manufactured GF foods within budget and convenience stores persists. A clear positive is the larger range available within online stores, regular and premium supermarkets compared with previous reports.[12 13] Online stores have the potential to greatly improve access to GF foods, however, it is noteworthy that the majority of GF foods within online stores were more expensive than those within physical stores. Contemporary barriers exist to accessing GF food from online stores, such as poor access to the internet, costs associated with being online and poor digital literacy; these disproportionately impact those socioeconomically disadvantaged, of poor literacy, rural communities, those with disabilities and include the older generation.[19 20] The distinction between availability and accessibility must be considered; improving geographical availability to those who can least afford it, at costs which are unapproachable, does not equate to accessibility. This is an area for further research to investigate the accessibility of GF foods for all population groups of people with coeliac disease.

None of the convenience stores and only one budget store stocked any of the surveyed GF foods, a situation that has not improved in recent years.[12 13] This is especially significant for populations who are reliant on convenience stores and budget supermarkets as their main food source, such as the socioeconomically disadvantaged, those affected by poor levels of car ownership, the isolated elderly and those with physical disabilities.[21 22] Of relevance, a recent study revealed South Asian patients with CD were unable to find GF foods in their local Asian food stores.[23] Pharmacies, through prescriptions, can double the locations where GF foods are sourced.[24] Receiving GF foods on prescription is associated with better GF dietary adherence scores,[25] possibly by improving the economic burden and accessibility issues for some patients. The large variation in GF prescribing practices within England, with an overall trend in reducing amounts of GF foods prescribed,[26] will further impact on the availability of GF foods. Both the availability and cost of GF foods have previously been shown to impact on patients' quality of life and GF dietary adherence.[14–17] Even with prescriptions in place, as in parts of the UK, the financial burden on an individual diagnosed with

Table 3 Median cost, in pence sterling per 100 g*, of gluten-free foods and percentage difference in cost between gluten-free (GF) and gluten-containing (GC) foods in regular and premium supermarkets

Food categories	Premium Supermarkets	Regular Supermarkets	Budget	Health food stores	Online stores	Median (IQR) % difference between GF and GC* Premium	Regular	P values
White bread loaf	65 (61–68)†‡§ n=10	57 (52–60)†¶** n=10	105 n=1	151 (150–156)‡¶†† n=6	74 (65–144)§**†† n=10	273 (79–467)	495 (457–565)	0.077
Brown bread loaf	69 (66–72)†‡ n=10	55 (46–67)†¶** n=7	56 n=1	107 (106–112)‡¶†† n=6	76 (65–86)**†† n=10	255 (187–324)	400 (400–800)	0.014
White Bread rolls	92 (90–93)†‡ n=10	67 (66–76)†¶** n=10	-	150 (150–152)‡¶†† n=6	94 (81–127)**†† n=10	300 (210–389)	393 (363–578)	0.134
Brown bread rolls	103 (96–103)†‡ n=7	86 (70–97)†¶** n=10	70 n=1	150 (153–152)‡¶†† n=6	102 (91–147)**†† n=10	281 231–281)	536 (450–650)	0.001
Flaked breakfast cereal	92 (92–92) n=5	81 (66–85) n=10	65 n=1	69 (69–78) n=10	100 (66–119) n=10	109 (109–117)	54 (51–181)	0.812
Cereal bars	176 (172–257) n=10	164 (62–182)¶** n=10	206 n=1	231 (231–236)¶ n=7	232 (184–294)** n=9	34 (30–78)	26 (–49–40)	0.289
Pasta	50 (40–59)‡§ n=10	34 (26–65)¶** n=10	32 n=1	126 (117–130)‡¶ n=10	93 (72–111)§†† n=10	–12 (–21–15)	58 (38–227)	0.004
Plain flour	29 (18–40)† n=10	17(17-17)†¶ n=10	-	43 (25–51)¶ n=5	19 (17–44) n=10	38 (–32–100)	198 (55–398)	0.160
Crackers/crispbreads	211 (160–259)†‡ n=10	118 (101–191)†** n=10	179 n=1	58 (58–170)‡†† n=9	239 (146–294)**†† n=10	110 (84–123)	108 (50–313)	0.002
Sweet biscuits	139 (139–141)†‡ n=5	110 (75–130)†¶** n=10	93 n=1	172 (158–172)‡¶ n=7	189 (126–234)** n=10	124 (124–128)	84 (19–277)	0.108
Whole sponge cake	110 (80-82)§ n=5	84 (66–91)** n=10	-	106 n=1	177 (100–220)§** n=7	27 (25–33)	38 (11–61)	0.176

*Cost for each food was calculated as the mean cost cheapest and most expensive for each store. The Median values (inter-quartile range) are presented for each store type. Data is non-parametric, Kruskal-Wallis analysis undertaken to determine difference between store types; a significant difference between groups was observed for all food categories (P<0.05), except flaked breakfast cereals and oats. Mann Whitney tests to compared between store categories, Significant difference (P<0.05) between
†premium and regular supermarkets,
‡premium and health food stores,
§premium and online stores,
¶regular supermarkets and health food stores,
**regular supermarkets and online stores,
††health food stores and online stores. Convenience stores did not stock any of the GF foods surveyed. Sandwiches and wraps only one option available from two regular supermarkets.

CD can be significant, adding an average of £861 to food shopping costs over a year.[27] Our study reports GF breads continue to be significantly more expensive than their GC counterparts. The exceptionally high comparative cost of GF breads has been consistently reported.[12 13 28] GF breads require alternative grains and complex manufacturing processes in order to provide a palatable, nutritionally adequate product, which together incur additional expense. We also report a greater percentage difference in costs between GF and GC breads in regular compared with premium supermarkets; key when taking into consideration the largely absent GF foods in budget supermarkets, thus impacting on those with the smallest food budgets greatest. There appears to be a narrowing in cost difference for GF compared with GC flour, pasta and biscuits which is encouraging to see. A strength of our study is only including cost values from stores where GF and GC foods were available, eliminating store-type bias. Our study does have limitations, our physical store data are from a single city and do not necessarily reflect the rest of the country or other countries. Our study focused on cereal-based GF foods, it is outside the scope of this study to extrapolate the findings towards the GF diet, which comprised foods naturally GF, prescribed GF foods and other non-cereal-based GF foods (eg, sauces and sausages).

There are very limited data from the UK exploring the impact of reduced access to prescribed GF foods with a greater reliance on commercially available sources. A situation has developed where people with coeliac disease from lower socioeconomic groups are at risk of not being able to afford GF foods, thus impacting their ability to adhere to the GF diet and potentially leading to coeliac disease-related morbidity and additional healthcare costs.[1] Longitudinal studies are needed to assess the impact of policy changes in GF prescribing on dietary adherence and inclusive of data on morbidity associated with gluten consumption.

CONCLUSIONS

Although GF food availability has increased, this is predominantly in the premium markets. The GF food desert within convenience stores and budget supermarkets will continue to disproportionately impact poor socioeconomic cohorts, the elderly and physically disabled. Additional barriers exist when accessing GF foods from online stores. The growth of the GF food market in recent years has not led to the anticipated transformation in accessibility of manufactured GF foods nor reduced the price of GF staple foods. Research is needed to accurately assess the current and real-life economic burden of undertaking a lifelong GF diet in a diverse population of people with coeliac disease. Our study findings highlight subpopulation groups are likely to have higher treatment burden from a GF diet, this is important to highlight to policymakers, and inform the conversations between healthcare professionals and people with coeliac disease.

Significant of this study

What is already known on this topic

- Lifelong, strict adherence to a gluten-free diet is the only treatment for coeliac disease. The rise in popularity of gluten-free foods and the reduction in prescribed gluten-free foods has increased the demand for commercially available gluten-free foods.

What this study adds

- The growth of the gluten-free food market in recent years has not led to the anticipated transformation in accessibility of commercially available gluten-free foods. Gluten-free foods are scarcely available in budget and convenience stores and their high cost persists. The treatment burden disproportionally impacts poor socioeconomic cohorts, the elderly and physically disabled.

How might it impact on clinical practice in the foreseeable future

- The study aims to inform policymakers when considering gluten-free prescribing by highlighting the need to consider all population groups with coeliac disease. It will inform the conversations between healthcare professionals and patients with coeliac disease, by increasing awareness of the economic burden and access issues when adhering to the gluten-free diet.

Contributors OH contributed to the study design, undertook data collection and preliminary analysis and co-wrote the manuscript. YMJ formulated the original study idea, contributed to the study design, supervised all aspects, undertook additional analysis and co-wrote the manuscript. Both authors approved the final version of the manuscript submitted for publication.

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