



Review

A systematic review of the knowledge and training of food service workers on food allergies

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Abstract: *Background:* Food allergies are adverse reactions to a specific food antigen which is mediated by immunological mechanisms and are fast rising to become a significant public health concern. Around 1% of the world's adult population suffers from food allergies. The prevalence of food allergies which can be life-threatening is commonly estimated to affect 3–5% of the adult population in North America. *Objectives:* The purpose of this study is to review published food allergy knowledge and training amongst food service workers and identify the policies in place concerning food allergies globally. *Methodology:* Documented food service workers' knowledge and training about food allergies published between September 2006 and February 2021 were comprehensively reviewed. A widespread literature search was carried out using subject headings, search terms, and keywords. Results were examined in groups to explore patterns through research. *Results:* A total of 18 relevant studies that analyzed the food allergies knowledge and training of food service workers were reviewed. Eight studies (44%) were performed in the USA, followed by two studies (11%) in the UK, and one study each (5%) for New Zealand, Turkey, Malaysia, France, Western Romania, Germany, Brazil, and Canada. In the studies, respondents were asked a series of questions to assess their level of knowledge and the types of training relating to food allergies they received. *Conclusions:* This study identified the gaps in policy, as well as knowledge and training

among food service workers, to manage food allergies safely, thus emphasizing the importance and need for food allergy training.

Keywords: food allergy; food allergy knowledge; food allergy training; restaurant; food safety; food operator; food handler; food legislation

1. Introduction

Food allergies are fast-rising significant public health issues, estimated to affect 3–5 percent of the adult population in North America [1]. Approximately 2.5 million Canadians self-reported at least one food allergy [2]. Among the Swiss population, an estimated 1–10% of individuals suffer from food allergies [3]. Around 1% of the world's adult population suffers from food allergies, while the figures are higher for children [4].

Food allergies result from adverse immune reactions like immunoglobulin E (IgE) mediated, non-IgE mediated, and mixed IgE and non-IgE mediated reactions that occur after the consumption of specific allergy-causing foods [5].

Most foods that contribute to the occurrence of food allergies include mustard, milk, eggs, peanuts, fish, mollusks and crustacea, tree nuts, sesame seeds, soy, sulphites, and wheat [6]. Health Canada and the Canadian Food Inspection Agency (CFIA) also refer to these as priority allergens because they cause 90 percent of adverse immune reactions [7]. According to Wasserman and Watson, these products have effects on various target organs like cutaneous, upper respiratory, cardiovascular, and gastrointestinal (oral and lower) [8]. These effects may occur either immediately or hours after food consumption, resulting in different symptoms like erythema, sneezing, vomiting, diarrhea, nasal congestion, eczema, or redness of the skin. Metcalfe et al. stated that some of these reactions can be severe reactions (anaphylaxis) and in some cases, fatal [9]; however, for a person with a food allergy, fatal food anaphylaxis is less common than accidental death in the general population [10]. For example, hospitalizations for anaphylaxis brought on by food have grown between 1998 and 2018; however, in one study, the case fatality rate had dropped partly due to improvements in the recognition and management of anaphylaxis [11].

According to Statistics Canada, in 2017, 22 million people ate out every day, with total food sales of \$65 billion [12]. In 2014, less than 60 percent of people had home-cooked meals, compared to 74 percent of people who ate home-cooked meals in 1984 [13]. This rise in percentage shows that there has been an increase in eating out. This can be due to people wanting to change what they normally eat at home, people's busy schedules, and the proximity of food service establishments to people's homes and places of work. [14]. In the United States of America (USA), the food service industry recorded a 73.1 percent increase in sales in 2019 from people eating out. Additionally, 54.8 percent of individuals ate out when compared to the 45.2 percent that ate at home [15].

One of the difficulties encountered in a restaurant by individuals living with food allergies is ordering meals that are free from their food allergens [16]. This is because people have reported multiple allergic reactions while eating outside of their houses. Xu et al. [17] examined 92 deaths due to anaphylactic reactions in Ontario and found out that 40 cases out of the 92 were food related, including the priority allergens, and 24 cases out of the 40 were from eating at food service establishments. Food allergies among adults in the USA having at least one food allergy was

estimated to be 10.8%, corresponding to >26 million US adults [18]. The European Commission admits that 7 out of 10 allergic reactions usually occur due to eating out [16].

Allergic reactions to foods consumed in restaurants are common and can be severe; therefore, due to the number of allergic reactions from eating out, it is imperative to highlight the importance of training restaurant staff and mandatory disclosure of allergenic ingredients in meals [19]. Due to the increase in the number of people dining out, it is becoming a challenge for food service workers to provide their customers with food free from allergens. Hence, more awareness is required regarding the need for rigorous allergy avoidance [20]. To further reduce the incidence rates, food service workers must be knowledgeable, understand, and be able to communicate the different risks associated with some foods to their customers [16]. This can be done by providing customers with allergen-specific ingredients contained in menu items, avoiding cross-contact during food preparation and service, and providing customers with food free from allergens based on their request. Thus, it is important to understand the level of knowledge and training of food service workers in handling food allergies. This study will summarize food service workers knowledge on food allergies, as well as compare the knowledge with their level of education, their role in the food preparation chain, their level of training, and the regulatory policies in place for food service workers concerning food allergies.

2. Materials and methods

2.1. Literature search strategy

An electronic search was carried out on the following databases for the full selection of eligible articles published between 2006 and 2021: Concordia library, PubMed, MedlinePlus, Mendeley, Google Scholar, ResearchGate, Global Health, SCOPUS, CINAHL, and PSYCHINFO. To improve the quality of this review, a flow diagram and tables were used for this purpose using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline. A search for grey literature documents (research reports and theses) was also performed using the Google search engine.

2.2. Keywords and search terms

The main keywords used were as follows: food allergy, food allergy knowledge, food allergy training, restaurant, food safety, food operator, food handler, and food legislation.

Additional search terms used were as follows: “food allergy*” OR “gluten source*” AND “food operator*” OR “food handler*” OR “waiter*” OR “food manager*” AND “food allergy training” OR “food allergy knowledge” OR “food safety*” AND “restaurant*” OR “food establishments*” AND “food legislation” OR “food labeling” OR “food labelling” (Table S1).

2.3. Selection criteria

2.3.1. Inclusion criteria

The review included studies published in English as either journal articles or dissertations. In addition, review and opinion papers were included to ensure that the current review would be as comprehensive as possible and that all relevant peer-reviewed publications were identified.

Research studies (mainly cross-sectional surveys-online, postal, and in-person) conducted on knowledge and training on food allergy globally, with no age limit, males and females were included, and studies on all types of food services, including those in schools, were performed.

2.3.2. Exclusion criteria

Research studies without food allergies and studies conducted for food allergies due to home-cooked, daycares, hospitals, food trucks, or cabin-cooked meals were all excluded.

2.4. Data extraction, management and assessment of articles for selection bias

Data extracted for further analysis were summarized using tables. Tables were prepared considering the year of publication, the journal, study location, sample size, data collection methods, age, types of food service, and educational level. Additionally, the knowledge of food service workers on food allergen identification, methods used for training, duration of the training, and the number of food service workers trained on food allergies were investigated. Authors TA and CB extracted data and assessed potentially eligible publications for inclusion, while authors AS and RI cross-checked for accuracy. Disparities were resolved by consensus.

Each selected article was critically appraised for selection bias using a checklist developed by the authors that is specific to the review objectives with the above stated criteria for tabulation. The authors did not use scales with summary scores to distinguish study qualities since this study was not designed for meta-analysis.

2.5. Data analysis

The data were collected on a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and frequency distribution for the variables was estimated using percentages.

3. Results

Using keywords, 2400 articles were identified. An additional 15 articles were identified through grey literature searches. Articles that appeared more than once and for other reasons were excluded and 915 articles were included. The articles were screened by reviewing the title and abstract; 870 articles were excluded that did not meet the inclusion criteria and did not apply to the purpose of this study. Then, 45 articles were selected for eligibility evaluation. The full-text article search was made, and if not found, full access was requested either from the authors or through the librarian. These 45 articles were thoroughly reviewed and 27 were excluded because they did not meet the inclusion

criteria. Finally, 18 articles were selected for the qualitative syntheses of this study because the articles were applicable to the purpose and met the inclusion criteria of this study (Figure 1).

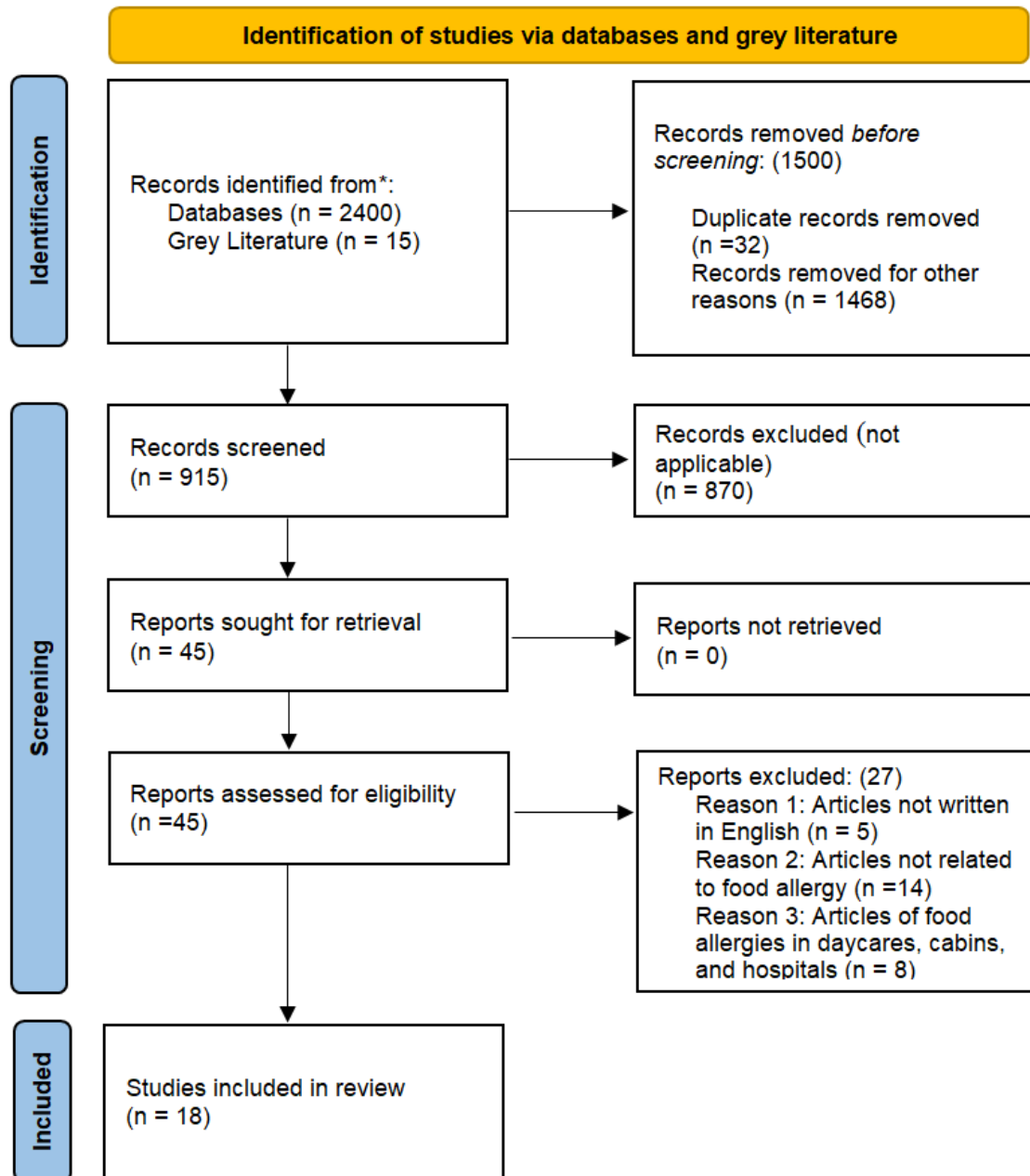


Figure 1. Flow diagram of study selection.

This study reviewed 18 studies that investigated the knowledge and training of food service workers on food allergies. The attributes of these studies are shown in Table 1. Most of the studies were published in 2016 (22.2%, 4/18) and 2019 (16.7%, 3/18). Eight studies (44.4%, 8/18) were performed in the USA, two studies (11.1%, 2/18) were performed in the United Kingdom (UK), and one study (5.6%, 1/18) each was performed in New Zealand, Turkey, Malaysia, France, Western Romania, Germany, Brazil, and Canada.

Table 1. Attributes of synthesized cross-sectional studies.

S/N	First author	Year	Country	Sample size	Data collection methods (questionnaire)	Outcome assessed	
						Food allergies knowledge	Food allergies training
1.	Bailey S	2011	UK	90	Telephone	Yes	Yes
2.	Choi JH	2013	USA	193	Self-administered	No	Yes
3.	Wham CA	2014	New Zealand	124	In-person	Yes	Yes
4.	Sogut A	2014	Turkey	351	In-person	Yes	Yes
5.	Shafie AA	2015	Malaysia	117	In-person	Yes	No
6.	Lee YM	2016	USA	229	Online	Yes	Yes
7.	Radke T	2016	USA	644	In-person	Yes	Yes
8.	Wen H	2016	USA	16	Telephone	Yes	Yes
9.	Lee YM	2017	USA	185	Postal	Yes	Yes
10.	Lefèvre S	2019	France	100	Telephone	Yes	Yes
11.	Jianu C	2019	Western Romania	121	Postal	Yes	Yes
12.	Loerbroks A	2019	Germany	295	Self-administered/In-person	Yes	No
13.	Soon JM	2020	UK	30	Telephone	No	Yes
14.	Ahuja R	2007	USA	100	Telephone	Yes	No
15.	Ajala AR	2010	Brazil	74	Postal	No	Yes
16.	Dupuis R	2016	USA	187	In-person	Yes	No
17.	McAdams B	2018	Canada	208	Postal	Yes	No
18.	Lee YM	2018	USA	339	Online	Yes	Yes

All studies used a cross-sectional design to evaluate the prevalence of different outcomes. The outcomes assessed included food service workers' knowledge (83.3%, 15/18) and the training (72.2%, 13/18) related to food allergies. Questionnaires were used for the data collection across all selected studies, and it was administered in different formats through the telephone, in-person, postal, and online. However, the in-person method was used more frequently (33.3%, 6/18) than the others.

3.1. Description of eligible studies

The overall characteristics of these studies are highlighted in Table 2. While 66.7% (12/18) of the studies pre-tested their data collection methods, 33.3% (6/18) did not specify if their studies were pre-tested or not. Most of the studies investigated restaurants (94.4%, 17/18), cafés and fast-food stores (27.8%, 5/18), and university restaurants (5.6% 1/18).

To compare the results of the various studies, an acceptable degree of the food service workers' homogeneity was considered. The roles of food service workers are broken down into the following categories: owners and managers. The food safety decision-makers typically own the restaurant and are responsible for other staff members and the daily operation that involves the preparation and serving of food.

Table 2. Overall characteristics of the studies that analyzed the food allergies knowledge and training.

S/N	First author	Pre-testing data methods	Types of food service	Kinds of food service workers (%)			Gender (%)		Age range (years)	Experience range (years)	Educational level (%)		
				Manager/ Chef owner	Waiter	Other	Male	Female			High school– diploma	Bachelors– graduate studies	
1.	Bailey S	Pilot study	Restaurants	61.11	16.67	22.22	NS	58.89	41.11	17–70	0.5–38	NS	NS
2.	Choi JH	Expert review	University (restaurant, café, other)	NS	77.20	NS	NS	37.82	62.17	18–>50	1.5–8	84.45	4.14
3.	Wham CA	NS	Restaurants, café, other	100	NS	NS	NS	NS	NS	NS	>5	NS	NS
4.	Sogut A	NS	Restaurants	16.80	17.09	66.09	NS	81.48	18.51	NS	0–38	NS	NS
5.	Shafie AA	Pilot study/expert review	Restaurants	23.93	28.20	26.49	21.36	NS	NS	NS	NS	72.64	27.35
6.	Lee YM	Pilot study/expert review	Restaurants	NS	20.08	43.66	36.24	22.27	77.72	<20–>50	1–>30	86.46	13.53
7.	Radke T	NS	Restaurants (fast food)	43.01	32.76	24.22	NS	57.14	42.70	NS	<2–>4	49.53	50.46
8.	Wen H	Expert review	Restaurant	100	NS	NS	NS	NS	NS	NS	NS	NS	NS
9.	Lee YM	Expert review/food professionals	Restaurant	73.51	23.24	NS	3.24	50.27	49.72	<21–>50	<1–39	63.24	36.76
10.	Lefèvre S	Pilot study	Restaurant	60	12	28	NS	69	31	NS	>7	NS	NS
11.	Jianu C	Pilot study	Restaurant, fast food, coffeeshop, catering premises	9.09	26.44	36.36	28.09	41.32	58.68	21–>51	<1–>20	88.42	11.57
12.	Loerbroks A	NS	Restaurant	29.15	15.93	48.13	6.77	62.03	37.96	NS	NS	39.25	60.75
13.	Soon JM	Food professionals	Restaurant	93.33	6.66	NS	NS	33.33	66.67	18–64	<1–>5	60	40
14.	Ahuja R	Expert review	Restaurant, fast food	42	24	32	2	NS	NS	NS	NS	NS	NS
15.	Ajala AR	NS	Restaurant	16.21	16.21	NS	67.56	NS	NS	NS	NS	82.40	13.51
16.	Dupuis R	NS	Restaurant	47.8	28.8	16.3	8.7	50.3	49.7	18–>66	NS	22.40	77.6
17.	McAdams B	Food professionals	Restaurant	16.3	38.9	32.2	NS	48.1	51.4	14–33	>2	NS	48.60
18.	Lee YM	Expert review/food professionals	Restaurant	32.44	13.56	29.49	24.48	69.03	30.97	<20–>50	<1–>30	81.41	18.58

NS: not specified, this means information that relates to this was not specified in that study.

Table 3. Assessment of food allergy knowledge across studies.

S/N	First author	High temperature limits allergens from causing food allergies (%)	Cross contact of food allergens with allergen-free food can occur during cooking (%)	Identify a food item that causes food allergy (peanut) (%)	Consuming small amount of allergen is safe (%)	Water can dilute food allergies (%)	Removing an allergen from a prepared meal (%)	Food allergies can lead to death (%)	Federal law requires labelling of foods that causes food allergies (%)
1.	Bailey S	NS	NS	NS	NS	NS	NS	NS	NS
2.	Choi JH	NS	87.04	NS	NS	NS	NS	NS	NS
3.	Wham CA	87.90	93.54	NS	86.29	41.93	78.22	NS	NS
4.	Sogut A	NS	NS	28.20	46.15	54.41	64.95	64.95	NS
5.	Shafie AA	NS	NS	93.16	49.57	NS	NS	51.28	NS
6.	Lee YM	69.86	NS	95.63	89.51	NS	71.61	95.63	9.17
7.	Radke T	NS	NS	64.13	78.60	NS	92.30	95.49	NS
8.	Wen H	NS	93.75	NS	NS	NS	NS	NS	NS
9.	Lee YM	NS	NS	96.76	86.48	NS	70.81	89.18	21.08
10.	Lefèvre S	NS	NS	NS	NS	NS	NS	8	NS
11.	Jianu C	25.62	60.33	76.86	74.38	NS	67.77	NS	NS
12.	Loerbroks A	83.73	NS	30	82.37	65.42	82.71	90.17	NS
13.	Soon JM	NS	NS	NS	NS	NS	NS	NS	NS
14.	Ahuja R	35	NS	93	24	34	25	NS	NS
15.	Ajala AR	71.62	NS	82.43	86.48	68.90	79.72	NS	NS
16.	Dupuis R	93.30	NS	NS	88.30	75.90	89.30	97.20	NS
17.	Mc Adams B	87.01	NS	NS	77.88	NS	93.26	99.51	NS
18.	Lee YM	69.32	NS	97.93	82.59	NS	68.14	93.80	12.09

This table shows the percentage of respondents that answered the questions correctly. NS: not specified, this means information that relates to this was not specified in that study.

Chefs are defined as follows: the food handlers working openly with food and are usually responsible for planning menus and performing duties such as cooking, preparing food, and supervising the kitchen staff.

Waiters are defined as follows: the individual who serves people food and beverages in restaurants.

In this instance, “Others” include kitchen assistants who are often responsible for washing, cleaning and maintaining proper sanitation in the kitchen area, and they rely on the chef for what to do in terms of food handling and preparation.

Regarding the nine studies that indicated age, 67% of the respondents were between 14 and 50 years of age [21–29]. Most respondents surveyed in five studies (27.7%, 5/18) had over 30 years of work experience in the food industry [21,23,24,28,30].

When the level of education of the respondents was compared among the eleven studies that indicated it, on average, 66.38% of participants earned a high school diploma while 33.57% had college degrees [4,22–26,28,29,31–33].

3.2. Assessment of food allergy knowledge

Each of the studies aimed to increase food allergy knowledge on a variety of topics that should be understandable to a commercial food service worker. The food allergy knowledge questions obtained from the analysis of the extracted data are summarized in Table 3, while the common questions that were asked by the respondents in the studies are shown in Table 4.

Table 4. The common food allergy knowledge questions.

Food allergy knowledge questions	Yes n(%)	No n(%)
Does cooking with high temperatures e.g., frying limit food allergens from causing allergies?	9(50)	9(50)
Cross contact of food allergens with allergen-free food can occur during cooking?	4(22)	14(78)
Can you identify a food item that causes food allergy? (Peanut)	10(56)	8(44)
Is it safe for allergic customers to consume foods that contain small amount of allergens?	13(72)	5(28)
Can water be given to allergic customers to dilute food allergens after consumption?	6(33)	12(67)
Can an allergen be removed from a finished meal (e.g., taking off nuts) to provide safe meals for food allergic customers?	12(67)	6(33)
Can food allergies lead to death?	10(56)	8(44)
Does federal law require labelling of foods that cause food allergies?	3(17)	15(83)

Yes: number of studies that analyzed the questions. No: number of studies that did not analyze the questions.

As shown in Table 4, the most common question asked was “is it safe for allergic customers to consume foods that contain smaller amounts of allergen”, and this was represented in 13 (72.2%, 13/18) of the 18 studies [4,23–28,30–35]. The second most common question asked was “can an allergen be removed from a finished meal (e.g., taking off nuts) to provide a safe meal for food allergic customers”, which was found in 12 studies (66.6%, 12/18) [4,23–28,30,31,33–35]. According to Bailey et al. [21], 23% of the respondents (90) agreed that it was safe for allergic customers to consume foods that contain smaller amounts of allergen, and 21% agreed that a meal can be considered safe once an

allergen is removed. However, Sogut et al. [30], found out in their study that 55% (351) of the respondents incorrectly answered the following question: “can water be given to allergic customers to dilute food allergens after consumption”. Dupuis et al. [26], also reported that 24.1% of respondents answered the same question incorrectly.

Furthermore, although it was not suggested that cooking with high temperatures (e.g., frying) can limit food allergens from causing allergies, an understanding of this was seen as crucial, as it was addressed in 50% (9/18) of the studies [4,23,25–28,31,34,35]. Overall, the reviewed papers stressed the need for food service workers to be able to identify the priority allergens. Across the studies, 55.6% (10/18) were consistently able to identify peanuts as a major food allergen from the questionnaires given [4,23–25,28,30–33,35]. Additionally, there were many other food allergens that respondents seemed able to identify alongside peanuts, including milk, eggs, shellfish, and nuts (e.g., tree nuts).

Despite the prevalence of food allergies globally, only two studies (11.1%, 2/18) assessed if the respondents were well-informed on the policy concerning the labeling of foods with food allergens [23,36].

3.3. Assessment of food allergies training

The questions that all respondents were asked regarding food allergy training across the studies are shown in Table 5. Food allergy training was conducted in 16 (88.9%, 16/18) of the studies reviewed, though the methods of training were different, as shown in Table 6.

Table 5. The food allergy training questions.

Food allergy training questions	Yes (%)	No (%)
Number of respondents trained on food safety	6(33)	12(67)
Number of respondents trained on food allergy	16(89)	2(11)
Full course food allergy training	5(28)	13(72)
In house food allergy training	8(44)	10(56)
Group food allergy training	3(17)	15(83)
Duration of food allergy training	5(28)	13(72)
Number of respondents interested in future food allergy training	6(33)	12(67)

Yes: number of studies that analyzed the questions. No: number of studies that did not analyze the questions.

Table 6. Assessment of food allergy training across studies.

S/N	First author	Number of participants with food safety training certification (%)	Number of participants trained on food allergy (%)	Method of food allergy training (%)			Hours of training	Interested in future training (%)
				Specialized full course	In-house (designed in house)	In-house group (outside trainer)		
1.	Bailey S	90	33.33	3.33	15.56	NS	NS	47.78
2.	Choi JH	38.34	26.94	NS	NS	NS	NS	NS
3.	Wham CA	NS	25	NS	16.12	NS	NS	27.06
4.	Sogut A	33.61	17.09	1.42	NS	NS	NS	76.63
5.	Shafie AA	NS	35.04	NS	NS	NS	NS	NS
6.	Lee YM	NS	36.68	18.77	25.32	20.08	<1–4 hrs	NS
7.	Radke T	34.62	40.52	NS	NS	NS	NS	NS
8.	Wen H	NS	81.25	NS	93.75	NS	NS	NS
9.	Lee YM	NS	67.02	NS	16.76	43.24	<1–4 hrs	NS
10.	Lefèvre S	74	13	NS	NS	NS	<1–14 hrs	NS
11.	Jianu C	43.80	NS	8.26	47.93	NS	NS	NS
12.	Loerbroks A	NS	45.76	NS	NS	NS	NS	18.62
13.	Soon JM	NS	96.70	26.67	70	40	<1–4 hrs	86.70
14.	Ahuja R	NS	42	NS	NS	NS	NS	61
15.	Ajala AR	NS	6	NS	NS	NS	NS	NS
16.	Dupuis R	NS	NS	NS	NS	NS	NS	NS
17.	McAdams B	NS	43.8	NS	19.2	NS	NS	NS
18.	Lee YM	NS	47.19	NS	NS	NS	<1–>4 hrs	NS

This table shows the percentage of respondents that answered the questions. NS: not specified, this means information that relates to this was not specified in that study.

The methods employed by the studies that were analyzed show that an in-house training method was used in eight studies (44.4%, 8/18), [21,23–25,29,34,35,37], while three studies (16.6%, 3/18) employed the services of a professional food allergy trainer [23,24,29]. Specific specialized food allergy training courses were used by food service workers in five studies (27.8%, 5/18) [21,23,25,29,30]. The study by Bailey et al. [21] was the only one that indicated that respondents took food allergy training as part of a first aid course. It was interesting to observe that the duration of the food allergy training was between less than an hour to over four hours, and this was similar across the five studies (27.8%, 5/18) that specified it [23,24,28,29,36].

In terms of the target population, 16 studies (88.9%, 16/18) analyzed food service workers that were trained on food allergies. Six studies (33.3%, 6/18) went further to investigate respondents who had food safety training certification to ascertain the source of their food allergy training [21,22,25,32,33,36]. Six studies (33.3%, 6/18) further investigated and revealed respondents' interest in the need for further training on food allergies [21,29–31,34,35].

4. Discussion

The eighteen studies reviewed and assessed the knowledge and training of food service workers on food allergies. The most important findings in this study are that food service workers possess minimal food allergy knowledge and training to manage food allergies safely. Moreover, there are inadequate food allergy policies at restaurants/food establishments. This raises concerns for food-allergic customers visiting restaurants globally.

There were differences across the studies on food allergies knowledge and training; some studies [22,34,37] investigated only a particular group of food service workers, which means their responses might not represent that of the other group of food service workers present in those restaurants. In the study conducted by Lefèvre et al. [36], chefs and waiters were more knowledgeable about food allergies than owners and managers; this is acceptable because they are the major food handlers and can inform the customers of the food ingredients. However, it would be suitable for the owners and managers to have adequate knowledge of food allergies because this will enable them to ensure that training and knowledge are a requirement for the other staff and that measures are implemented accordingly.

Many studies reported that their respondents were unable to identify fish and soy as major allergens when compared to peanuts, milk, eggs, and shellfish. Peanuts are commonly used allergens because many international cuisines use peanuts in food, including Indonesian (e.g., satays), Thai (e.g., curries), Vietnamese (e.g., crushed peanut as a topping, spring rolls), Indian (e.g., certain curries), and Chinese (e.g., egg rolls, certain sauces) [6]. It is important to be able to identify soy and fish as major allergens because fish is gradually becoming a staple food, and soy is a major ingredient used for cooking in restaurants, and can therefore be hidden in food items.

Common inaccurate information found across some studies suggested that cooking with high temperatures, such as baking and deep-frying, could either limit or eliminate allergens [4,23,25–28,31,34,35]. This could be because of misinformation or misinterpretation of food allergies as a microbial organism by food service workers; hence, believing that once the food is heated up and it reaches a safe internal temperature, it is hot enough to kill harmful germs. However, even if foods with allergens are cooked on high heat and other methods of food processing, it still does not reliably destroy food allergens and does not ensure safety for people with food allergies [6]. Additionally, cooking (deep frying and baking) foods with allergens and foods free from allergens together can lead to cross-contact [27]. Food service workers have the tendency of frying foods with allergens and allergen-free foods together, which can lead to cross-contact; this is harmful to customers with a food allergy. Similarly, it is a misbelief that water can dilute food allergens after consumption, since most allergic reactions happen within minutes and a trace amount has the potential to cause a severe allergic reaction [6]; additionally, water can influence an enzyme turnover in different ways, such that irrespective of the reaction type, the functionality of enzyme is maximal at an optimum level of water, beyond which the enzyme performance is declined due to the loss in enzyme stability [38]. Respondents in Choi & Rajagopal and Ahuja & Sicherer [22,35] had the lowest rating on food allergy practices related to cross-contact because they confused cross-contamination with cross-contact. Cross-contact is the accidental contact between allergen and non-allergen in foods and their proteins mix, while cross-contamination is the contact between raw and cooked foods; the latter relates to microbial contamination [39].

Arendt et al. [40] have shown the importance of training as a mechanism for the transfer of knowledge. Across the studies, it was agreed that those with food allergy training demonstrated a good knowledge of food allergies when compared to their colleagues without food allergy training. Managers who had previous food allergy training were more likely to have plans in place to manage food allergies, plans to manage an allergy emergency, and training in place for their staff [23,34]. The same applies to those with higher education levels (graduates); this might indicate that higher education offers the respondents better access to information about food allergies [26].

Regardless of the type of training undertaken by food service establishments (e.g., specialized full course, designed in-house, in-house group by an external trainer, or online training), food allergy training and retraining must be included in the regular schedule for the food industry workers. Across the studies, many respondents agreed that a fully specific specialized food allergy course delivered in person was the best method for food allergy training when compared to it being delivered as part of a course (e.g., a first aid course). This is because it will allow them the opportunity to ask questions and have discussions at the restaurant and create a more comfortable and friendly environment, where the attendees will be able to practice what they have been taught, as compared to the online method of training.

The most common responses from respondents when asked if they were interested in future food allergy training include financial constraints, high food service employee turnover, and time constraints. Once a restaurant opts in for the specialized full-course training compared to the other training options, it might eventually lead to a reduced cost. From these studies, there seems to be no difference in those interested in future food allergy training in gender, age, or role in the food preparation chain. Despite more awareness, accidental exposures to food allergens still happens, as reported in a study where the majority are handled incorrectly by healthcare professionals [20].

Avoiding cross-contact with food allergens, identifying food items that contain allergens on the menus, and communicating with customers about food allergies were the most common food allergy-related topics covered in the training sessions [29,37]. Thus, understand these topics by food service workers could lead to a reduction in food allergy incidents in a restaurant. While food safety certification is mandatory for food handlers when compared to food allergy training, participation in this is voluntary; this was seen in 33% of the studies. The duration of training in the studies reported to be between one and four hours. In food industries, working hours are long and demanding, leaving little time to be committed to food allergy training.

Surprisingly, in two studies Lee & Sozen and Lee & Barker [23,24], only a few of the respondents knew that federal law does not require all food allergens to be listed on foods in restaurants. In New Zealand legislation (the Food Standards Code), food labelling laws require that the priority allergens are stated on food labels. While it is not mandatory for manufacturers to include precautionary statements such as “may contain traces of peanuts”, these are usually only used if the manufacturer feels there is a significant risk of cross-contact [41]. For foods that are not required to bear a label, there is a requirement to provide accurate information on the allergen status of food to the purchaser upon request [41]. The new labelling regulations in Europe were instigated by the death of a teenager, Natasha Ednan-Laperouse, resulting from an allergic reaction to sesame in a baguette she had purchased from a sandwich shop [42]. To address the risk of hidden allergens, some countries in Europe, including the UK, have further extended this rule by requiring food handlers who provide food information face-to-face to display a notice inviting customers to ask questions about food allergens in

the food they are requesting. Changes to the allergen labelling requirements in the UK came into effect on October 1, 2021 [42].

In Canada, food manufacturers are mandated to declare the presence of priority allergens on the label of a prepackaged food product; whoever does not abide by the rule could violate the Food and Drugs Act and the Safe Foods for Canadians Act, which can technically lead to enforcement measures and a product recall [43]. However, unlike food manufacturers, restaurants, bakeries, delis, catering operations, and food distributed in vending machines are not obliged to do the same as for foods prepared on-site. Moreover, they are not required to list priority food allergens for menu items, though they can have an ingredient list, just in case the customer requests it. In Canada, a person operating a commercial food restaurant must have someone with a food safety certificate at any time when five or fewer food handlers are working on the premises, but nothing specific for food allergies. Most food owners or managers decide on their own to enroll their staff in the available food allergy training courses to educate food service managers and front-line staff on how to prepare and serve food that is safe for customers with food allergies. Up-to-date information will aid advocacy efforts and educate patients, allergists, and the restaurant industry on best practices for dining out to improve the quality of life for food-allergic people [19]. Additionally, it is recommended that training programs must be adapted to the participant's needs and characteristics to be easily accessible and lower costs [25]. Moreover, standardized training of food service staff members such as a web-based approach [44], is required since variable training or low-quality training could lead to continued high risk in the foodservice sector for consumers with food allergies. In Australia, free nationally standardized online training courses have been developed to increase accessibility [45].

5. Study limitation

This study analyzed research studies published only in the English language. Also, this study is not a meta-analysis and did not carry out any statistical analysis of the results, which perhaps would have made this study more qualitative and consistent if they were done.

6. Conclusions and recommendations

This study identified the gaps in policy as well as knowledge and training among food service workers to manage food allergies safely. Many studies have indicated that food service workers need to have adequate food allergy knowledge and training; however, most of them do not put in much effort because no legislation mandates it. It is strongly recommended that regulatory policies regarding food allergies are made mandatory for restaurants to enable food-allergic customers to feel safe when dining out. Food owners and managers should have specially designed food training courses that are specific to their own company's environment. The course should cover the basics of food allergy and anaphylaxis, principles to develop allergen risk management procedures, strategies for identifying and managing risks, avoiding cross-contact and cross-contamination in the kitchen, appropriate food handling procedures, creating allergy-aware cooking processes, and developing safe serving practices and communication protocols. Hence, there is a need for more training and commitment from the food industries and the government to address this global issue.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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