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Food allergen recalls in the United Kingdom: A critical analysis of reported recalls from 2016 to 2021

Sim Ray Yue^{a,b,*}, Rajeev Shrivastava^b, Katrina Campbell^a, Michael John Walker^a

^a Institute for Global Food Security, School of Biological Sciences, Queen's University Belfast, 19 Chlorine Gardens, Belfast, Northern Ireland, BT9 5DL, United Kingdom

^b Department of Biology, Edge Hill University, St Helens Road, Ormskirk, Lancashire, L39 4QP, United Kingdom

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ABSTRACT

Allergen food recalls issued by food regulatory bodies in the UK from 2016 to 2021 are analysed herein by food type, allergenic food group, reasons for recall, and food expiry status. Trends and relationships have been assessed. Food allergen-related recalls in the UK have tended to increase annually despite increased awareness and regulations until 2019, peaking at 118 recalls before decreasing to 82 and 84 in 2020 and 2021 respectively. Recalls due to allergens were the main reason for food recalls at 57.6% (n = 597), with milk (25.2%) being the most recalled allergenic food group. Most recalls (40.0%) were issued due to the omission of priority allergens from the list of ingredients. The supermarket Lidl issued the most recalls with 37 recalls involving 62 products. 6.0% of recalls with expiry dates (n = 480) passed their best-before or use-by dates, of which 14 products (48.3%) had use-by dates which were microbiologically unsafe to be consumed once past the relevant dates, and cereal & bakery products accounted for 30.4% of all recalls with expiry dates. These analyses suggest that allergen-related recalls still present risks to consumers and the food industry, with larger retailers recalling the most despite modern facilities. More attention must be focused on all food allergen recalls, particularly the omission of intentionally added foods containing priority allergens from the list of ingredients. In addition, allergen-based recalls of food with expired or shortly to expire dates, which pose uncontrolled risks to consumers with food allergies, have been identified.

1. Introduction

Food allergy remains a global public health issue, where 1–2% of adults and 5–6% of children currently live with at least one diagnosable food allergy (Poppy, 2016; Wearne, 2017) equal to over two million people in the United Kingdom (UK). The European Union (EU) Regulation 1169/2011 on food information to consumers (European Union, 2011) identifies 14 key allergens of significant importance in the EU (priority allergens). This regulation was implemented in the four UK Nations (England, Northern Ireland [NI], Scotland, and Wales) in 2014 through the Food Information Regulations 2014 (Scottish Statutory Instruments, 2014; Statutory Instruments, 2014; Statutory Rules of Northern Ireland, 2014; Welsh Statutory Instruments, 2014), making it a legal requirement for food businesses and manufacturers to ensure that clear food allergen information for these 14 allergens was provided for consumers (European Union, 2011; Food Standards Agency [FSA], 2017a; Barnett et al., 2018).

Regulation 1169/2011 is based on a Codex Alimentarius standard, which identified eight main food groups known to cause food hypersensitivity and provides international guidance on their labelling on pre-packed foods (Codex Alimentarius, 2018). As food products containing these priority allergens as ingredients cut across diverse food supply chains that people consume daily, it is of utmost importance for individuals to be aware of what food allergens are present to prevent unwanted food allergen-related (FAR) reactions (Kwon et al., 2020). Living with a food allergy can severely undermine an individual's and their families' quality of life as there is a constant need to exercise awareness to avoid unwanted consequences (Warren et al., 2015). This imposes restrictions on their daily lifestyles in the food choices that have to be made, which contribute to increased levels of anxiety and stress (Antolín-Amérigo et al., 2016; Walker et al., 2016). The use of voluntary precautionary allergen labelling (PAL) intended to inform consumers with allergies, but over-utilisation and lack of harmonisation of PAL has led to miscommunicated risks towards consumers, reduced trust of PAL

* Corresponding author. Institute for Global Food Security, School of Biological Sciences, Queen's University Belfast, 19 Chlorine Gardens, Belfast, Northern Ireland, BT9 5DL, United Kingdom.

E-mail address: y03@qub.ac.uk (S.R. Yue).

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statements, and can be restrictive to the diets of specific individuals (Ross et al., 2018; Walker et al., 2018; The Food and Agriculture Organisation of the United Nations and World Health Organisation [FAO/WHO], 2021a).

Avoiding the consumption of all allergenic food is the only effective method to prevent FAR reactions (Poppy, 2016; Surojanametakul et al., 2021), but accidental ingestion still occurs frequently due to inadequate labelling practices, cross-contamination during manufacturing, and miscommunication by staff, posing potential health risks (Martin, 2020). The number of hospital admissions associated with primary diagnoses of FAR reactions based on clinical codes reported across the four UK Nations from 2014 to 2020 are listed in Table 1, with an overall increase of 49.7% of recorded medical episodes from 2014/15 to 2019/20 (Digital Health and Care Wales, 2021; National Health Service Digital, 2021; Yue, 2022). These admissions represent approximately 65% of food-related medical episodes, which is significantly higher than food-borne disease-related hospitalisations at 35% (Poppy, 2016). There are approximately ten food allergy-related deaths yearly, with young adults more prone as they start to make independent food choices for the first time, potentially preventable if appropriate allergen labelling and measures are in place (Wearne, 2017; Food Standards Agency, 2020a).

The death of Natasha Ednan-Laperouse in 2016 after consuming a sesame-containing baguette triggered widespread awareness of problems surrounding the allergen labelling of food that is 'pre-packed for direct sale' (PPDS) in the UK (Food Standards Agency, 2019a; Institute of Food Science & Technology, 2021). Since 1 October 2021, a new legal requirement ('Natasha's law') means food businesses must include accurate full ingredient and allergen labelling information directly on PPDS food within the UK (Statutory Instruments, 2019; Food Standards Agency, 2020b; Statutory Rules of Northern Ireland, 2020; Welsh Statutory Instruments, 2020; Scottish Statutory Instruments, 2021). While allergen labelling has been mandatory on pre-packed products in the EU since the implementation of Directive 2003/89/EC in 2003 (European Union, 2003), the threat of unclear allergen information persists (Turner et al., 2021). Fig. 1 highlights the condensed summary of the relevant food allergen legislation that has been introduced in the EU and subsequently implemented in the UK, apart from Natasha's Law after the UK left the EU on 31 December 2020 (Yue, 2022). Despite additional legislation and the efforts of increasing awareness on food allergens in the UK through programmes such as the 2018 EasytoASK campaign which targeted both food business operators (FBOs) and consumers (Sudworth, 2020), the number of FAR recalls being issued in the UK is still alarmingly high.

In the UK, FAR recalls due to inaccurate allergen information provided for consumers are reported by the FSA and Food Standards Scotland (FSS), with the number of recalls increasing since 2013 (Food Standards Agency, 2017b). External factors such as the time taken to evaluate the significance and scale of the risks derived from the affected food products (Food Regulation, 2017), drive delays in the recall process, initiated in line with Articles 14 and 19 of the General Food Law [Regulation (EC) No. 178/2002] and subsequent notification to consumers (Food Standards Agency, 2019b). Such delays mean that consumers may have already purchased and consumed the

Table 1

Reported hospital admissions with primary diagnoses of allergic food reactions in the UK from 2014/15 to 2019/20 (Digital Health and Care Wales, 2021; National Health Service Digital, 2021; Yue, 2022).

UK Nations	2014/ 15	2015/ 16	2016/ 17	2017/ 18	2018/ 19	2019/ 20
England	4312	4763	5485	5921	6456	6718
Northern Ireland	249	243	232	284	333	274
Scotland	439	423	415	442	444	558
Wales	172	184	175	197	174	190
Total	5172	5613	6307	6844	7407	7740

allergen-undeclared food products, posing detrimental health risks (Soon et al., 2020). Taking into consideration the numerous impacts recalls have on the UK economy such as food hypersensitivity-related hospitalisations costing approximately £80 million yearly (Food Standards Agency, 2020a), recall costs and reputational damage to FBOs (Poza & Schroeder, 2016; Page, 2018), it is essential to understand the contributing factors behind these recall trends.

While there have been two previous studies regarding FAR recalls in the UK using publicly-available data from 2016 onwards, the first study used the information obtained to classify the different reasons for recalls which was a small portion of their study, with their main focus on using root cause analyses from the FSA to identify specific operational errors by food manufacturers, and proposing an incentive-based approach to improve food allergen management by food manufacturers (Jia & Evans, 2021). The second study looked at the different allergenic food groups, reasons for recalls, and the genres of food involved, although these were a summary of recalls from 2011 to 2020 as a whole on a wider global scale (Soon & Abdul Wahab, 2021). Furthermore, to our knowledge, no work has been done on the expiry status of recalled allergenic food products in the UK.

In this study utilising publicly-available data from the FSA (England, NI, and Wales) and FSS recalls from 1 January 2016 to 31 December 2021, trends are established by the type of food recalled; number of recalls; the allergenic food groups involved; the reasons behind the recalls; the relationship between recalling frequencies with the number of products recalled by manufacturers, supermarkets, or retailers; and the relationship between expiry status and the genre of food. We aim to provide specific avenues for food manufacturers and food regulatory organisations to focus their efforts on improving food allergen labelling, ultimately reducing FAR recalls which are preventable and improving both safety and quality of food for consumers in the UK.

2. Methods

2.1. Data collection

Data collected from 1 January 2016 to 31 December 2021 from the relevant platforms below were analysed to contribute to the literature on reported UK food allergen recalls involving packaged foods with intended allergen labels (no PPDS food were reported after 1 October 2021) over the past six years. FSA is the competent authority for England, NI, and Wales, hence FSA quarterly datasets for these jurisdictions from 1 January 2016 to 31 December 2019 were retrieved from the UK's government authoritative open-source data website (data.gov.uk). The data were stratified by FAR (Food Standards Agency, 2020c) and non-FAR recalls (Food Standards Agency, 2020d). Data on food recalls from 1 January 2020 to 31 December 2021 were obtained through food recall alerts reported through FSA's Alerts (Food Standards Agency, 2022a). For food recalls in Scotland, where the competent authority is FSS, data from 1 January 2016 to 31 December 2021 were obtained through food recall alerts reported through FSS' Alerts (Food Standards Scotland, 2022).

As information from the raw datasets was usually insufficiently detailed for FAR recalls, more specific information was extracted from The National Archives for 2016 to 2017 recalls (The National Archives, 2017) and FSA Allergy Alert (2018–2021 recalls) for England, NI, and Wales, and FSS Alerts (2016–2021 recalls) for Scotland. This involved scrutiny of either recall documents accompanied with specific details provided by food manufacturers, or, in their absence, information published by the FSA to identify keywords (Table 2), which were then recorded in Microsoft Excel®. Data retrieved from all sources were compared to ensure that recalls for subsequent analysis were not duplicated.

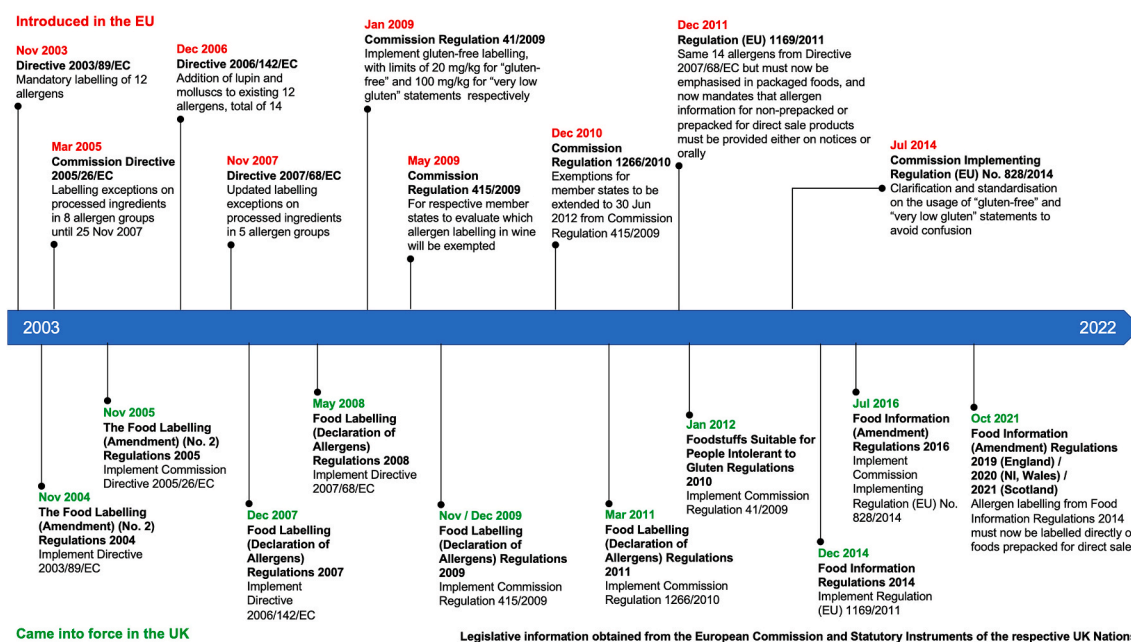


Fig. 1. Condensed major legislation implementation associated with food allergen labelling in food for sale in the United Kingdom (Yue, 2022).

Table 2

Common keywords to identify reasons for recall related to the list of ingredients (LI).

Reason	Keywords
Omitted Priority Allergens in LI	'they contain', 'product containing', 'it contains', 'product contains', 'due to the omission', 'missing'
Cross-Contamination	'contains small amount of', 'contamination', 'cross-contamination', 'may contain', 'due to the presence', 'should not contain', 'traces'
Packaged Incorrectly	'some packs', 'instead', 'incorrectly packed', 'has been filled', 'packs may', 'incorrectly contain', 'small number of packs'
Unemphasised Priority Allergens in LI	'incorrect labelling', 'incorrect allergen', 'incorrectly labelled', 'incorrect', 'insufficient allergen labelling', 'not clearly'
Not Labelled in English	'no English', 'not labelled in English', 'not mentioned in English', 'foreign language'
False 'Free-From' Claims	'gluten-free', 'dairy-free', 'vegan', 'free-from'

2.2. Data extraction

For non-FAR recalls, determining the type of food recall (microbiological, physical, chemical, incorrect dates, improper hygiene, food quality issues, and non-English labels) for each distinct category were done by identifying relevant keywords provided in each recall.

For FAR recalls, additional information collected included keywords to identify the reasons for recall (Table 2), quantity of products that were recalled, and expiry dates which have been split into best-before dates which concerns food quality and are still microbiologically safe to consume after the specified date, and use-by dates where products are no longer safe to consume after the specified date due to microbiological concerns (Food Standards Agency, 2021a).

Variables extracted and classified for further analysis included information on the type of food recall, allergenic food groups involved, reasons for each recall, the number of food products recalled per recall, food manufacturers, the genre of food which are the food categories that products fell under, date of recall, and expiry dates (best-before or use-by dates).

2.3. Data processing

Extracted information on all recalls from datasets was processed according to the different type of food recalls, with this study's focus on FAR recalls. Using pre-processed data for FAR recalls, allergenic food groups involved and reasons for recalls were converted into binary format. In order to further evaluate the possibility of food with inaccurate allergen information being consumed when near or after their expiry dates, the following new variables 'days to expiry', 'whether the recalled product will expire within seven days', or if it has 'passed the expiry dates', differentiated by best-before or use-by dates were created to investigate the risk of their consumption without the opportunity to be made aware of the inaccurate allergen information represented by these products. Recalls with no best-before or use-by dates provided were excluded from any expiry-related information.

2.4. Data analysis

Processed allergen recall data trends were analysed and illustrated with Microsoft Excel®, RStudio (RStudio, 2022), and Tableau (Tableau, 2022) respectively.

3. Results and discussion

3.1. Recalls by type

From 2016 to 2021, 1036 food recalls were reported by the FSA and FSS as depicted in Fig. 2. Allergen-related recalls (57.6%) accounted for more than half of all UK recalls issued, followed by recalls for microbiological reasons (19.0%), and physical contaminants (16.7%) which included plastics or metal debris.

The results observed continues the allergen-related recall trend in the UK, with FAR recalls making up 50.4% of the total recalls from 2013 to 2016 (Food Standards Agency, 2017b). Furthermore, this study only focused on recalls of pre-packed food from recall alerts reported by the FSA or FSS publicly, and did not include FAR cases not reported on the product recall alert platforms. Examples of cases not directly reported on the alert platforms include food consumed in restaurants or takeaways (Soon, 2018) such as the case of Megan Lee who died after consuming peanuts (Walker, 2019), hospital settings such as the death of Louis

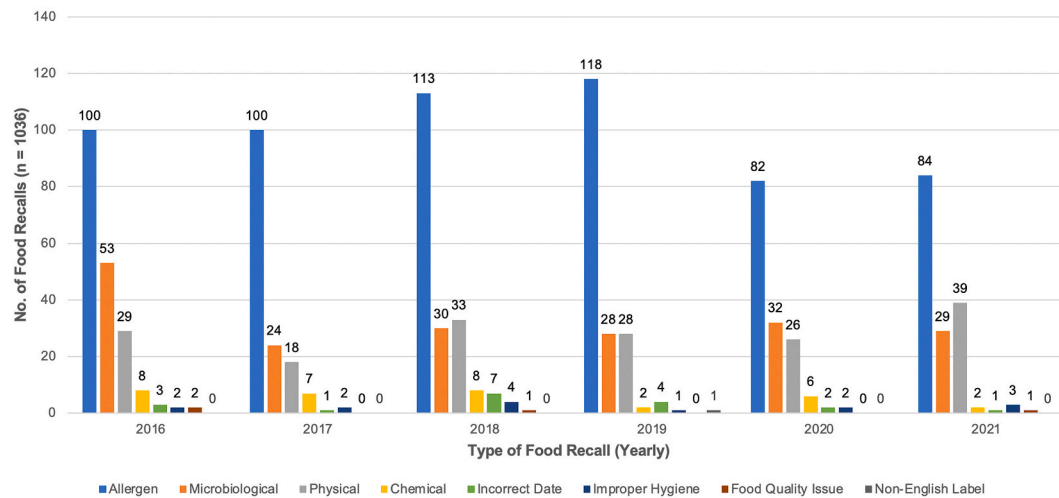


Fig. 2. Type of yearly food recalls from 1 January 2016 to 31 December 2021.

Oliver Tate reacting to milk whilst hospitalised in 2015 (Byrne, 2018), and pre-school or school settings (Ferran et al., 2020).

Overall, the data reported herein are consistent with recent recalls data published from 2017 to 2020 in the United States, where 44.5% of recalls by the Food and Drug Administration for non-meat and non-poultry products (The Food Industry Association, 2021a) and 37.8% of recalls for meat and poultry products (The Food Industry Association, 2021b) were allergen-related and were the most frequent type of reported recalls. Similarly, allergen-related recalls were the leading type of food recall reported by the Food Standards Australia New Zealand (FSANZ), accounting for 45.5% of recalls from 2016 to 2021 (FSANZ, 2022).

However, although allergen-related alerts have increased in the EU in recent years (Soon & Abdul Wahab, 2021), microbiological hazards were the leading cause for food notifications from 2018 to 2020 reported by the Rapid Alert System for Food and Feed (RASFF) in the annual reports (European Union, 2019; European Union, 2020; European Union, 2021). It is also important to note that RASFF use the term 'notifications' which are split into 'alerts', 'border rejection', 'information', and 'news' categories. Before 2019, the annual reports specified frequencies for each category, including alerts which resulted in product recalls. However, this information is no longer present in the 2020 report which does not discuss recall frequencies specifically (European Union, 2019; European Union, 2020; European Union, 2021).

3.2. Recalls by year

Across the six years from 2016, 597 FAR recalls were reported in the UK (Fig. 2). There was a slight increase in annual recalls across the four years from 2016 to 2019, with a year-on-year (YoY) growth rate of 4.21%. FAR recalls in 2016 and 2017 were identical before increasing steadily in 2018 and 2019. This was in line with overall increases reported by the FSANZ with 14.3% (FSANZ, 2022) and the EU with 24.7% (European Union, 2020) YoY growth rate respectively from 2013 to 2019. Besides increased awareness of food allergens by FBOs and consumers (Conrado et al., 2021), other contributing factors to this rise over the years may include increased food manufacturing volumes to meet the demand of busy consumers with fast-paced lifestyles (Sen et al., 2021) and improved food recall reporting and surveillance networks (Soon & Abdul Wahab, 2021).

However, a decline of 15.3% was observed in 2020 from 2019. 2020 saw the lowest number of food recalls in the UK since 2016 including a sharp reduction in allergen-related recalls, followed by a slight increase in 2021 (Food Standards Agency, 2022a). The reduction was potentially due to both the direct and indirect impacts of the Covid-19 outbreak in

2019 on the food industry globally, which resulted in reduced food production (Aday & Aday, 2020) as FBOs had to deal with ongoing absenteeism among staff due to the rise in cases throughout the pandemic (Larue, 2020). There were also Covid-19-related limitations on allergen testing and food safety inspections by regulatory officers perhaps with missed FAR issues, leading to decreased recalls (Miles, 2020). Moreover, recall incidences occurring each year depend on various factors, including UK consumer trends and new legislative implementations (Randles, 2018; Soon & Abdul Wahab, 2021).

3.3. Recalls by allergenic food group

Recalls from 2016 to 2021 issued in the UK reported a total of 597 FAR recalls which represented 969 incidences of allergenic food groups reported in Fig. 3. This phenomenon was due to multiple allergens involved per recall, with 27.3% of recalls associated with at least two allergenic food groups affected in a single recall. Products containing milk were most frequent allergenic food group recalled within the UK from 2016 to 2021 and accounted for 25.2% of the 14 key allergenic food groups reported. This was significantly more than products containing cereals containing gluten (16.9%), nuts (10.6%), soya (10.3%), eggs (8.5%), mustard (7.1%), and the other allergenic food groups recalled.

Milk, primarily bovine, is used in many modern manufactured food products (Khan et al., 2019). Moreover, the UK has experienced an alarming threefold-increase in hospital admissions regarding FAR anaphylaxis reactions from 1998 to 2018, with cow's milk mainly responsible for reactions in children (Conrado et al., 2021), contributing to the importance of recalling food products with inaccurate milk allergen labelling in a Westernised diet with a considerable reliance on dairy products (Hettinga & van Valenberg, 2017). This pattern is also observed in the US with 36% of FAR recalls concerning milk from 2007 to 2012 (Gendel & Zhu, 2013) and Australia with 30% from 2012 to 2021, although this number reported by FSANZ might be higher as 17% of recalls were deemed as recalls with multiple allergenic food groups and might include products containing milk (FSANZ, 2022).

Recalls involving milk, cereals containing gluten, nuts, soya, eggs, mustard, peanuts, and sesame generally increased over the years before a sharp drop was observed in 2020. Apart from fish and molluscs, recalls involving all the other allergenic food groups decreased in 2020 from the year before, with a 39.3% reduction (56 to 34 recalls) observed in milk recalls. Significant decreases in FAR recalls in 2020 were also noted in sesame (100%, 11 to 0 recalls), mustard (63.2%, 19 to 7 recalls), and cereals containing gluten (46.9%, 32 to 17 recalls). Due to the small sample sizes of results obtained for celery, crustaceans, sulfur dioxide,

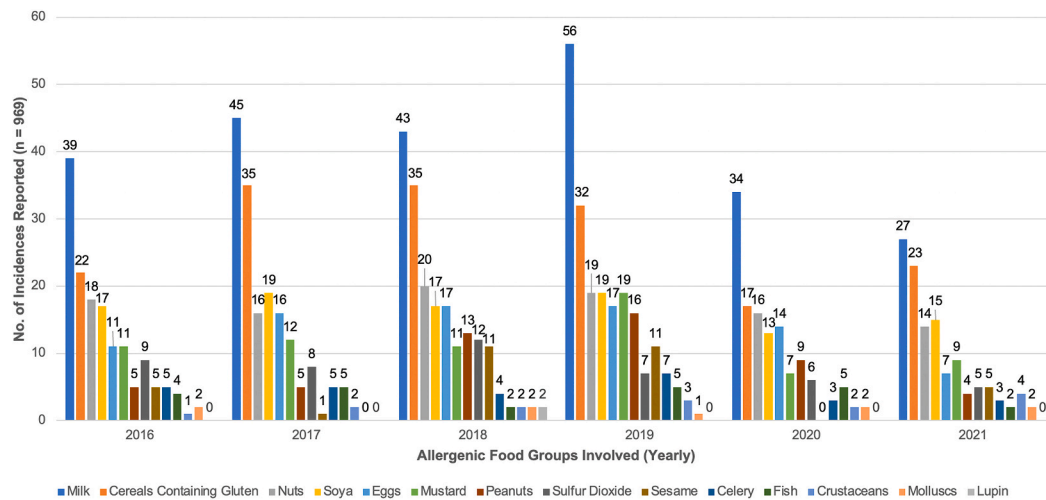


Fig. 3. Allergenic food groups involved in product recalls from 1 January 2016 to 31 December 2021.

fish, molluscs, and lupin between 2019 and 2020, interpreting the observations was limited. Recalls reported in 2021 were also similar to 2020 as compared to before Covid-19.

These reductions most likely resulted from a combination of factors, Covid-19 related issues, and improvements in allergen labelling procedures by FBOs through programmes by the FSA (Walker, 2018).

3.4. Recalls by reason

In the 597 recalls issued, six distinct reasons were identified (Fig. 4) through common keywords (Table 2) present in recall documents, and the overall context of each recall was analysed to facilitate the coding of reasons. With certain limited exceptions, the labelling of a pre-packed food must include a list of ingredients (LI) in descending order of weight, as recorded at the time of their use in the manufacture of the food (European Union, 2011, Art. 18). Omission from the LI of intentionally added foods containing priority allergens (i.e. in the product specification but not present in the LI), was the main reason (Omission of priority allergens in LI) for FAR recalls in the UK (40.0%). This was significantly higher than cross-contamination (18.9%) where products were found to unintentionally contain traces of other unwanted allergens which might have entered at any point throughout the

manufacturing stages by accident (Food Standards Agency, 2021b), and mispacks (17.1%) where products were put in the incorrect packaging (Walker et al., 2018). The three lowest incidences of reasons behind recalls were unemphasised priority allergens in the LI (10.2%) which were not distinguished from other non-allergenic ingredients correctly (European Union, 2011, Art. 21(1)(b)), recalled products not being labelled (e.g. name of the food, LI, and other mandatory particulars (European Union, 2011, Art. 9) in a language easily understood by consumers in the Member States where the food was marketed (European Union, 2011, Art. 15(1)) which is English in the UK (7.1%), and misleading food information contrary to Art. 7 of European Union, 2011 (6.7%) where demonstrably false ‘free-from’ claims were made that products were plant-based, vegan-friendly, or ‘free-from’ [a particular ingredient, e.g. milk, egg, or nuts] but were found to contain the specified allergens that were declared ‘free-from’. It is instructive for allergen management to stratify cross-contamination and unintended allergen presence (UAP) with these false claims generally in products that have been declared to be free of the specified allergen.

The most common reason recorded in recalls from Australia and New Zealand, Canada, Europe, Hong Kong, the UK, and the US from 2011 to 2014 used the term ‘not indicated on label’ (Bucchini et al., 2016), as well as alerts in the UK from 2016 to 2019 using the term ‘mislabelling’

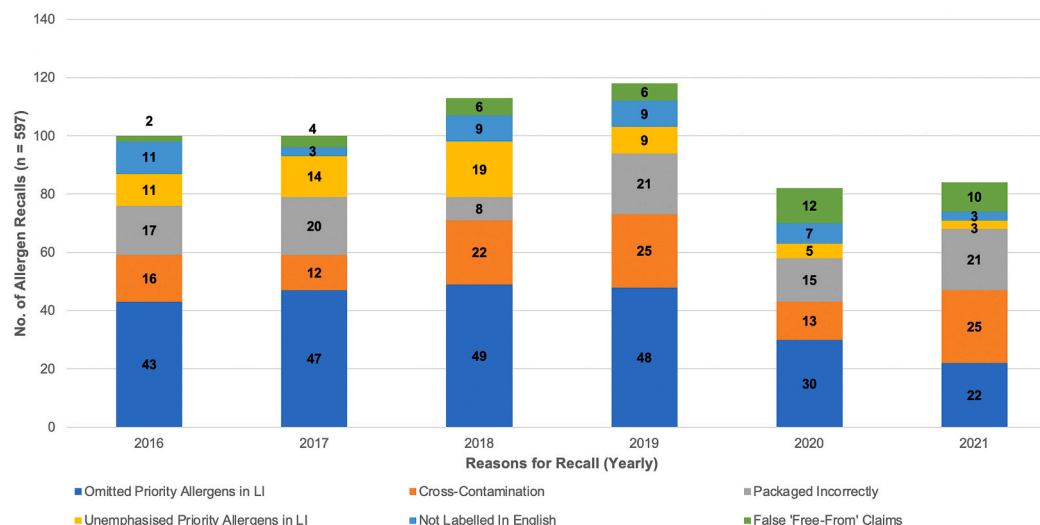


Fig. 4. Reasons for allergen-related product recalls related to the list of ingredients (LI) from 1 January 2016 to 31 December 2021.

(Jia & Evans, 2021). Similarly, most reported global food allergen recalls from 2011 to 2020 were also determined to be due to undeclared allergen information (Soon & Abdul Wahab, 2021). However, it is essential to note that there were slight differences in determining and classifying the reasons in previous studies. This study relies on a new method of characterisation of keywords utilised in the recall documents and highlighted in Table 2. Furthermore, different food regulatory bodies have different criteria when recalling foods and even within the UK this is not consistent, having different keywords used across the same type of FAR recalls reported by the FSA/FSS and the food manufacturers (Bucchini et al., 2016; Soon & Abdul Wahab, 2021). Causes of recalls provided by the FSA/FSS and food manufacturers might differ as well, with the latter providing more accurate descriptions in some cases (Food Standards Agency, 2020e).

Allergen-related recalls, increasing globally and more frequent compared to other recall types (Soon & Abdul Wahab, 2021), deserve closer attention for a number of reasons. Some have been outlined above (introduction) but in addition, as exemplified by our findings: (a) the life-threatening potential of UAP for consumers who purchase food based on 'allergen-free' claims for medical or dietary reasons (Messina & Venter, 2020); and (b) consumers are likely to trust allergen labelling from reputable FBOs (Gendel et al., 2014), potentially with unwanted allergic reactions when those FBOs make labelling errors (Verma et al., 2017).

Moreover, apart from two maximum limits in EU/UK food law for regulated food hypersensitivity food groups, 'gluten-free' with a limit of 20 mg/kg gluten and sulphites with a limit of 10 mg/kg as SO₂ stated in Commission Implementing Regulation (EU) No. 828/2014 (European Union, 2014) and Regulation 1169/2011 respectively (European Union, 2011), other 'free-from' labelling statements remain non-specifically regulated under general food law (Food and Drink Federation, 2015; Food Standards Agency, 2020f). Interestingly, a 'gluten-free' statement is potentially confusing if it leads consumers to expect gluten-free foods to contain no gluten at all (Makovicky et al., 2017). The question of 'how much is too much' [allergen], first posed by Taylor et al., 2002, has received considerable attention but as yet no official sanction has taken place (Houben et al., 2020; Remington et al., 2022). However, the question of thresholds or action levels for priority allergens is currently under discussion at Codex (FAO/WHO, 2021a; FAO/WHO, 2021b; FAO/WHO, 2022).

3.5. Recalls by manufacturer

From 2016 to 2021, 316 unique manufacturers or FBOs issued 597 recalls for a total of 1213 unique products (updated prior versions of products excluded, Fig. 5). Throughout the six years, 52.5% (166/316) recalled one product, 30.4% (96/316) recalled two to five products, and 17.1% (54/316) recalled at least six products.

The eight FBOs with the highest frequency of food recalls were Lidl, Waitrose, Tesco, Sainsbury's, Asda, Co-Op, Morrisons, and Booths, which are major UK supermarket chains based on grocery market share percentages (Coppola, 2021), excluding Booths which mainly operates in Northern England. These eight organisations combined were responsible for 28.9% and 18.8% of total recall frequencies and the number of products recalled respectively, reflecting the market share that these organisations hold in the food industry although it is important to note that these results only look at FAR recalls. Lidl, a German-based discount supermarket brand issued 67.6% (25/37) FAR recalls due to allergen information and ingredient list not being labelled in English, although this labelling error was not observed from 2020 onwards. A contributory factor may be that Lidl operates a 'world food theme' and sources products in multiple countries (Competition & Markets Authority, 2018).

Interestingly, all the eight FBOs have issued recalls due to either cross-contamination or the presence of unwanted allergens, accounting for 23.3% of their combined recalls despite their investments in BRC7 (British Retail Consortium Global Standard 7) facilities to control allergen risks and having the capabilities to manufacture food products on different production lines or sites (Food and Drink Federation, 2015). With significant recall costs at an average of £1 million per recall (Walker, 2018) improved practice guidance for FBOs to ensure adequate allergen labelling is required.

Operational errors derived from 12 internal and five external factors were characterised and analysed in 60 recalls by the FSA from 2018 to 2019, with errors in labelling checks (21.7%), updating ingredient data (16.7%), and checking of packed products (10.0%) being the most common reasons for allergen labelling lapses. In addition, 24 operational errors were tentatively established through literature reviews, setting a starting point for manufacturers to evaluate their manufacturing practices and identify areas of concern (Jia & Evans, 2021). In addition, lack of or miscommunication of allergen information

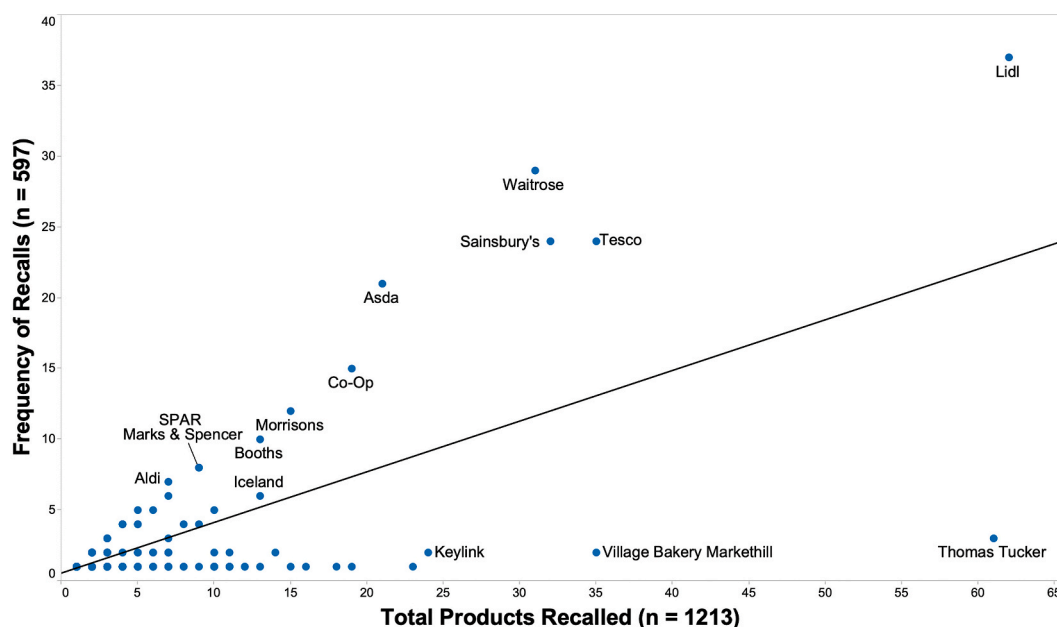


Fig. 5. Relationship between the frequency of recalls and total products recalled by 316 unique manufacturers from 1 January 2016 to 31 December 2021.

by ingredient suppliers across the supply chain, is a factor (Soon & Abdul Wahab, 2021). It is important to note that as the root causes of why recalls occur tend to be under-reported, the reversal of this trend should be highly encouraged (Soon & Abdul Wahab, 2021).

It is a legal obligation for FBOs to be responsible in carrying out risk assessments, disclose any allergen lapses if food leaves the FBO curtilage, and make the decision to initiate any recalls by informing the FSA/FSS and the local enforcement authorities (Food Standards Agency, 2019b). After product recalls are officially reported by the FSA or FSS through the alert platforms, consumers can choose to be notified by opting for the free email or text message subscription service (Food Standards Agency, 2022b). Retailers would post information on these recalls both digitally on their websites and physically in shops at affected outlets to disseminate relevant information of the recalls such as the products and allergens affected, batch codes, and expiry dates to consumers (Food Standards Agency, 2021c). In addition, to raise awareness of the recalls, many local news websites publish information on these details to maximise the reach (Gibbons, 2021; Doody, 2022; Miller, 2022). These actions will allow for the recalled products to be removed from the shelves and avoid any potential risks (Food Standards Agency, 2019b).

An important and significant food allergen case study is the unfortunate death on 18 April 2019 of the teenager Ruben Bousquet, after consuming 'allergen-free' popcorn purchased at an Odeon cinema outlet, which was determined at inquest to have been cross-contaminated with cow's milk allergen. Unfortunately, the root cause of when and where the cross-contamination occurred was not determined, citing untimely food allergen sampling and testing (Courts and Tribunal Judiciary, 2020). After the incident, the popcorn manufacturer, Thomas Tucker Ltd, issued three recalls of 61 products in total in August 2019 (Fig. 5) after establishing the presence of milk proteins in various popcorn products.

3.6. Recalls by expiry status and genre of food

To the best of our knowledge, this is the first report on the expiry status of FAR recalls in the UK. A limitation of the recall data provided by FSA/FSS and FBOs was that only 80.4% (480/597) of FAR recalls provided expiry date information (either best-before or use-by dates); 15.9% of recalls had no expiry dates provided (every product produced before this point were recalled, with the term 'all date codes' present in recall notices), and 3.7% of recalls classified as updates were omitted. While most of the recalled products were not near their expiry dates, there were some on the verge of expiring or had passed their expiry dates at the time of recall.

About one-fifth of the recalls did not provide specific best-before or use-by dates despite the collaborative efforts between the FSA/FSS and FBOs across the supply chain when initiating recalls of affected allergenic food products (Randles, 2018). Furthermore, recall alerts which mentioned 'all date codes' in the recall notices indicate a lack of traceability in the food supply chain as they were unable to pinpoint when the specific batches affected were first manufactured (Food Standards Agency, 2019c). This contrasts with most recalls which provided specific batch codes with either best-before or use-by dates to inform consumers on which specific batches were affected.

For recalls with expiry date information provided, the expiry statuses

Table 3
Expiry classifications of allergen-related product recalls by best-before and use-by dates from 1 January 2016 to 31 December 2021.

Expiry classification	Best-before dates	Use-by dates	Total
Not Expired	303	34	337
Expire within 7 days	33	81	114
Expired	15	14	29
Total	351	129	480

of the recalled products were stratified as 'not expired', 'will expire within seven days', or 'already expired at the time of recall' (Table 3). For 29 products that were already expired at the time of recall, 14 were products with use-by dates (48.3%), while 15 products had best-before dates (51.7%). Out of 114 products that would expire within seven days from the time of recall, 81 were products with use-by dates (71.1%), while the remaining 33 were products with best-before dates (28.9%).

While all FAR recalls present a certain degree of risk to consumers with food allergies, it is concerning that some recalls are issued close to or after the product expiry dates. This deprives relevant consumers of the opportunity to be notified and protect themselves (European Commission, 2018). While consumers who understand the difference between best-before and use-by dates will not consume products after the expiry of their use-by dates, negating the allergen risk, there is in fact poor public understanding of the difference between 'use-by' and 'best-before' (Toma et al., 2020; Ipsos Mori, 2021; Barone & Aschemann-Witzel, 2022). As products with best-before dates are still microbiologically safe to consume, it is possible for these products to be retained and consumed even after the relevant date (Ipsos Mori, 2021). The classification of the genre of food and their expiry status are outlined through cross-tabulation in Table 4, with nine food categories identified and are split into different expiry statuses. For recalls with expiry dates provided (n = 480), cereal and bakery products accounted for 30.4% of all recalls, followed by ready-to-cook and sugar-based confectionery with 24.6% and 13.8% respectively. Cereal & bakery products exhibited the highest recall rate, and this trend is supported by 19.8% of UK recalls from 2013 to 2016 (Food Standards Agency, 2017b) and 31.5% of US recalls from 2007 to 2012 (Gendel & Zhu, 2013). While 70.2% of FAR recalled products were not expired from the date of recall, 23.8% of recalls were set to expire within seven days, while 6.0% of products had expired.

Ready-to-eat, ready-to-cook and cereal & bakery products exhibited 54.3%, 48.3%, and 30.8% respectively of recalls that were within seven days of or had past their expiry dates. These products include bread, sandwiches, or fresh foods, which are kept at either ambient or refrigerated conditions with short expiry dates (Brunner et al., 2010) and quick turnover, hence more focus should be placed on these genres by FBOs and regulatory bodies to reduce FAR recalls. Despite having more recalls than ready-to-eat products, fewer sugar-based confectionery recalls were near-to or had their date expired (Table 4). No doubt this is due to high sugar/low water activity which reduces spoilage, leading to longer shelf-life (Subramaniam, 2011).

Regardless, inaccurate allergen labelling across all genres of food still pose unnecessary risks to consumers. Information sent out to consumers might not be immediate as it takes time for recall processes to be initiated (Food Standards Agency, 2017b), and each day spent evaluating potential risks and costs involved in recalling the products could potentially lead to consequences for consumers with food allergies (Walker et al., 2018).

Table 4
Cross-tabulation of the genre of food based on expiry status of allergen-related product recalls from 1 January 2016 to 31 December 2021.

Genre of Food	Not Expired	Expire within 7 days	Expired	Total
Beverages	11	0	0	11
Cereal & Bakery Products	101	31	14	146
Condiments, Dressings, Sauces & Spices	48	6	0	54
Nut, Nut Products & Seeds	15	0	0	15
Ready-to-cook	61	48	9	118
Ready-to-eat	21	21	4	46
Soups & Broths	8	3	1	12
Sugar-based Confectionery	60	5	1	66
Supplements	12	0	0	12
Total	337	114	29	480

4. Conclusion

The findings from this study will provide useful information for both FBOs and regulatory bodies to collaborate and implement more robust allergen detection systems to focus their efforts on the most affected areas to reduce recalls, as well as to improve future prevention strategies. These findings will also provide useful comparisons towards food allergen recalls status in other countries, particularly the trends in recent years.

Allergen-related recalls remain the main type of food recall in the UK. The main UK trends reflect global trends in economically comparable jurisdictions. The decline in allergen recalls in 2020 from 2019 followed by a slight increase in 2021 may have been for reasons largely associated with the Covid-19 pandemic, but other factors may have been in play. It will be interesting to see if the previous upward trend in year-on-year allergen recalls resumes. The root causes of allergen-related recalls tend to be under-reported; the reversal of this trend should be highly encouraged with open disclosure and collation of root cause information to assist in reducing allergen recall frequencies.

A significant number of products were either date-expired or within seven days of date expiry at the time of recall. Products with 'best-before' dates ($n = 351$) dominated those with 'use-by' dates ($n = 129$) in the data (Table 3) however the latter exhibited a much higher percentage within seven days of expiry (62.8% against 9.4%), and over twice the level of date-expired products (10.9% against 4.3%). Despite the recall therefore consumers with allergies may have consumed these products without being aware of the allergen risk. Ready-to-eat, ready-to-cook, and cereal & bakery products, which may have a short shelf-life, exhibited high frequencies of recalls that were within seven days of or had expired and should be closely monitored. To the best of our knowledge, this is the first report which looked at the expiry status of FAR recalls in the UK.

The pace of international activity on allergen risk analysis and risk management has accelerated in the last year including a FAO/WHO series of three expert group reports in 2021. These reports include recommendations on priority allergens (FAO/WHO, 2021a; FAO/WHO, 2022), establishing reference doses for some priority allergens (FAO/WHO, 2021b), and PAL statements (FAO/WHO, 2021c). The FAO/WHO recommendations will be discussed within Codex Alimentarius and may well lead to revisions in the General Standard for the Labelling of Prepackaged Foods, (Codex Alimentarius, 2018). This in turn may lead to revised labelling legislation in the future, with the FSA recently consulting on the provision of PAL in the UK (Food Standards Agency, 2022c).

The implications of these developments include current 'free-from' and 'gluten-free' statements that may need to be revised. The ambiguity of a PAL statement while relevant to wheat-allergic individuals on a 'gluten-free' product suitable for those with coeliac condition is nevertheless confusing (European Union, 2011; Food Standards Agency, 2017a; Makovicky et al., 2017). There is currently no regulation for other 'free-from' foods (Food and Drink Federation, 2015). Thus, this study is timely in providing a baseline analysis of recall data prior to potentially far-reaching changes in food allergen risk analysis, risk management, and legislation.

However, it is important to note that there are limitations in this study such as data obtained from regulatory bodies and manufacturers were generic with limited detail of each recall, and FAR recalls reported by the regulatory bodies only comprise of incidents alerted to them and there could be FAR-affected products currently on the shelves undetected. In addition, there was no information on the quantifiable results from analytical evaluations or risk assessments performed for each recall from the publicly-available data. Furthermore, there were also discrepancies in the number of food alerts between the FSA and National Archives, and FSA datasets, where some recalls were missing from the latter. With regards to how the recalls were initiated, for recalls reported by the FSA from 2013 to 2016, 61% of alerts were from the food

industry, 29% were from local authorities, 5% were initiated by the European Union, and the remaining 5% were by governmental organisations, laboratories, and consumers (Food Standards Agency, 2017b). However, information for recent years is not available from the FSA/FSS currently. The specific data examined in this study illuminate some of the reasons for allergen recalls, however there are many influencing variables hence we have discussed our findings in the light of other related work.

In the context of improving the handling and reporting of allergen-related product recalls, we put forward several recommendations. Businesses are performing relatively well considering that the number of affected products being recalled are low compared to the total amount of food products being manufactured in the UK (Department for Environment, Food & Rural Affairs, 2022), although products with inaccurate allergen information are still making their way to consumers. Manufacturers and retailers need to focus on managing allergen labelling at all stages of the supply chain to drive down recalls by recognising the errors prior to distribution to retailers, particularly recalls of omitted priority allergens in LI, packaged incorrectly, unemphasised priority allergens in LI, and not labelled in English. These are categories which should not slip past the manufacturers' own risk management systems to consumers in the first place, and strengthening their in-house checks would make food safer for consumers susceptible to food allergic reactions (Soon & Manning, 2017). Furthermore, the advancement of food allergen detection technologies such as enhanced lateral flow devices with optical readers on smartphones which are more rapid and straightforward to use as compared to conventional bioanalytical methods, can be used for faster on-site analysis and results (Ross et al., 2018; Nelis et al., 2020). In addition, the implementation of standardised reporting procedures and incentive-based improvements in checking appropriate allergen labelling in the UK with a strict and systematic checklist before distribution to retailers will be beneficial towards FBOs, food regulatory bodies, and consumers (Food Standards Agency, 2020e; Jia & Evans, 2021). This can also be complemented with the usage of quality assurance systems with interactive or text-based artificial intelligence capabilities to scan the packaging and detect food products which do not conform to labelling guidelines before they are released to the market, preventing recalls from occurring in the first place (Friedlander & Zoellner, 2020). By addressing these labelling issues early, it would undoubtedly reduce economical and reputational damage caused by recalls (Pozo & Schroeder, 2016; Food Standards Agency, 2020a).

Further work is required to identify potential advancements for food manufacturers and regulatory bodies in early detection of FAR recalls before affected products are distributed to retailers for sale to consumers, and analysis of other variables such as the impact of embracing a blockchain-based allergen declaration system for uniform reporting across the food industry. In addition, it would be useful to look at future recalls regarding allergens in both PPDS food and non-prepackaged food as new legislation such as Natasha's Law gets implemented and evidence on these recalls becomes available to see how FBOs disclose and monitor food allergens. These improvements and recommendations above will ultimately help to make the UK a safer place for consumers with food allergies by improving both the safety and quality standards of food.

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CRedit authorship contribution statement

Sim Ray Yue: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Rajeev Shrivastava:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision. **Katrina Campbell:** Conceptualization, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. **Michael John Walker:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision.

Data availability

Supplementary data for the study is available at Mendeley Data Repository: <https://doi.org/10.17632/n9tjg5szgb.2>

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Appendix A. Supplementary data

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