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# Food allergen knowledge, attitude and practices among UK consumers: A structural modelling approach

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## Abstract

Food allergies are becoming more prevalent and affect up to 1 – 2% of adults and 5- 8% of children in the UK. This study investigated the food allergen knowledge, attitude towards food allergens and food allergy management practices among food allergic and intolerant consumers and / or their family members and carers. Questionnaires were distributed at three major Free From events in the UK in 2017 and 2018. Structural Equation Modelling (SEM) was used as a confirmatory technique to determine the model's validity. Cereals containing gluten, milk and eggs were the most common triggers reported by the consumers. Other trigger foods such as chocolate, garlic, maize, onions, red and white meat, spices, and fruits such as apples and cherries were also reported. Consumers demonstrated very good understanding on the severity of allergic reactions, prevention method and hidden egg ingredients. Overall, consumers were relatively good in the knowledge section. The participants were motivated in their personal allergen avoidance towards food allergens especially in checking food labels, preference for more free from product choices and handwashing. Consumers did not rely on dietary apps or social media to find out about allergen-free food products. Both knowledge and attitude did not translate into food allergy management practices. Significant correlation between knowledge and attitude was identified suggesting that as knowledge decreases, so will their attitude scores. This study suggests that targeted and systematic food allergy management topics and peer support could be used to improve consumers' knowledge and attitude to positively impact food allergen handling practices.

## Highlights

Consumers demonstrate relatively good knowledge in food allergens  
Food allergen knowledge and attitude did not directly affect food allergen handling practices  
A significant relationship between knowledge and attitude was identified

**Keywords:** food allergy; intolerance; prevention; Structural Equation Modelling

## Introduction

The prevalence of food allergy in infancy has increased to 10% particularly in westernised regions and is more common among children compared to adults (Osborne et al., 2011; Sicherer & Sampson, 2018). Food allergy is an adverse immune reaction that occurs upon exposure to specific food (Moore, Stewart, & de Shazo, 2017) and symptoms range from mild skin reactions to severe

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anaphylactic reactions. At the global level, Codex stated that the eight common food allergens (cereals containing gluten, egg, milk, soy, peanuts, tree nuts, fish and shellfish) shall be declared (Codex, 1985). These eight main food allergens contribute 90% of food allergic reactions (Bush & Hefle, 1996). In the UK, food businesses are regulated by the EU Food Information for Consumer Regulation No. 1169/2011 (EU FIC). Food businesses are required to present allergen information clearly (emphasis by font, style or background colour) for prepacked foods in the list of ingredients. Food businesses such as food services providing and selling non-prepacked foods are required to provide allergen information for the inclusion of any of the 14 specified food allergens (celery, cereals containing gluten, crustaceans, egg, fish, lupin, milk, molluscs, mustard, peanuts, sesame seeds, soya, sulphur dioxide and tree nuts) (Regulation EU No. 1169/2011).

Peanuts, tree nuts and fish are the most common cause of food allergic reactions among adults in the UK while children are commonly affected by milk, eggs and peanuts (NHS, 2016). Strict avoidance of food allergens is the main preventative and management of food allergic reactions. However, adherence to an allergen-free diet could be challenging particularly when consumers are dining out or purchasing ready meals (Begen et al., 2018). According to Versluis et al. (2014), between 21 – 31% of accidental consumption of allergens occurred while eating in restaurants and 13 – 23% occurred at workplace or school canteens. Each year in the UK, 10 patients die from food-induced anaphylaxis due to undeclared allergenic ingredients (FSA, n.d.). Recent fatalities due to presence of food allergens in takeaway meals and sandwiches underscore the importance of food allergen management, food allergen labelling and allergy awareness among catering staff (BBC News, 2018a, b; Soon, 2018a).

A number of food allergen management studies had been carried out among food service workers (Ajala et al., 2010; Dupuis et al., 2016; Soon, 2018a; Wham & Sharma, 2014). Food service staff often receive food allergy training and such training had proven positive in Bailey, Kindratt, Smith, & Reading (2014) where restaurant employees were able to answer food allergy questions, better management of food allergens (e.g. review ingredient lists) and improved communication with customers. Food service staff are provided with the essential training and knowledge of food allergen management (Lee & Sozen, 2016). On the other hand, individuals with food allergic reactions and/or intolerance often rely on their own initiatives to learn and manage their conditions and associated risks. Children and vulnerable individuals manage their conditions with support from family members, carers or healthcare providers. A number of consumer studies are associated with eating out practices (Begen et al., 2018; Leftiwch et al., 2011) and food allergen labelling and purchasing habits (Barnett et al., 2011; Marchisotto et al., 2017). Food allergy management deals with food allergen avoidance, managing symptoms, treatment of allergic reactions as a result of accidental exposure and communicating food allergic consumers' needs (Davis & Kelso, 2018; Venter, Sicherer, & Greenhawt, 2019). There remain limited studies on knowledge of food allergic consumers and/or their family

members and carers', their attitude and practices towards food allergens. This study investigates the food allergen knowledge, attitude towards food allergens and food allergy management practices among food allergic and/or intolerant consumers and / or their family members and carers. Food allergen knowledge refers to the understanding of or information about food allergen acquired through experience or education while attitude is a feeling or opinion about food allergies and practice refers to the action or application of food allergy management (Cambridge Dictionary, 2019a, b, c). Structural equation modelling (SEM) method was used as a confirmatory technique to determine the proposed model validity. SEM had been used in a number of food safety studies (Baser, Ture, Abubakirova, Sanlier, & Cil, 2017; Chen, 2017; Lim, Chye, Sulaiman, Mohd Suki & Lee, 2016) and only one study had utilised SEM in food allergy study (Soon, 2018b). In this study, the author postulates the following hypotheses based on Baser et al. (2017), Lim et al. (2017), Schwartz (1975), Shafie and Azman (2015) and Soon (2018b). The following hypotheses are proposed:

H1: Food allergen knowledge does not directly affect food allergen handling practices

H2: Attitude towards food allergen directly affects food allergen handling practices

H3: Food allergen knowledge and attitude are correlated

## **Methodology**

### **Questionnaire development**

The questionnaire was constructed and divided into five sections: (i) demographics; (ii) epidemiology; (iii) knowledge (10 questions); (iv) attitude (10 questions); and (v) practices (10 questions). The questions were developed based on previous studies (Choi & Choi, 2016; Marchisotto et al., 2016; Shafie & Azman, 2015; Soon, 2018b). In the food allergen knowledge section, participants were given options e.g. "yes", "no" or "uncertain" to prevent participants from selecting the correct answer by chance. In the attitude and practices section, participants were asked to rate based on a Likert scale of 1 (strongly disagree / never) to 5 (strongly agree / always). A pilot study was conducted among 20 participants (excluded from the actual study) to ensure the clarity and suitability of wordings.

### **Data collection**

The author visited two main Free From events in Liverpool (3 – 4 Nov 2017 and 3 – 4 2018) and London (7 – 9 July 2017). Another Free From event scheduled in Glasgow in 3 – 4 March 2018 was cancelled. The Free From event caters to consumers with allergies and intolerance needs and exhibits a number of free from food, cosmetics and household items. It draws 12,000 number of visitors in 2017 (ACC Liverpool Group, 2018). Consumers experiencing food allergies or intolerance, or those who are carers to individuals with food allergies / intolerance and those interested in free from food products were invited to participate in the study. The reason why family members were included in the survey was because third party allergen avoidance is also practiced by family members and carers

and they require the skills and experience to manage food allergens at home and interpret food allergen information (Gowland, 2015). The study was explained to them using an information sheet and consent was obtained prior to completing the survey. The author utilised a face to face approach during such events as it returns a higher response rate as consumers are interested in the topic.

### **Statistical analysis**

Descriptive and Exploratory Factor Analysis (EFA) was conducted using SPSS 24.0. EFA was performed to extract items from knowledge, attitude and practices based on factor loadings greater than 0.4 (Baser et al., 2017; Soon, 2018b). Based on the extracted items, SEM was conducted using Analysis of Moment Structures (AMOS) and confidence level was set at 95%.

### **Results and Discussion**

A total of 254 questionnaires were returned of which 252 were valid. All the consumers approached and invited by the author agreed to participate in the study, resulting in a 100% response rate. Most of the respondents were females, with the highest representative from the 45 – 54 and 55 – 64 year old categories. This is similar to previous surveys in the UK where female respondents dominated the samples (Cole, Peek, & Cowe, 2018; Gadema & Oglethorpe, 2011). Females also tend to be the main decision maker in food purchasing decisions (Cole et al., 2018) and main caregivers (DunnGalvin et al., 2006; Swinkels, van Tilburg, VerbakeL, & van Groenou, 2017). Almost 40% of the respondents graduated with a degree and about 10% have a postgraduate degree reflecting a highly educated group of consumers. More than 45% of the consumers and about 37% of the consumers' family members have had not experienced food allergic reactions before but this could be due to the fact that consumers with food intolerance, coeliac disease (CD) patients or those with personal lifestyle choices also participated in the study. Participants were mostly diagnosed by general practitioners, allergists and other healthcare practitioners (e.g. consultants, gastroenterologists and dietitians). It is interesting to note that 30 respondents self-diagnosed their food allergies / intolerance. Cereals containing gluten (35%), milk (17.8%), eggs (6.9%) and peanuts (6.4%) were the most common causative agents reported by the participants (Table 1). Cow's milk, wheat, egg, soy, peanut, tree nuts, fish and shellfish results in the majority of food allergic reactions in Europe (Nwaru et al., 2014). In the UK, food allergy affects about 1 – 2% of adults and 5- 8% of children (Buck, Hattersley, & Kimber, 2010). Coeliac disease patients selected cereals containing gluten as the main causative ingredients that aggravate their autoimmune disease. About 1 – 2% of the global population are affected by CD (Collin, Vilppula, Luostarinen, Holmes, & Kaukinen, 2018). The incidence rate of CD was 19.1 per 100,000 person in the UK (West, Fleming, Tata, Card, & Crooks, 2014).

Insert Table 1 here

More than 90% of the respondents were aware of the danger of food allergens and the best way to avoid an allergic reaction is to avoid the causative agent. There was less certainty when it comes to the potential for cross contact of allergens via hands as 15.9% and 16.7% answered incorrectly or were uncertain about the statement. 38.1% believed that tree nuts are similar to peanuts while 48% were uncertain about this statement. A third of the respondents knew that high temperature cooking does not destroy food allergen and more than half recognised that rinsing cooking utensils with water only is insufficient. 46.4% were uncertain that most food allergens are protein-based products. More than half of the respondents knew that buckwheat is not listed as a food allergen in UK/EU and up to 89% of the respondents are aware of potential hidden egg ingredients in food products (Table 2). Most of the respondents have good understanding of hidden allergenic ingredients in food products and knew that consuming even a small amount of food allergen will cause an allergic reaction and in severe cases, it can be fatal. Respondents scored 67% in the overall knowledge section and were relatively good. This demonstrates that the respondents understood what is needed to control and manage their food allergies and/or intolerance.

In Soon (2018a), one third of takeaway staff did not know that allergens can be transferred by hands. Food allergens can be transferred from hands during food preparation (Sheehan et al., 2018). Brough et al. (2013) revealed that peanut protein persisted on hands 3 hours after peanut consumption. Thermal processing can influence allergenicity by modifying the allergenic protein via protein denaturation, restructuring of disulfide bonds or formation of new intra/inter molecular bonds (Ekezie, Cheng, & Sun, 2018). The changes that occur may influence allergenicity positively, negatively or indifferently, e.g. the modified structure of proteins may introduce new allergy generating sites or loses the original allergenicity (Vanga & Raghavan, 2017). It is true that most food allergens are glycoproteins (oligosaccharide + protein) (Ekezie et al., 2018) but respondents may associate food allergenicity with the type of food product rather than the composition and structure of the food allergens. Foods with hidden allergens can be dangerous for food allergic patients. Anibarro, Seoane and Mugica (2007) reported that 22.4% of 530 food reactions were considered to be due to hidden allergens. Food allergy knowledge and awareness are critical to the safety of consumers with food allergy. This is particularly important to family members and/or carers of food allergic individuals as they are faced with the expectation to manage food allergies, recognise symptoms and treat food allergic reactions and anaphylaxis. Equipped with food allergy knowledge can boost confidence and improve food allergy prevention strategies and preparedness for anaphylaxis (Gupta et al., 2009; Tsuang et al., 2019).

Insert Table 2 here

There were strong agreement among respondents concerning checking of food labels, preference for more free from choices and that one should wash their hands after coming into contact with food

allergens. Respondents also felt that there should be more information provided about allergen-free food when ordering food online and agreed that it is their responsibility to inform staff of their food allergies if ordering via telephone. Consumers were less certain about purchasing of food with allergenic ingredients even if other household members can consume the product with no adverse health effects. Neither were consumers confident in being able to handle a food allergy emergency situation (Table 3).

Studies had been conducted among food allergic consumers who disregard food labels especially those bearing food allergen advisory statements (Robertson et al., 2013). Consumers are confused with Precautionary Allergen Labelling (PAL) and the use of PAL often frustrate and restrict consumers' food choices (Ong, 2008; Sharma, Pereira, & Williams, 2015). There's a higher level of risk taking among consumers because of 'label fatigue' among consumers which increase the tendency to disregard advisory labels (Robertson et al., 2013). In Sheth et al. (2008) and Sheth et al. (2010), the authors found 6.3% and 8.3% (n=695) of allergic individuals who ignored PAL went on to have a resultant allergic reaction to material that was present in the food through cross contamination. Edwards and Thomas (2018) recommended the triple check of food labels i.e. read the label at the store, when unpacking the groceries and before serving. It is encouraging to note that respondents felt very strongly about checking of food labels. Handwashing is key to prevent cross contact of food allergens and Perry, Conover-Walker, Pomes, Chapman and Wood (2004) recommended that hands should be washed with soap to remove protein residue. Perry et al. (2004) found that using plain water and antibacterial hand sanitiser left detectable peanut on hands. When ordering food online in the UK, consumers with food allergens are directed to contact the restaurants / takeaways directly to determine if allergen-free meals could be prepared and delivered. At the moment, there are limited information and studies in this area, and is definitely worth exploring. The uncertainty in dealing with a food allergy emergency demonstrates the importance of competence in using an auto-injector and calling the emergency helpline if someone is suffering from a food allergic reaction.

Insert Table 3 here

Consumers frequently read the food labels to check for allergenic ingredients and wash their hands before preparing allergen-free meals. When dining out, consumers frequently inform staff about their food allergies and would verify that their meals are indeed allergen-free when served. On the contrary, the respondents seldom use dietary apps or Quick Response (QR) codes to find out if food products contain any allergens. There were also less reliance on social media to find suitable eateries when dining out. Not all respondents find the advisory labelling helpful though (Table 4).

Insert Table 4 here

According to Begen et al. (2016), consumers with food allergies / intolerances preferred to rely on written information before and during their eating out experiences. This can be done by checking the venue websites, checking the recipes on the internet and menus displayed in the restaurant window. Verbal information from knowledgeable and perceptive staff increased consumers' confidence in the safety of their meals. Potentially, the reliance on written and verbal information provided by the restaurants enable consumers to be confident in their meals. Most consumers did not use food allergy apps to determine if a product is suitable or to find out more information about the ingredients. There are multiple dietary apps provided to food allergy and intolerant users today such as the Foodmaestro food app which helps to validate if a product is suitable and to look for alternative products across major retailers in the UK (Foodmaestro, 2017). The Biteappy (2018) app helps to search for allergy friendly restaurants worldwide. It is worth exploring the type and source of information used by food allergic individuals (e.g. advice from healthcare practitioners, online allergy support group, media, restaurant reviews) to make their decisions in food choices and allergy management. Precautionary allergen labelling (PAL) remains an area of confusion. Walker, Hazel and Points (2018) proposed that a target should be agreed on between government and retailers for a reduction in the variants of PAL wordings within the next three years.

EFA was applied in factor analysis to extract the items for knowledge, attitude and practices. The score of  $< 0.40$  is used to select items (Baser et al. 2017). A total of four items from knowledge, three items from attitude and one item from practices were removed. The Kaiser-Meyer-Olkin (KMO) measure of sampling value for food allergen knowledge, attitude and practices were 0.614, 0.603 and 0.696 respectively. These values fulfil Hair, Black, Babin, Anderson, and Tatham (2010) who stated that the criterion of validity should be  $> 0.60$ . Hair, Anderson, Tatham and Black (1998) also recommended observing more than one indicator to evaluate the model fit (Table 5).

Insert Table 5 here

CFI measured 0.90 indicating a good model fit. GFI and NFI were slightly below the cut off value but were comparable to Baser et al. (2017) and Wang et al. (2017). The RMSEA and RMR measured below 0.08 (Hu & Bentler, 1999; MacCallum et al., 1996). Based on the indices and comparison with other similar studies, the hypothesised model had an acceptable fit.

Insert Figure 1 here

Insert Table 6 here

Figure 1 and Table 6 explains the magnitude and relationship between food allergen knowledge, attitude towards food allergen and food allergy management practices. Food allergen knowledge has

a negative and insignificant relationship ( $\beta_1 = -0.02$ ,  $p > 0.05$ ) with food allergy management practices hence supporting H1. The theoretical interpretation from Figure 1 is that food allergy management practices will decrease 0.02 unit with each incremental unit in knowledge. Although this does not indicate a direct, linear relationship between knowledge and practices, but this finding reiterates that having good food allergen knowledge may not translate into good practices. Previous studies by Baser et al. (2017), Soon (2018b) and Ko (2013) support this finding.

Attitude towards food allergens were found to have a positive and insignificant relationship with practices ( $\beta_1 = 0.05$ ,  $p > 0.05$ ) hence rejecting H2.  $\beta_1$  indicates that food allergy management practices increase by 0.05 unit with each unit increase in attitude. This contradicts previous findings where Baser et al. (2017), Soon (2018) and Lim et al. (2016) reported significant relationship between food safety attitude and practices. Although the respondents scored highly in most of the attitude mean items, this does not translate into food allergy management practices. This could be due to the fact that consumers seldom rely on apps or social media to check out suitable products or restaurants. Okumus, Ali, Billgihan, & Ozturk (2018) suggested that consumers' intention to use and adoption of dietary apps can be increased by increasing the apps' performance, ease of usage, social influence and degree of user innovativeness. The consumers in this study also did not often purchase, whole unprocessed ingredients to prepare their meals from scratch. In fact, they would like to have more free-from choices, indicating that consumers would prefer to purchase ready meals or semi-finished ingredients that do not contain the allergenic materials. Time saving in meal preparation was identified as a key driver in food choices (Casini et al., 2019). The two key strategies employed by the respondents in this study are handwashing before preparing allergen-free meal and communicating their needs to food service staff when eating out. There is a significant and negative relationship between food allergen knowledge and attitude in this study ( $\beta_1 = -0.20$ ,  $p < 0.05$ ), supporting H3. This indicates that knowledge and attitude dependently affect practices. As knowledge decreases, so will their attitude towards food allergens. Tan et al. (2013) found weak correlations between knowledge and attitude among food handlers while Soon (2018b) found insignificant relationship between both attributes among consumers.

The current best method to prevent food allergic reactions would be to adhere to a strict free-from diet. However, researchers are working on oral immunotherapies to build up tolerance for food allergens (Blumchen et al., 2018; Wasserman et al., 2018). The PALISADE Group of Clinical Investigators (2018) revealed encouraging results where peanut oral immunotherapy resulted in desensitisation among children and adolescents who were highly allergic to peanuts. Such trials can potentially prevent food allergic reactions and life-threatening circumstances as consumers' tolerance levels are increased and could tolerate accidental consumption of food allergens. This coupled with vigilant safe food handling and food allergy management practices can help to ensure the safety of consumers with food allergies. Food safety is not synonymous with the total absence of risk (FAO,

WHO, 1997). Similarly, zero risk for food allergic individuals is not a realistic option. Consumers, regulators, clinical researchers and food industry are working towards defining a tolerable level of risk (Madsen et al., 2010). Madsen et al. (2012) reported that the guiding principle in defining acceptable risk is the concept of minimising the overall risk and hence, the burden of disease caused by food allergy. Begen et al. (2016, 2018) carried out in-depth interviews to gain understanding of consumers' preferences for food allergy and intolerance (FAI) information and impact of such information when eating out while Begen et al. (2017) reported on the experiences of family members and carers' who eat out with children with FAI. In addition to quantitative surveys, it is recommended that in-depth interviews be carried out with the consumers to explore their views and food allergen handling practices especially the adoption of dietary apps in managing FAI.

## Conclusion

Consumers demonstrated relatively good knowledge in food allergens and are motivated in their personal allergen avoidance towards food allergy management. Most respondents however did not resort to using dietary apps or social media to find out more information about food products. Consumers also prefer to have more free-from choices and may not have time to prepare meals from scratch. The structural equation modelling showed an acceptable fit on food allergen knowledge, attitude and practices. Although knowledge and attitude did not directly affect their food allergy management practices, a significant relationship was identified between knowledge and attitude. A combination of knowledge and attitude can potentially modify food allergen handling practices. It is suggested that targeted and specific food allergy management topics and online or peer group support are provided to improve the knowledge-attitude relationships to positively influence their food allergen handling practices.

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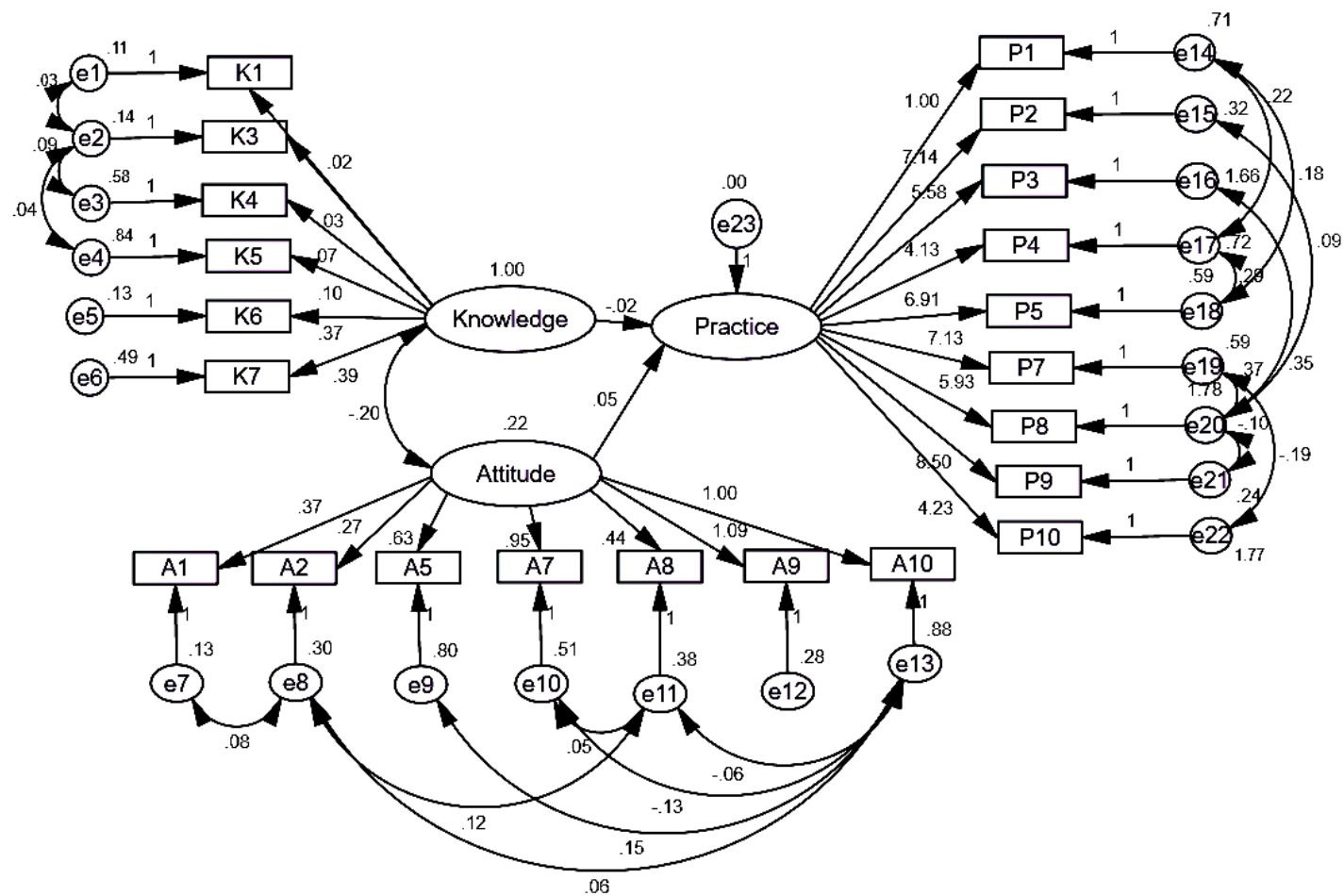
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**Figure 1** Structural Equation Modelling of food allergen knowledge, attitude and practices among UK consumers

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613 **Table 1** Demographic characteristics of participants (n=252)

| Variable                                                                                                                                                                              | Items                                                                              | Frequency (%) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|---------------|
| Gender                                                                                                                                                                                | Male                                                                               | 57 (23.0)     |
|                                                                                                                                                                                       | Female                                                                             | 195 (77.0)    |
| Age                                                                                                                                                                                   | 18-24                                                                              | 22 (8.7)      |
|                                                                                                                                                                                       | 25-34                                                                              | 36 (14.3)     |
|                                                                                                                                                                                       | 35-44                                                                              | 44 (17.5)     |
|                                                                                                                                                                                       | 45-54                                                                              | 55 (21.8)     |
|                                                                                                                                                                                       | 55-64                                                                              | 50 (19.8)     |
|                                                                                                                                                                                       | 65 years and above                                                                 | 36 (14.3)     |
|                                                                                                                                                                                       | Prefer not to say                                                                  | 12 (4.8)      |
| Education                                                                                                                                                                             | Primary education                                                                  | 2 (0.8)       |
|                                                                                                                                                                                       | Secondary education                                                                | 89 (35.3)     |
|                                                                                                                                                                                       | HNC or Foundation degree                                                           | 37 (14.7)     |
|                                                                                                                                                                                       | Degree                                                                             | 99 (39.3)     |
|                                                                                                                                                                                       | Masters                                                                            | 22 (8.7)      |
|                                                                                                                                                                                       | Doctorate                                                                          | 3 (1.2)       |
| Have you experienced food allergic reactions before (such as tingling or itching in mouth, swelling of lips, tongue, face or throat, dizziness, difficulty in breathing or fainting)? | Yes                                                                                | 108 (42.9)    |
|                                                                                                                                                                                       | No                                                                                 | 117 (46.4)    |
|                                                                                                                                                                                       | Uncertain                                                                          | 27 (10.7)     |
| Have your family member(s) experienced food allergic reactions before?                                                                                                                | Yes                                                                                | 136 (54.0)    |
|                                                                                                                                                                                       | No                                                                                 | 92 (36.5)     |
|                                                                                                                                                                                       | Uncertain                                                                          | 24 (9.5)      |
| The food allergies and/or intolerance experienced by you or your family were diagnosed by:                                                                                            | Allergist                                                                          | 62 (24.6)     |
|                                                                                                                                                                                       | General practitioner                                                               | 77 (31.0)     |
|                                                                                                                                                                                       | Paediatrician                                                                      | 21 (8.3)      |
|                                                                                                                                                                                       | Emergency physician                                                                | 2 (0.8)       |
|                                                                                                                                                                                       | Dermatologist                                                                      | 0             |
|                                                                                                                                                                                       | Self-diagnosis                                                                     | 30 (11.9)     |
|                                                                                                                                                                                       | Other                                                                              | 32 (11.9)     |
|                                                                                                                                                                                       | Not applicable                                                                     | 28 (10.3)     |
| Please select the foods you or your family member(s) are allergic to. Check all that apply*:                                                                                          | Milk                                                                               | 92            |
|                                                                                                                                                                                       | Molluscs (e.g. mussels, oysters)                                                   | 4             |
|                                                                                                                                                                                       | Peanuts                                                                            | 33            |
|                                                                                                                                                                                       | Tree nuts (e.g. almonds, cashews, hazelnuts)                                       | 29            |
|                                                                                                                                                                                       | Soybeans                                                                           | 22            |
|                                                                                                                                                                                       | Eggs                                                                               | 36            |
|                                                                                                                                                                                       | Fish                                                                               | 12            |
|                                                                                                                                                                                       | Cereal containing gluten (wheat, rye, barley, oats)                                | 181           |
|                                                                                                                                                                                       | Lupin (a common garden plant and seeds from some varieties are used to make flour) | 6             |
|                                                                                                                                                                                       | Sulphites                                                                          | 20            |
|                                                                                                                                                                                       | Celery                                                                             | 0             |
|                                                                                                                                                                                       | Crustaceans (prawns, crabs, lobsters)                                              | 9             |

|  |                                                                                                                                                                                                          |    |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
|  | Mustard                                                                                                                                                                                                  | 9  |
|  | Sesame seed                                                                                                                                                                                              | 8  |
|  | Others (e.g. anything high in histamine, chocolate, fermentable oligo-, di-, monosaccharides and polyols (FODMAP), fruits such as apples, cherries, garlic, maize, onions, red meat, spices, white meat) | 32 |
|  | Not applicable                                                                                                                                                                                           | 25 |

Note: \*Participants can select more than one food allergens

**Table 2** Food allergen knowledge (n=252)

| No. | Questions                                                                                   | Correct answers<br>Frequency (%) | Standard loadings |
|-----|---------------------------------------------------------------------------------------------|----------------------------------|-------------------|
| K1  | Allergen can be serious and in severe cases result in death                                 | True 240 (95.2)                  | 0.80              |
| K2  | Ingesting a small amount of food allergen will cause an allergic reaction                   | True 225 (89.3)                  | <0.40             |
| K3  | The best way to prevent food allergic reaction is to avoid the allergen                     | True 238 (94.4)                  | 0.71              |
| K4  | Allergens can be transferred by hands                                                       | True 170 (67.5)                  | 0.89              |
| K5  | Tree nuts (e.g. almonds, cashew nuts, Brazil nuts) are similar to peanuts                   | False 35 (13.9)                  | <0.40             |
| K6  | High temperature cooking such as roasting, baking and deep frying can destroy food allergen | False 191 (75.8)                 | 0.82              |
| K7  | Allergen cross contamination of cooking utensils can be prevented by rinsing with tap water | False 135 (53.6)                 | 0.81              |
| K8  | Which of the following causes food allergic reaction?<br><b>Protein*</b>                    | <b>103 (40.9%)</b>               | <0.40             |
|     | Salt                                                                                        | 0                                |                   |
|     | Sugar                                                                                       | 9                                |                   |
|     | Lipid                                                                                       | 7                                |                   |
|     | Unknown substance                                                                           | 16                               |                   |
|     | Uncertain                                                                                   | 117                              |                   |
| K9  | Which of the following is not categorised as food allergen in UK/EU?<br><b>Buckwheat</b>    | <b>128 (50.8%)</b>               | <0.40             |
|     | Almonds                                                                                     | 7                                |                   |
|     | Fish                                                                                        | 20                               |                   |
|     | Milk                                                                                        | 5                                |                   |
|     | Mustard                                                                                     | 23                               |                   |
|     | Uncertain                                                                                   | 69                               |                   |
| K10 | If an individual is allergic to eggs, which of the following food should be avoided?        |                                  | <0.40             |
|     | Mayonnaise                                                                                  | 21                               |                   |
|     | Pancakes                                                                                    | 0                                |                   |
|     | Meringues                                                                                   | 0                                |                   |
|     | Quiches                                                                                     | 0                                |                   |
|     | <b>All of the above</b>                                                                     | <b>224 (88.9)</b>                |                   |
|     | Uncertain                                                                                   | 7                                |                   |

\*Bold letters indicate correct answers in K8 – K10

**Table 3** Mean scores of items in attitude towards food allergens (1: Strongly disagree to 5: Strongly agree) (n=252)

| Items | Description                                                                                                                                                  | Mean | Standard deviation | Standard loadings |
|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------|-------------------|
| A1    | When purchasing food, labels should be checked if it contains any ingredients that can cause food allergic reaction                                          | 4.82 | 0.41               | 0.67              |
| A2    | There should be more free from choices to choose from                                                                                                        | 4.64 | 0.57               | 0.87              |
| A3    | I will not purchase food containing the food allergen (where I or a family member is allergic to) even though other household members are not allergic to it | 3.25 | 1.32               | <0.40             |
| A4    | Kitchen surfaces and cooking equipment are washed with hot soapy water and rinse to remove allergens                                                         | 4.33 | 0.71               | <0.40             |
| A5    | It is easy to prepare allergen-free meals by substituting with other types of ingredients (e.g. wheat can be substituted with quinoa)                        | 4.06 | 0.95               | 0.71              |
| A6    | Hands should be washed thoroughly after coming into contact with allergenic products to avoid cross contact                                                  | 4.64 | 0.49               | <0.40             |
| A7    | It is my responsibility to inform food services if I have any food allergies                                                                                 | 4.46 | 0.84               | 0.61              |
| A8    | When ordering food online, there should be more information provided about allergen free food                                                                | 4.48 | 0.65               | 0.67              |
| A9    | When ordering food via telephone, it is my responsibility to ask for allergen free food                                                                      | 4.49 | 0.74               | 0.66              |
| A10   | I believe I can handle a food allergy emergency situation at home or when eating out                                                                         | 3.62 | 1.05               | 0.61              |

**Table 4** Mean scores of items food allergen management practices (1: Never to 5: Always) (n=252)

| Items | Description                                                                                                   | Mean | Standard deviation | Standard loadings |
|-------|---------------------------------------------------------------------------------------------------------------|------|--------------------|-------------------|
| P1    | I purchase whole, unprocessed foods                                                                           | 3.67 | 0.85               | 0.65              |
| P2    | During shopping, I read the food labelling to check for allergenic ingredients                                | 4.59 | 0.77               | 0.69              |
| P3    | I use apps or scan the QR code to find out if the ingredients contain any allergens                           | 2.29 | 1.35               | 0.46              |
| P4    | I prepare my meals from scratch                                                                               | 3.93 | 0.90               | 0.59              |
| P5    | I look for alternative ingredients to use in my meal preparation or as food substitutes                       | 3.90 | 0.92               | 0.74              |
| P6    | I wash my hands before preparing allergen-free meal                                                           | 4.60 | 0.75               | <0.40             |
| P7    | When eating out, I frequent restaurants that cater allergen-free meals                                        | 4.10 | 0.93               | 0.68              |
| P8    | I check social media to identify suitable restaurants                                                         | 3.22 | 1.41               | 0.49              |
| P9    | I would inform the staff of my food allergies and seek confirmation that my meal is allergen-free when served | 4.56 | 0.79               | 0.71              |
| P10   | I find the precautionary allergen labelling 'May contain' helpful                                             | 3.63 | 1.37               | 0.85              |

**Table 5** Goodness of fit indices

| Fit indices                                     | Model value | Accepted value      |
|-------------------------------------------------|-------------|---------------------|
| $\chi^2/df$                                     | 1.98        | < 3 <sup>1</sup>    |
| Comparative Fit Index (CFI)                     | 0.90        | > 0.90 <sup>2</sup> |
| Goodness of Fit Index (GFI)                     | 0.82        | > 0.90 <sup>3</sup> |
| Root Mean Square Error of Approximation (RMSEA) | 0.06        | < 0.08 <sup>4</sup> |
| Normed Fit Index (NFI)                          | 0.70        | > 0.90 <sup>5</sup> |
| Root Mean Square Residual (RMR)                 | 0.05        | < 0.08 <sup>2</sup> |

<sup>1</sup>Kline (1998)

<sup>2</sup>Hu and Bentler (1999)

<sup>3</sup>Hooper, Coughlan and Mullen (2008)

<sup>4</sup>MacCallum et al. (1996)

<sup>5</sup>Bentler and Bonnet (1980)

**Table 6** Estimates of hypothesis paths for food allergen knowledge, attitude and practice

| Hypothesis | Paths                   | Estimate | C.R.  | P value |
|------------|-------------------------|----------|-------|---------|
| H1         | Knowledge → Practice    | -0.02    | -1.09 | 0.28    |
| H2         | Attitude → Practice     | 0.05     | 1.11  | 0.27    |
| H3         | Knowledge <--> Attitude | -0.20    | -3.40 | < 0.05  |