Global food recalls and alerts associated with labelling errors and its contributory factors

Abstract

Background: Food recalls and alerts associated with undeclared allergens and other forms of labelling errors are on the rise. Besides undeclared allergens, other mislabelling such as undeclared ingredients, providing wrong shelf-life, wrong or lack of storage instructions also pose significant health consequences to consumers. Hence, by identifying the causes of labelling errors, this would facilitate preventative and mitigating strategies in food supply chain. The aim of this study is twofold. First, the study aims to identify the affected food and drink categories, types of allergen, and other labelling issues and associated labelling errors. Second, it aims to identify the causes or contributory factors of labelling errors.

Scope and approach: This study reviews food recall, withdrawals, and alerts of five official food safety websites (Canadian Food Inspection Agency, Food Standards Australia New Zealand, UK Food Standards Agency, US Department of Agriculture Food Safety Inspection Service and US Food and Drug Administration) from 2011 – 2020.

Key findings and conclusions: A total of 2,470 food recalls and alerts linked to labelling errors were identified. Undeclared allergens were identified as the most common type of recall. Among the 2301 recalls and alerts associated with food allergens, 3,100 undeclared allergens were reported of which milk (26.55%), gluten (13.16%) and tree nuts (11.52%) were recorded as the top three contributors. Food products most affected by undeclared, incorrect or missing information associated with food allergens were baked goods (18.65%), ready-to-eat meals / heat and serve (11.10%) and confectionary (10.87%). There were alerts and recalls associated with undeclared ingredients (n=67), wrong expiry dates (n=36), undeclared ingredients & allergens (n=26), and other labelling issues such as incorrect claims or wrong usage / storage instructions (n=40). Most labelling errors remain unknown or un-reported. Where known or suspected causes were reported, packaging and printing error, supply chain failures, product formulation and ingredient change, cross contact and process failure / manufacturing error were recorded as contributory factors. The root cause of labelling error remains underreported or unknown and should be documented clearly and/or investigated further.

Highlights

- Labelling errors were divided into undeclared allergens, incorrect information, missing information, and illegible print.
- Milk, gluten, tree nuts, eggs, and soy were identified as the main undeclared food allergens.
- Baked goods, ready-to-eat/heat-and-serve and confectionary were the food categories with the highest number of undeclared allergens.
- Most labelling errors were due to un-reported or unknown causes; hence the contributory factors were not identified.
- Other reported known or suspected causes include packaging and printing error, supply chain failures, product formulation and cross contact.

Keywords: allergens; cross contact; food recall; ingredient change; labelling error; packaging error; product formulation; supply chain failure

Introduction

Food labelling is essential to help consumers to make healthier and safer food choices. Food labels allow consumers to make purchasing decisions that minimise (potentially lethal) personal health risk (e.g. in respect of food allergies). They allow consumers to make valid purchasing decisions and they evidenced that the product to be purchased is within its designated shelf life. Labelling also permits purchasing decisions to be aligned with personal beliefs and dietary restrictions (e.g. vegetarian or vegan products, halal, etc.). Finally, labelling permits consumers to select their favoured brands or products and allows people to plan how and when to use it. Regulations are in place globally to protect consumers. The Codex Alimentarius (Food Code) is a set of international food standards and guidelines including food allergen labelling that is used as a key reference by 186 countries worldwide. Codex Alimentarius recommends the declaration of 8 foods and ingredients known to cause hypersensitivity (FAO/WHO, 1991) on food packaging. Furthermore, in the UK, it has one of the strictest food allergen labelling requirements in the world, including Natasha's Law (whereby food businesses must include full ingredients labelling on pre-packaged foods for direct sale) that came into force in October 2021 (FSA, 2021a). It is currently mandatory that food labels declare 14 food allergens in the UK (FSA, 2021b) and EU (EU 1169/2011). Even so, despite these stringent legal requirements, it remains the case that annually in the UK, thousands of individuals suffer from serious allergic reactions to food that they have purchased and consumed (FARE, 2021; Marchisotto et al., 2017;). Food allergen labelling regulatory frameworks differ according to different countries. For example, US Food Allergen Labeling and Consumer Protection Act of 2004 (FALCPA) identified eight foods as major food allergens (egg, fish, milk, peanut, shellfish, soy, tree nuts, wheat). Sesame was added to the main allergen labelling list through the passing of the Food Allergy Safety, Treatment, Education and Research (FASTER) Act on 23 April 2021 and will become effective on 1 January 2023 (US FDA, 2021). The priority allergens in Canada are crustacean, egg, fish, milk, peanut, soy, tree nuts, wheat and triticale, sulphites, molluscs, mustard and sesame (Government of Canada, 2020). The Food Standards Code in Australia and New Zealand requires suppliers to declare the following food allergens (egg, fish, lupin, milk, peanut, sesame, shellfish, soy, tree nuts and wheat) when present (FSANZ, 2020a). In UK, 14 allergens are required to be declared including celery, cereals containing gluten, crustacean, egg, fish, lupin, milk, mollusc, mustard, peanut, sesame, soy, sulphite and tree nuts (FSA, 2021b).

Food recalls associated with undeclared allergens were identified as the most common cause of recalls and withdrawals globally (Potter et al., 2012; Sheridan et al., 2020; Soon et al., 2020; Spotz, 2018). Food Standards Australia and New Zealand (FSANZ) reported that between 2010-2019, undeclared allergens accounted for 40% of the total food recalls (FSANZ, 2019). Similarly, undeclared allergens were the leading cause of food recalls in the United States (Friedlander, 2020; Spotz, 2018). The number of undeclared allergens in Rapid Alert System for Food and Feed (RASFF) notifications had also increased in the past years (Soon et al., 2020; Yeung & Robert, 2018). Previous studies revealed that between one to four undeclared allergens were detected in food products (Blom et al., 2018; Remington et al., 2015; Shelver et al., 2021). Elevated levels of allergens such as milk and gluten were also found in food products declared as milk-free or gluten-free (Bedford et al., 2017; Bianco et al., 2022; de lar Barca et al., 2021). Labelling errors resulting in food allergens exposure impose considerably high healthcare and economic costs for food allergic and intolerant patients.

Food recalls associated with other forms of labelling errors had been reported due to undeclared meat species and ingredients, incorrect information such as wrong shelf life, and missing information (FSA 2020; FSANZ, 2020b; US FDA, 2019; USDA FSIS, 2020). Undeclared poultry and meat species were found in processed meat products. For example, Kane and Hellberg (2016) reported 21% (out of 48 samples) of meat and poultry samples contain additional undeclared meat species. Meanwhile a study by Chuah et al. (2016) revealed 78% of meat and poultry products contain false declaration of species and/or presence of undeclared meat species. Undeclared species in food products cause consumers to lose confidence and trust in supply chain as consumers are not getting what they paid for, and consumption of some animal species are forbidden due to religious beliefs. Incorrect information such as using 'best before' instead of 'use by' for high risk perishable foods in regions where perishable foods are considered unsafe after the 'use by date' in the EU and products must not be marketed after the date (Regulation EU 1169/2011). Providing the wrong extended expiry date (when the product had expired) can pose food safety issues to consumers.

Previous studies on food recalls, outbreaks and incidents associated with microbiological (Dada et al., 2021; Qiu et al., 2021; Somorin et al., 2020), chemical (Piglowski et al., 2019), allergen (Bucchini et al., 2016; Padua et al., 2018), physical hazards (Djekic et al., 2017), food products (D' Amico et al., 2018; Caldeira et al., 2021) and food contact materials (De Leo, 2020) had been conducted. However, studies on food recalls associated with labelling issues remain under-reported. The aim of this study is to analyse recalls or alerts in official food alerts, allergy alerts or food recall sites related

to labelling issues between 2011 to 2020. The secondary aim of the study is to identify the causes or contributory factors of labelling errors.

Scope and Approach

A systematic search and review of food recall, withdrawals and alerts was conducted. Table 1 lists the official food safety websites used to collate the information from 2011 – 2020. This timeframe was selected as Potter (2012), FSANZ (2019) and Soon et al. (2020) had conducted reviews of product recalls and undeclared allergens in the previous decade. Data from official websites were used as the websites provide credible, detailed, and accurate records of food recalls and alerts. Food alerts, public health alerts and allergy alerts that resulted in product recalls were also included in the search. A food alert is issued when an incident has occurred and may result in serious public health issue resulting in immediate action such as product recall. An allergy alert is issued when the allergy information on food label is incorrect or missing and the foods need to be recalled (FSA, 2020; FSS, n.d.). The same recall affecting multiple products (e.g. bakery, confectionary, appetisers) were counted once and only the most affected food product category was documented. Table 2 shows the type of data collected. The details of the labelling error were reviewed and categorised into types of labelling error i.e. undeclared allergen, undeclared ingredients, illegible print, incorrect information and missing information. If the cause or potential cause of errors were reported, these were collated and categorised into nine types of known/suspected causes or contributory factors i.e. cross contact, mislabelling, packaging error, printing error/artwork, process error/manufacturing error, product formulation & ingredient change, supplier change, supplier's ingredient and others (e.g. employee error, fraud, lack of knowledge, miscommunication). The contributory factors were classified using terms from US FDA and FSIS recalls, Bucchini et al. (2016) and Gendel and Zhu (2013). Where further information was unavailable, the suspected cause was categorised as un-reported or unknown. All data were extracted and transferred to Microsoft Excel. Data were screened to ensure repeated records were not duplicated including identification of withdrawal of recall announcements and amendments (Potter et al., 2012). Both the first and second author carried out random search validation with the original websites and triangulated the data with journal articles, company websites and media to ensure accurate data were recorded. Chord diagram provided by Fluorish (https://public.flourish.studio/visualisation/7570555/) was used to link the known/suspected causes and contributory factors of labelling errors to food and drink categories.

Insert Table 1 here

Insert Table 2 here

Results

Product recalls and alerts associated with labelling errors

2,470 product recalls and alerts associated with labelling errors were documented. This was divided into incorrect, missing or undeclared allergen information (93.16%), undeclared or incorrect ingredient information (besides allergen information) (2.71%), expiry date (1.46%), incorrect information for both ingredients and allergens (1.05%) and other labelling issues such as incorrect claims or identified as RTE when it's raw or missing nutrition facts (1.62%).

Labelling errors associated with allergens

A total of 2,301 recalls linked to allergens were identified. Undeclared allergens were identified as the most common cause of recall. 3,100 undeclared, incorrect, or missing information associated with food allergens were reported between 2011 – 2020. The number of recalls associated with labelling errors (n=2,301) were lower compared to the number of undeclared food allergens (n=3,100) since some foods contain two or more undeclared food allergens,. Milk (26.55%) received the highest number of reported recalls or alerts followed by gluten (13.16%), tree nuts (11.52%), eggs (11.42%) and soybean (11.03%) (Figure 1). Where identified, tree nuts such as almond (32.21%), walnut (16.25%) and cashew nut (10.36%) were the main tree nut allergens. There was 92 (3.99%) recalls where food and drink products contained more than three food allergens. Bakery products (18.65%), ready-to-eat meals / heat and serve (11.10%), confectionary (10.87%), savoury snacks (5.42%) and appetisers / sides (5.32%) were the most frequently reported food products with undeclared allergens (Figure 2).

Insert Figure 1 here

Insert Figure 2 here

The main type of labelling error was undeclared allergen (94.91%), followed by incorrect information (4.61%), missing information (0.39%) and illegible print (0.09%) (Table 3). Incorrect information includes incidents of declaring food products as free-from or low in certain food allergens e.g. 'gluten-free', 'dairy free', 'egg free', 'vegan' or even statement like 'product is free from all 14 food allergens' but the food products were found to contain the advertised free-from allergen. There were also reports of ambiguous labelling e.g. labelled as gluten free in the front-of pack labelling, but declared gluten in the ingredient list or stated Vitamin A (partially derived from fish oil) in

Supplement Facts section, but then stated 'Contains no common food allergens'. Among the type of incorrect information, printing or artwork error was a recurring theme. Food allergens were not emphasised correctly (e.g. not in bold font) or not declared in English in the UK, where it is mandatory to emphasise allergenic ingredients in the ingredient list by using bold font, contrasting colours or by underlining them (FSA, 2017). Missing information includes absence of advisory allergen labelling, ingredient list or lack of label. Although advisory allergen labelling is voluntary worldwide, some food businesses decide to recall their products when they realised the information were missing. Illegible print such as blurred ingredients and allergen labelling in print makes it difficult to read the statements.

Insert Table 3 here

Known/suspected causes or contributory factors for undeclared allergens

Based on the 2,301 labelling errors, we further categorised the reported and/or suspected causes and contributory factors for food allergens. Un-reported or unknown causes account for 66.28% of the labelling errors. Packaging error (15.86%), supplier's ingredients (5.74%), printing error (3.52%), product formulation and ingredient change (4.56%), cross contact (2.48%), change in supplier (0.43%) and process failure / manufacturing error (0.26%) were other known or suspected causes for undeclared allergens. An additional category for 'others' (0.87%) including miscommunication, lack of knowledge, employee error, fraud and supply chain error were documented. Among the known / suspected causes, packaging error (n=365) (please refer to turquoise arcs in Figure 3) commonly occurred in RTE meals / heat and serve (20%), bakery (12.33%) and confectionary (11.51%). Supplier's ingredients (yellow arcs) were identified as another main contributory factor in similar food categories such as baked goods (15.91%), confectionary (13.64%) and RTE meals / heat and serve (8.33%) (Figure 3).

Insert Figure 3 here

Labelling errors associated with ingredients

Incorrect ingredient information and undeclared ingredients were reported in various food and drink categories (n=67) especially in raw/cured and/or fermented meat and fish (35.82%), appetisers/sides (11.94%) and frozen meat and poultry-based products (10.45%). Undeclared ingredients include other meat and poultry species such as pork, beef, sheep, turkey, and chicken; preservatives such as sodium benzoate and sodium nitrite and flavour and sensory enhancer such as aspartame, colouring,

and monosodium glutamate. Incorrect information was identified in 8.95% of the food and drink products and the rest were due to undeclared ingredients. Examples of incorrect ingredient information include incorrect serving sizes, labelled as zero sugar when it contains sugar and exceeding marked alcohol content. The known or suspected causes for incorrect information include process failure / manufacturing error. For example, alcoholic beverages with exceeded marked alcohol due to secondary fermentation were linked to process failure. The cause for undeclared ingredients were largely un-reported or unknown (61.19%). Known or suspected causes associated with undeclared ingredients were packaging error (16.42%), printing error (1.49%), ingredient change or product formulation (4.48%), supplier's ingredient (1.49%), change in supplier (1.49%) and others (4.48%).

Other forms of labelling issues

Wrong expiry dates were notified in 36 food and drink products with both chilled, raw prepared meat and poultry (22.22%) and raw/cured and/or fermented foods (19.44%) being the most prevalent. All labelling errors associated with wrong expiry dates were identified in Australia, New Zealand, and UK official sites, where foods cannot be legally sold after the use by date as they may pose health or safety risk (FSA, 2021c; FSANZ, 2021a). Incorrect use by dates, for example food product was labelled as '12 February 2022' instead of '12 February 2020' or labelled as Feb 2016 instead of Jan 2016 were found in 31 recalls while incorrect best before dates were associated with five food recalls.

Other labelling issues such as providing incorrect information (60%) and missing information (40%) were found in 40 food and drink products. Wrong information such as inaccurate usage or consumption advice, incorrect cooking instructions, incorrectly bear USDA Mark of Inspection (when the company was not authorised to use the logo), incorrectly identified as RTE, and making false 'no antibiotics' claim were notified. Missing information includes missing cooking instructions, storage instruction or safe handling instructions, missing list of ingredients, nutrition facts, establishment number or USDA mark of inspection. There were also recalls where combination of undeclared ingredients & allergens (n=26) were found.

Discussion

Our findings are in line with previous studies where labelling error is the predominant cause for recall. Bucchini et al. (2016), reported between 42-90% of food recalls were explained as 'Not

indicated on the label' while Potter et al. (2012) stated mislabelling is consistently listed as one of the top three causes of recall in food industry (Potter et al. 2012). This study reveals the high rates of labelling errors leading to global food recalls and withdrawals.

Milk, gluten, soy, eggs, and tree nuts were identified as the main undeclared food allergens in this study encompassing Australia and New Zealand, Canada, US, and UK. Similarly, previous studies identified that milk, egg, tree nuts and wheat represented the most common undeclared food allergens in North America food recalls (Bucchini et al., 2016; Malyukova et al., 2012), undeclared milk, gluten, and egg were reported in Australia and New Zealand (Bucchini et al., 2016; Sheridan et al., 2020) and European Union (Bucchini et al., 2016; Padua et al., 2019). The high rates of undeclared allergens were also supported by study of food products imported from Mainland China where samples contained detectable milk, egg and wheat residues at VITAL® Action Level Two and Precautionary Allergen Labelling [PAL] is recommended for such products (Yee et al., 2021). The Voluntary Incidental Trace Allergen Labelling (VITAL®) is a voluntary guidance. It provides a standardised science-based risk assessment process and is highly useful for food industry to assess the impact of allergen cross contact and determine if precautionary statements are required (Taylor et al., 2018; VITAL Allergen Bureau, n.d.) In Blom et al. (2018), patients were followed-up for a year and were asked to report accidental allergic reaction and to send the culprit food products for testing. Cow's milk, peanut and tree nuts were detected in food products that did not declare the allergen on ingredient lists resulting in accidental food allergic reactions among the patients. 37% (n=51) of the products analysed contained 1 to 4 allergens that were not declared in the ingredient list. Although it was not reported in Blom et al. (2018), we suspect that the affected food products were not recalled. In a separate study, up to 23% of food samples (n=1125) were found to contain between 2.5 – 6,471 ppm milk in food products with Precautionary Allergen Labelling (PAL), posing potential health consequences if food allergic consumers were to ignore PAL (Manny et al., 2021).

Baked goods, RTE meals/heat & serve, confectionary, savoury snacks and appetisers/sides were the most common food categories affected by undeclared allergens. These foods are characterised by heterogeneity of raw materials and ingredients and are highly processed foods (Slimani et al., 2009). Studies revealed that bakery products, snacks and candies were the most recalled categories due to undeclared allergens (Do et al., 2018; Gendel & Zhu, 2013). In non-pre-packed bakery items, milk was detected in 31/73 of baked products advertised as 'cow's milk-free' (Trendelenburg et al. 2015), egg and soy were found in 22/363 and 71/284 bakery samples (Khuda et al., 2016a, b). Milk, gluten, egg, and soy were often used as sub-ingredients in product formulation mix. For example, this study

revealed hidden allergens in sub-ingredients such as gluten in soy sauce, egg in egg wash glaze, and soy lecithin in releasing agent. Food labelling can be misleading especially if labels contain unfamiliar ingredient names or derivatives of food allergen (Puglisi & Frieri, 2007). Using proteins such as albumin, lecithin, sodium caseinate and whey and not declaring its common name was another cause for undeclared food allergens. It is a requirement in most food allergen labelling regulations to declare food allergen in simple, plain English terms to ensure clear and uniform understanding (FALCPA, 2004; FSA, 2017; FSANZ, 2021b; Government of Canada, 2018).

Processed meat and poultry products were identified as the main food categories affected by undeclared species. This reiterates previous studies where undeclared species in processed meat continue to be identified in commercial products. Shehata et al. (2019) found 14% (n=100) of sausage products sold in Canada contained >1% undeclared species, while 20.83% (n=48) of ground meat products sold in US were mislabelled (Kane & Hellberg, 2016) and one fifth of meat samples tested in the UK contained species not listed on the label (Mackay, 2018).

Packaging and printing error /artwork

Packaging error has been identified as a cause for undeclared allergens and ingredients. This is consistent with the findings from Gendel and Zhu (2013) where large number of recalls were caused by failures in label control. In our study, incidences of packaging error occurred when the wrong package or label was used, wrong product was used, comingling of labels and food occurred, and lack of label cross checking. If food production uses multiple similar packaging, operators may mistakenly use the wrong packaging. This could be due to complacency or lack of training and label review (Ridler, 2021). This study also revealed that inadequate label review has led to employees using labels produced earlier on the same day or placing the wrong film onto labelling machine. Another potential cause for mislabelling error is labelling food products for export. Certain foods for export require an over-sticker on the ingredient list and if the product has not been relabelled correctly or exported with incorrect allergen information, this could result in international food recall (Ridler, 2021).

Kumar and Budin (2006) reported that inspection of food processors found 50% of food producers did not have any label cross-checking system in place. The lack of label review may have contributed to using the wrong labels. Ridler (2021) suggested implementing a start-up validation process to confirm the product, packaging / label, and other requirements before commencing the production

run. Food label and artwork creation is a lengthy and complex process and goes through an iterative loop of designs, revisions, approval, reproduction, and print (Vazquez et al., 2003). The iterative process and revisions of artwork may leave room for error, especially when regulations changed, and terminologies are updated. Whinnett (2021) discussed some of the common challenges associated with artwork creation and management. Errors in artwork design could potentially be caused by data errors due to copy and paste, misalignment of specification and artwork versions, artworks being managed through disparate systems, availability of cross functional production information and handling of artwork design by cross functional teams.

Cross contact

Cross contact is the unintentional incorporation of food allergen into a food and can occur at any stages of the food supply chain i.e. at farm level to catering services (Do et al., 2018). Cross contact as a reported cause for undeclared allergens was noticeably small in this study. Cross contact was identified as the root cause of 7.1% of allergen recalls (n=732) (Gendel and Zhu, 2013) and between 0-17% of recalls were linked to cross contact in production (Bucchini et al., 2016). Milk, gluten, and peanut were the main allergens reported in cross contact incidences in this study and involved foods such as bakery, confectionary and snacks. The nature and physical state of the allergenic food matrix e.g. gluten in the form of flour and use of milk powder enables the allergen to spread easily (Galan-Malo et al., 2019). Milk powder also contains 8 – 10 times more protein than liquid milk (Diaz-Amigo, 2010). Although the use of peanut paste reduces the spread of allergenic dust compared to crushed peanut or peanut meal, however, it poses a challenge in cleaning (Stone & Yeung, 2010). Similarly, the removal of heterogeneously distributed pieces of allergen materials such as peanut or tree nuts are also difficult (Roder et al., 2008). Cross contact can result from ineffective allergen control programme such as inadequate cleaning of shared processing and packaging equipment, improper production scheduling resulting in allergenic proteins carried over into next product, lack of physical separation, cross contact from airborne dust and aerosols carrying allergenic protein due to handling and cleaning techniques e.g. sieving and use of compressed air for cleaning and lack of allergen-specific validation and verification procedures (Jackson et al., 2008). Food allergen can also be present due to cross contact in the raw material and ingredient supply chains (Spanjersberg et al., 2009). Undeclared ingredients including meat species could also be caused by cross contamination of animal species in processed meat. According to Chung & Hellberg (2020), this is due to incomplete cleaning of grinding equipment leading to cross contamination of animal species.

Supply chain failures

Although supply chain failures are categorised as 'external' types of error and include operational errors caused by suppliers such as missing or incorrect labelling of ingredients (Jia & Evans, 2021), cross contact, switching to alternative ingredients without informing their clients; the causes for supply chain failures are similar to those listed in Figure 3. If an ingredient supplier fails to label all food allergens correctly, it will be difficult for the food manufacturer to declare them correctly. Hence supplier control and effective risk communication of ingredient status across the supply chain are important (Crevel et al., 2010). However, food manufacturers also play a significant role in obtaining and assessing food allergen risks from their suppliers (Jia & Evans, 2021). Supply chain failures have serious consequences as the ingredients may have been sent to different manufacturers or co-packers and could result in multiple nationwide or even international recalls.

Failure to update label due to product reformulation or ingredient change is another cause for undeclared allergen. The failures were mostly associated with lack of communication between supplier – manufacturer – label design. Examples include failure of manufacturer to inform labelling department of the ingredient change; manufacturer submitted the change to the labelling department but the change was not made; company reformulated and updated the labelling but employees incorrectly used the old formulation for production. Lack of knowledge or awareness about changes in food labelling regulations for different regions where the product is to be sold can also cause issues of mislabelling (Ridler, 2021).

Although most incidents were unintentional, it is possible that some of the causes for undeclared allergens and ingredients were linked to fraud. For example, soy and almond proteins were intentionally added to dairy products while gluten containing cereal and soy were added to coffee products as they were cheaper ingredients and could cause serious consequences to public health (de Moura Ribeiro et al., 2017; Visciano & Schirone, 2021).

Unknown or un-reported causes of labelling errors

Most of the reported labelling errors in the review did not specify the actual or suspected cause. . The actual cause for the error was either not reported, unknown or potentially not investigated further. The unknown incidents in this study could be deliberate or unintentional and potentially caused by other factors as shown in Figure 3 or simply due to human error and lack of verification (Kowalska et al., 2018). The huge number of unknown causes of labelling error is a cause for concern. We suggest using the US FDA and FSIS sites as excellent examples of reporting the causes for labelling errors. Both sites provide some of the most comprehensive information on the cause or

factors contributing to mislabelling and recall. It is suggested that the root cause of labelling errors should be documented and/or investigated to prevent similar incidents.

Limitations

The Rapid Alert System for Food and Feed (RASFF) was not included as the site was undergoing site maintenance during the review. RASFF was reviewed in numerous previous studies. Not all sites have a complete list of food recalls from 2011 – 2020. Only official and publicly available sites in English language were included and therefore relevant sites in other languages were missed. The high number of recalls from the official sites should not be negatively regarded as poor manufacturing practices and allergen control, but potentially due to better surveillance and reporting systems. Some food and drink categories were not detailed in the official sites, and the products were categorised based on the descriptions provided. This study did not include an analysis on the evolution or changes to food labelling regulations. It is likely that legislative changes affected labels and could result in labelling errors especially when food labels were not updated accordingly. It is also complex, lengthy, and resource-consuming to conduct a full investigation for each recall hence, most recalls or alerts did not include the suspected or actual cause for the labelling error. A large proportion of contributory factors for undeclared allergens and ingredients were unknown, and the causes could be accidental, or deliberate and are potentially linked to other root causes such as human error and lack of verification. Root cause analysis such as those conducted by Soon et al. (2020) will provide the agri-food industry with better information on how to prevent such incidences from recurring.

Conclusion

This study identified the known/suspected causes and contributory factors associated with labelling errors. Food recalls caused by undeclared allergens, ingredients, or labelling issues were recorded across 28 food and drink categories. Highly processed foods such as baked goods, RTE meals / heat & serve, confectionary, savoury snacks and appetisers/sides recorded the highest number of undeclared allergens. Milk, gluten, soy, eggs, and tree nuts were the top five undeclared allergens. Undeclared ingredients such as other meat and poultry species, preservatives and flavour and sensory enhancer were also recorded. The main type of labelling error is undeclared allergen, incorrect information, missing information, and illegible print. Most labelling errors were due to un-reported or unknown causes; hence the contributory factors were not identified. Among the known or suspected causes, packaging error, supplier's ingredients and production formulation & ingredient changes were the main contributory factors. The root causes of labelling errors remain under-

reported or unknown and should be documented and/or investigated further to prevent similar incidents.

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