RAPID EVIDENCE ASSESSMENT OF RESEARCH QUESTIONS ON FOOD HYPERSENSITIVITY

Final Report – FS430465

05 May 2021

EXECUTIVE SUMMARY

Introduction
The Food Standards Agency (FSA) contracted RSM UK Consulting LLP (RSM) to conduct a Rapid Evidence Assessment (REA) to establish the evidence base regarding priority research areas in the field of Food Hypersensitivity (FHS). The aim of the review is to synthesise and summarise the evidence base, evaluating the current understanding regarding the research questions and identifying areas for future research. This serves to ensure access to the best available science and evidence and inform how the FSA can support appropriate and effective actions to ensure food safety and consumer choice

The first stage of this review was a Priority Research Setting Exercise involving a general public survey and workshop with stakeholders/ consumer representatives. This resulted in ten priority research areas emerging (see findings section below) which guide this REA.

Methodology
RSM developed a search protocol (available in Appendix 3) to guide the database and grey literature searches. The search protocol included details on the sources of evidence (academic searches, grey literature search, call for evidence, and manual searches), search terms used, and screening processes. It also specifies the evidence review parameters (or inclusion/exclusion criteria) as follows: English language, OECD studies, published since 2000, human studies, and primary research that is relevant to priority research areas.

The searches resulted in 11,467 studies found from academic databases and 35 documents through other sources. Out of these studies, 192 progressed through two screening stages and are summarised in the findings in Section 3. There were two screening stages:

- **First level screening**: 11,467 retrieved abstracts were screened for relevance to the research areas and 10,297 of these were excluded based on inclusion/exclusion criteria. Studies meeting inclusion criteria or where a decision could not be made on the abstract alone, progressed to second level screening.
- **Second level screening**: Full texts were screened for 1,205 studies (including documents from other sources) and upon further scrutiny, 1,007 of these were excluded. The first and second level screening for manual searches were conducted simultaneously.

After screening, 192 studies moved to the data extraction and quality appraisal stage. The study team extracted details of each study such as study population, methodology, study type, findings, key themes, and, strengths/limitations reported. A quality appraisal was completed according to GRADE methodology for each study. Commentary was recorded on quality and generalisability, and a quality rating applied. Findings were synthesised into themes for each research question.

The final stage of the process covered the overall quality assessment for the themes under each research area. This stage assessed the evidence base for the themes of each research area by assigning separate quality ratings to each theme. GRADE methodology was again used but enhanced with WHO quality of evidence ratings for non-randomised control trials/clinical studies. An aggregated rating was also applied to the overall evidence base for each research question.

Conclusions and evidence gaps
In the table below, we provide conclusions on the breadth, depth, and quality of the evidence base for each research area. We highlight where there are gaps in the evidence bases and provide recommendations for future research.

Research Areas	Summary	Key Findings	Evidence gaps and research recommendations
1. Risks posed to people with FHS by new/novel foods and/or processes	• Evidence base is **insufficient**, with 11 of 15 studies being of 'low' or 'very low' quality • Most studies focus on sensitivity to or allergenicity of novel foods, which have limited generalisability as they are all on different foods	• No findings determined as there is a wide range of novel foods/processes studied across the topics, which makes it difficult to generalise findings	• Lack of data on likelihood of allergenic materials migrating into food from bio-based packaging • Few primary research-based studies on risk assessments and protocols to monitor risk • More well-designed research on each novel food is required to support the tentative conclusions
2. Improving traceability of allergens in the food supply chain	• Evidence base is **insufficient** • Only 2 studies of 'very low' quality relying on self-reported data, which reduces data reliability. Sample sizes are also small for both studies	• No findings determined due to the paucity of evidence base	• More well-designed high- quality research is required to provide robust evidence to support understanding of supply chain to make necessary improvements / recommendations
3. Risks posed due to shared production of foods, and how can these be mitigated	• Evidence base is **weak but suggestive**, with 8 of 11 studies being 'low' or 'very low' quality • Limited generalisability from studies beyond where the samples were retrieved from (ie pizzerias in a part of Italy, health food shops in Sweden etc.)	• The evidence is supportive of the role of safe cleaning and cooking procedures in reducing the risk of contamination in shared preparation areas and using appropriate wet cleaning methods, but monitoring is required.	• Robust evidence needed with larger samples and higher quality study designs • Studies needed on cross-contamination in other commercial settings where food is prepared such as canteens, street food kitchens and kitchens for food served on planes • Confirmatory studies needed on monitoring effects over time

4. Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe	• Evidence base for this is **insufficient,** with all 9 studies of 'very low' quality • Studies are based on self-reported data and have small sample sizes	• Some evidence on consumer preferences for written/information protocol from Food Business Operators (FBOs) is suggestive but insufficient	• Only 3 UK based studies of consumer behaviour • Robust evidence needed using high quality study designs • Intervention studies needed to show effect
5. Allergen labelling, including Precautionary Allergen ("may contain") Labels	• Evidence base is **weak but suggestive,** with all 30 studies are of 'low' or 'very low' quality • Most studies are based on self-reported data, retrospective data collection, and have small sample populations	• Good consistency in evidence on consumer preferences for "may contain" labels which is suggestive but insufficient • FA consumers want indicators on labels that give clear direction on whether the product has undergone a risk assessment and may contain an allergen	• Only 3 UK based studies • Well-designed high-quality research with UK population(s) required • Intervention studies needed to show effect over longer time periods. When data is collected and analysed over the longer term, decision-makers can survey the evidence and make predictions about future risks and where resources should best be directed.
6. Informing the FSA as to incidents involving FHS	• Evidence base is **insufficient**, with 2 studies of 'very low' quality • One study has small sample size and unbalanced groups, while the other is indirect as effectiveness of reporting systems is not the focus	• No findings due to paucity of evidence base	• No studies on obstacles that hinder reporting • Well-designed research on reporting systems, their effectiveness, and obstacles hindering reporting is required

7. Impact of co-factors on reaction severity	• Evidence base is **weak but suggestive,** with 11 of 12 studies being of 'low' or 'very low' quality. • Mainly self-reported data and retrospective studies (recall bias) • Only study of 'moderate' quality is RCT on associations between exercise, sleep deprivation, and reaction severity	• Evidence showing fairly consistent associations between exercise, sleep deprivation and increased reaction severity, but shortcomings in the available evidence precludes a more definite judgement	• Insufficient RCTs available • No studies on communicating risk of co-factors to consumers with FHS • More well-designed research (in particular RCT's) is required to support the tentative findings
8. Impact of socioeconomic factors (including race/ethnicity) on FHS	• Evidence base is **weak but suggestive,** as all 36 studies are 'low' or 'very low' quality • Studies rely on self-reported data and retrospective studies • Most studies focus on ethnicity and socioeconomic differences in prevalence of FHS	• Evidence available is suggestive of differences according to ethnicity, with higher risk of FA among non-White ethnic groups compared to White ethnic groups, but opposite is true for prevalence of Coeliac Disease (CD)	• Only 7 studies conducted in exclusively UK context • Lack of compelling evidence on economic impact of FHS • Robust evidence needed using high quality study designs in UK population(s) • Cost of illness studies using validated measure of FA needed
9. Impact of environmental exposures on the risk of developing FHS	• Evidence base is **insufficient**, with 36 of 38 studies being of 'low' or 'very low' quality • There is a reliance on self-reported data, unclear participant selection methods, and there are largely retrospective studies	• Evidence have inconsistent findings on effect of gluten intake and likelihood of CD • Limited evidence on environmental exposures	• Robust evidence needed on the different environmental exposures using high quality study designs • Prospective and longitudinal studies needed, particularly for FA
10. Current knowledge of FHS amongst the general public	• Overall evidence base is **weak but suggestive,** with all 39 studies being of 'low' or 'very low' quality • Mainly self-reported data from surveys/qualitative interviews. Studies could also have selection bias as participants were selected from allergy groups	• Evidence available is suggestive of incorrect beliefs across a wide array of population subgroups but shortcomings in the available evidence precludes a more definite judgement	• No studies on attitudes and behaviours of the public • Only 6 studies conducted in exclusively UK context • Studies needed that assess public knowledge across FHS and against other chronic diseases

CONTENTS

1. INTRODUCTION 8
2. SEARCH METHODOLOGY AND RESULTS 13
3. FINDINGS 22
4. DISCUSSION 120
5. CONCLUSIONS 130
ACKNOWLEDGMENTS 135
REFERENCES 136

1. INTRODUCTION

1.1 Aim and objectives of the Rapid Evidence Assessment

The Food Standards Agency (FSA) contracted RSM UK Consulting LLP (RSM) to conduct a REA in the field of FHS.

The aim of the project is to conduct a review of available primary evidence in order to answer key research questions on the topic of FHS identified through a Priority Research Exercise conducted by the FSA.

The objectives of this REA are as follows:

- To establish the current evidence base (and thus evidence gaps) relevant to Priority Research Questions identified during a Priority Setting Exercise on Research into FHS.
- To synthesise and summarise the evidence base, assessing the current understanding against each research question and the requirements for further research.
- Report findings and make recommendations.

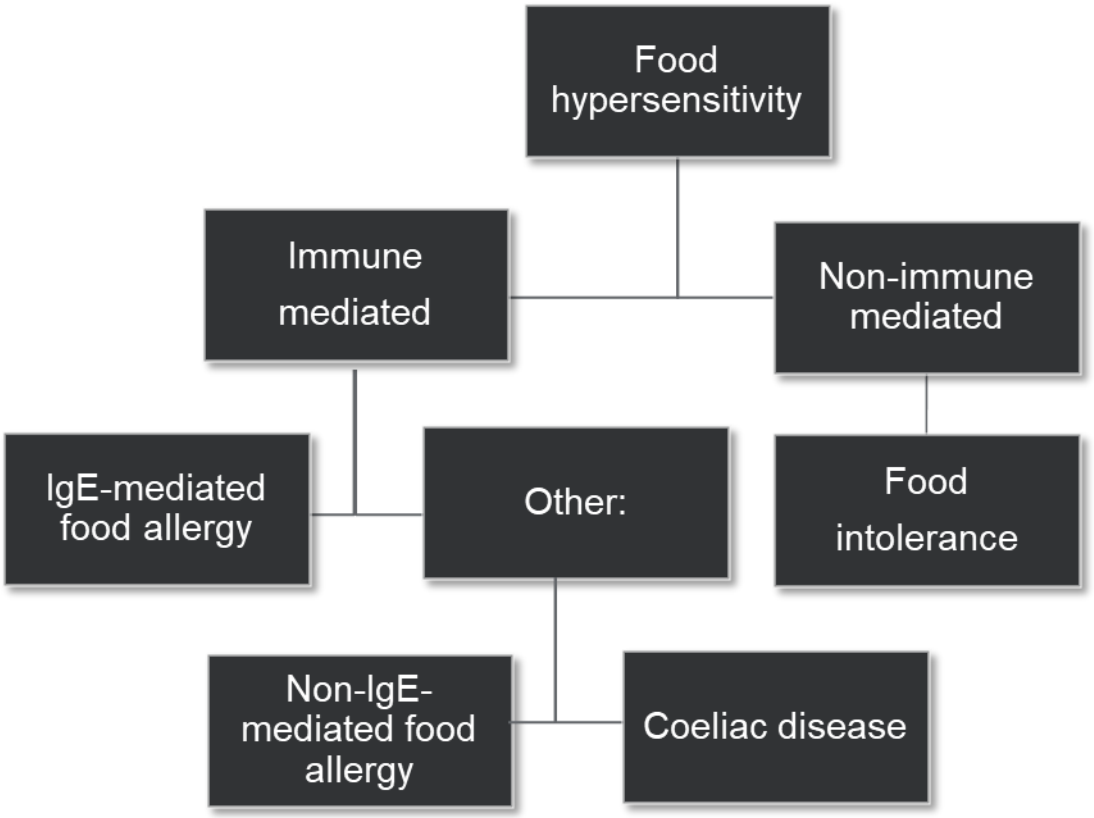
1.2 Background information

FHS includes the following three broad categories:

- **Immunoglobulin E (Ig-E) mediated food allergy group:** antibody-mediated allergy, in which the antibody typically responsible for an allergic reaction is part of the Ig-E isotype. (Johansson et al., 2004). https://www.jacionline.org/article/S0091-6749%252804%252900930-3/fulltext#back-BIB1 Allergic reactions can be divided into immediate-onset reactions (occurring up to 2 hours from food digestion) and immediate plus late-phase (immediate onset symptoms followed by prolonged/ongoing symptoms) (WAO, 2017). https://www.worldallergy.org/education-and-programs/education/allergic-disease-resource-center/professionals/food-allergy
- **Non-Ig-E mediated food hypersensitivity. This includes:**
    - **Non-Ig-E mediated food allergy**: allergy commonly associated with T-cell mediated immune responses. Experiences delayed onset of symptoms which occur 4 to 28 hours after food ingestion (WAO, 2017).
    - **Coeliac disease (CD) group:** an autoimmune response where the body's immune system attacks its own tissues when consuming gluten, which damages the gut lining and the body is unable to properly absorb nutrients from food (Coeliac UK, n.d.). https://www.coeliac.org.uk/information-and-support/coeliac-disease/about-coeliac-disease/
- **Food intolerance group:** a series of adverse reactions to foods that are not immune mediated. These include metabolic disorders, responses to pharmacologically active food components such as caffeine, theobromine in

chocolate or tyramine in fermented cheeses, or toxic reactions to food (WAO, 2017).

Figure 1. Food hypersensitivities classification (adapted from Sampson et al., 2014)



The FSA working in partnership with the Science Council, is reviewing the commissioning of research into FHS. The purpose of which is to ensure access to the best available science and evidence and identify how the FSA can support the delivery of appropriate and effective actions to ensure food safety and consumer choice.

The first stage of this review was a Priority Research Setting Exercise involving a general public survey and a workshop with stakeholders/ consumer representatives, using adapted James Lind Alliance methodology. The result of the exercise was ten priority research areas which guide this REA (the second stage of the wider review).

1.3 Research questions

The FSA set out the priority research areas and questions in the Invitation to Tender, which were established during the FSA's priority setting exercise. The ten priority research areas which guide this REA are:

Indicative uncertainty	Research Question	Relevant examples
1. Risks posed to people with FHS by new/novel	In individuals with FHS, what measures are needed to	eg. The use of pea protein in protein concentrates, which is often declared only as

foods and/or processes	monitor for FHS reactions due to: • new uses of known allergens? • novel proteins which might induce sensitisation and thus clinical reactivity? What protocols should the FSA have when assessing the risk to consumers with FHS posed by novel foods/ processes/ packaging? What data exist as to the likelihood of allergenic proteins in biobased food contact materials migrating into foods?	"vegetable protein" in ingredients listing. eg. Wheat-based starch in packaging, or latex-based binders in packaging and sustainable cutlery. Does not refer to risk of occupational allergy due to biobased food contact materials.
2. Improving traceability of allergens in the food supply chain	How should allergen information be communicated to consumers with FHS, in order to: • Improve consumer confidence in terms of possible allergen content? • Reduce the incidence of unintended allergen exposure?	
3. Risks posed due to shared production of foods, and how can these be mitigated	What are the health risks to consumers with FHS due to allergen cross-contact during food production? How effective are different control options in reducing these health risks?	eg. Shared production in small kitchens. Use of shared ovens (eg. gluten-free foods cooked in the same oven as gluten-containing foods). eg. Different cleaning strategies.
4. Communicating risk, so that consumers with FHS can be confident that the food they	What are the most effective ways for FBOs to communicate a level of competence (with respect to allergen risk management) to consumers?	

are provided is safe		
5. Allergen labelling, including Precautionary Allergen ("may contain") Labels	What forms of allergen labelling are effective for consumers to make informed decisions as to whether a food is "safe" for purchase/ consumption?	Labelling to inform both what is present, what might be present (through cross-contact), and what is not present (whether or not a "free-from" claim is made).
6. Informing the FSA as to incidents involving FHS	What evidence is there for different reporting systems (eg. mandatory hospital reporting, reporting by FBOs) to deliver useful data to regulators that can impact on reducing the risk of unintended allergen consumption? What are the barriers that prevent reporting of near misses and other incidents to official bodies?	Reporting systems might include: • Mandatory/ voluntary reporting by healthcare professionals. • Direct reporting by FBOs • Strategies to overcome fear of enforcement such as no-blame approaches to increase reporting • Direct reporting by members of the general public (and how to mitigate against the risk of "noise" in the signal) • Surveillance of serious incidents eg. deaths via the coronial system
7. Impact of co-factors on reaction severity	In consumers with FHS, what are the factors which can increase the risk of a severe reaction? How should risk posed by co-factors be communicated to those affected by FHS?	Incorporates both general advice to all FHS consumers, and individualised advice with respect to patient-specific co-factors.
8. Impact of socioeconomic factors (including race/ethnicity) on FHS	What are the socioeconomic factors which impact on risk in consumers with FHS? How do cultural attitudes impact on the management of FHS?	Includes: • understanding the impact of ethnicity/ race as a potential confounder • language difficulties in getting effective advice and communicating consumer needs • impact on affordability/ accessibility/ availability to appropriate foods for those with FHS

9. Impact of environmental exposures on the risk of developing FHS	What are the factors that drive a loss of immune tolerance to food allergens?	Applies to both adults and children A priority question once FSA better understands how common loss of prior tolerance is as a presenting symptom.
10. Current knowledge of FHS amongst the general public	What are the current gaps/ inaccuracies in knowledge with respect to FHS amongst the general public?	Focus on general public, but also applies to specific stakeholders eg. FBOs, healthcare.

2. SEARCH METHODOLOGY AND RESULTS

2.1 Search methodology

The priority research areas set out above determined the scope for this REA. A search protocol (see Appendix 3) was devised to guide the database and grey literature searches which were carried out between December 2020 and January 2021[1]. Recognised procedures and protocols were followed. AMSTAR 2 and CASP quality guidelines were followed as appropriate for a REA. This will be included in the appendix.

2.1.1 Sources of evidence

The searches encompassed four main sources of evidence:

- Standard scientific databases for academic research/ literature relevant to the research questions.
- Grey literature from a range of government/ public agency sources produced outside of traditional publishing channels (ie. not represented in academic research/ literature databases).
- Research and literature received by key stakeholders from our call for evidence in January 2021.
- Manual/targeted searches for research topics where the volume of evidence was low to ensure full coverage of the evidence base. This was guided by our advisors' knowledge of the topics and the literature available.

The following academic searches were completed:

- Scopus by Elsevier searches covering the following databases:
    - MEDLINE
    - PubMed
    - Embase
- EBSCO database covering the following research databases:
    - MEDLINE
    - CINAHL
    - UK and Ireland Reference Centre
    - Academic Search Complete

Additionally, grey literature sources were searched for relevant articles. Sources included the websites of relevant charities, such as Anaphylaxis Campaign, Allergy UK or Coeliac UK. Google searches were also conducted, focusing on original, unpublished research in FHS.

Finally, a call for evidence was distributed to key stakeholders through the FSA such as academic organisations, charities, UK and non-UK regulatory bodies, clinicians, industry organisations, and NGOs. The call for evidence was also done directly by

RSM to other charities, UK and non-UK regulatory bodies, industry organisations, and NGOs

The purpose of this call for evidence was to capture any non-confidential research that has not been published.

2.1.2 Search terms

To limit the searches to the most relevant research, parameters were narrowed to studies published post year 2000, in the English language and covering OECD countries only. Search terms varied across the databases/ research areas, but included as a minimum the following combinations:

food hypersensitivities OR food hypersensitivity OR food allergy OR food allergies OR food intolerance OR coeliac OR coeliac OR food allergen OR food allergens OR food sensitivities OR food anaphylaxis

Additional search terms for each of the priority research areas/questions are detailed in the separate search protocol.

2.2 Screening and Search Results

In the sub-sections below, we set out the inclusion/exclusion criteria used, number of search results produced from each source of evidence, and the screening process used to reach the final number of studies used in our findings.

2.2.1 Application of inclusion/ exclusion criteria

All identified studies were subjected to the following inclusion and exclusion criteria:

Inclusion criteria	Exclusion criteria
Related to one or more of the following topics: • Risk to consumers with FHS posed by new/ novel types of foods/ processes/ packaging (eg. Biobased packaging) • Traceability of allergens in the food supply chain • Cross-contamination/ cross-contact of allergens during food production and ways to reduce this risk • Communication of allergen risk management from FBOs • Allergen labelling • Communication of allergen information which is not on labelling (eg. online shopping product description) • Reporting systems on incidents involving FHS obstacles that hinder reporting • Other factors which increase risk of severe reaction (eg. Example)	• Not in the English language • Published prior to 2000 • Study population in a non-OECD country • Does not meet any inclusion criteria • Case Studies/Case Reports/Case Series (Excluded because they rank very low in the hierarchy of evidence), Systematic Reviews, Opinions, meetings and conference abstracts and any other type of articles not based on primary research. Overall, these were excluded as they fall outside the remit of a REA • Animal studies excluded as results cannot be directly extrapolated from animals to humans.

• Socioeconomic/ cultural factors related to FHS (eg. Example) • Environmental exposures on the risk of developing FHS (eg. Example) • Current knowledge of FHS amongst general public	*Note that systematic reviews were used as guidance for any supplementary manual searches needed

2.2.2 Search Results

Below details the total number of studies found from each source of evidence. At this stage, only the abstracts were retrieved. After deduplication, the volume of abstracts retrieved from each source was:

- Academic databases: 11,467
    - Scopus: 9,676 abstracts
    - EBSCO: 1,791 abstracts
- Other sources: 35
    - Grey literature search via Google: 16 documents
    - Manual searches: 5 documents
    - Call for evidence: 2 documents
    - Studies identified by the FSA: 12 documents (these were key papers suggested by the FSA to be used as checks for the searches)

The number of studies retrieved and their progress through screening and data extraction is summarised in Figure 2 below.

2.2.3 First level screening

There were 11,470 retrieved abstracts with duplicates having already been removed by University College Cork (UCC) before our receipt of them. During the screening process, there were an additional 3 citations that were duplicates and were thus removed. The remaining 11,467 abstracts were divided among six reviewers and screened for relevance to the research questions. Studies that met the inclusion criteria, or those where a decision could not be made based on the abstract alone, were progressed to the second level screening stage, which involved full text review of the retrieved studies.

At this stage, 10,297 abstracts were excluded based on inclusion/ exclusion criteria. The full texts of 1,170 abstracts were then downloaded via UCC library services and progressed to second level screening. The number of studies taken through to stage 2 is summarised in Figure 2 below.

2.2.4 Second level screening

The full texts were screened for 1,205 studies (including documents from other sources) against the priority research areas and upon further scrutiny, 1,007 of these were excluded. The number of studies taken through to data extraction is summarised in Figure 2 below.

During the second level screening stage, the exclusion criteria were applied to the full texts, which ended in full text data extraction and quality appraisal.

Additionally, for Research Area 9: Impact of environmental exposures on the risk of developing FHS, there was already previous research done by the FSA on these topics (ie breastfeeding, solid food introduction, maternal intake of vitamins during pregnancy, infant formula), which covered relevant studies until 2018. Thus, the scope of this REA for these topics was to only include post-2018 studies.

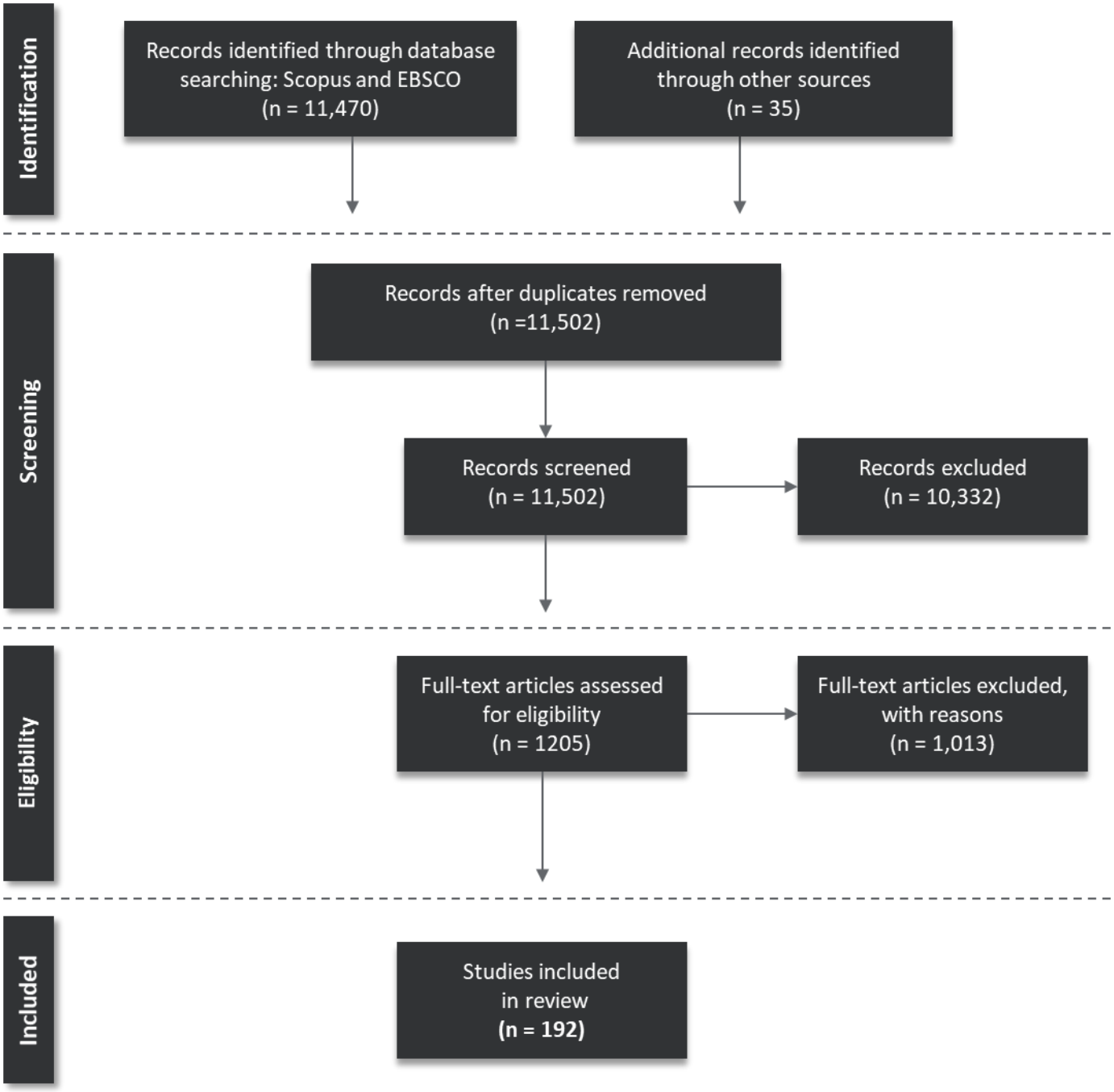
The table detailing the number of excluded papers for each exclusion criterion at each stage can be found in Appendix 5.

2.3 Study selection for the review

In total, 177 studies progressed to the next stage of data extraction and quality appraisal, along with two grey literature documents, five manual search studies, 12 studies from the FSA and two call for evidence documents. The grey literature on FHS were mainly systematic reviews and guidance booklets on best practices for FBOs, thus were excluded. The manual searches mainly resulted in reviews and not primary research, thus were excluded.

The final number of included studies in the review is 192. Citations of all 192 studies are included in References, and detail on the papers screened and included at each stage are provided in the diagram below.

Figure 2: PRISMA flow diagram



2.4 Data extraction and quality appraisal

During the full text reviews of retrieved studies, once determined that a study met inclusion criteria, studies were separated into relevant research questions for ease of allocation and review. Note that a few studies were relevant to multiple research questions. The following information was logged in an Excel database:

- Study information (title, authors, publication year)
- Country of origin
- Study type and aims

- Methods
- Strengths and limitations
- Findings
- Key themes/topics
- Relevant outcomes
- Study quality (using GRADE methodology)
- Level of risk of bias

2.4.1 Quality appraisal of each study

Next, a full quality appraisal of the studies was completed alongside data extraction using the GRADE methodology (included in appendix). This involved assigning an overall rating on the quality of the study together with evidence of any risk of bias. Two types of assessment were completed:

- For Randomised Controlled Trial (RCT) studies, appraisal was made against the risk of bias due to:
    - randomisation process used;
    - assignment/ deviations from intended intervention(s);
    - missing outcome(s) data;
    - bias in the measurement of outcomes; and
    - selection bias in reported results.
- Non-RCT studies were appraised against the risk of bias due to:
    - confounding factors;
    - the selection of study participants;
        - Some studies select participants with food allergies. Diagnosis of food allergy is important as double-blind, placebo-controlled food challenge (DBPCFC) is the gold standard. Whether studies are graded down for not using food challenges depend on the type of study.[2]
    - the classification of intervention(s) if any are used;
    - deviations from intended intervention(s) if any are used;
    - missing data;
    - bias in the measurement of outcomes; and
        - Presence of food allergy can be a measurement of outcomes for some studies. Like above, studies not using DBPCFC will be graded down.
    - selection bias in reported results.

[2] Eg. For studies on quality of life or preferences, questions on diagnosis/use of epinephrine injectors will be sufficient. For studies on co-factors/severity, diagnosis needs to be DBPCFC

These metrics informed an overall risk of bias rating which were then used as evidence for the rating assigned to the quality of the study.

2.4.2 Quality assessment of each research area/ theme

The quality of evidence available for each research area are summarised in the appendix. For each research question, we have synthesised the studies into an Evidence Profile table explaining the reasons for grading down the quality of evidence for every theme available in a research topic.

The GRADE evaluation was performed using the metrics below to determine whether to grade down a body of evidence. Following the GRADE approach, as a starting point:

- randomised trials without important limitations provide high quality evidence
- observational studies without special strengths or important limitations provide low quality evidence

From that starting point, certainty/quality of evidence was then rated down one level per metric:

- Risk of bias
- Imprecision
- Inconsistency
- Indirectness
- Publication bias

For some research topics, all included studies were observational studies which did not work as well with the narrow definitions of the GRADE language. Thus, for these research topics, we've added in the quality of evidence rating system produced by the WHO. These can be easily mapped to the ratings in the GRADE approach. We've also included a note in the findings tables indicating which rating approach is of higher relevance for the specific theme.

The table below provides the official definitions of the WHO and GRADE ratings and how they're mapped to one another. There is also a composite rating made up of a combination of the WHO and GRADE ratings, which is used to describe the overall evidence base for each research question:

WHO ratings and definitions	GRADE ratings and definitions	Composite ratings and definitions
Convincing evidence: Evidence based on epidemiological studies showing consistent associations between exposure and disease, with	**High:** We are very confident in the evidence supporting the recommendation. Further research is very unlikely to change the estimates of effect.	**Convincing:** Extensive evidence base of high quality studies showing a high level of consistent

little or no evidence to the contrary. The available evidence is based on a substantial number of studies including prospective observational studies and where relevant, randomised controlled trials of sufficient size, duration and quality showing consistent effects. The association should be biologically plausible.		findings, also direct evidence
Probable evidence: Evidence based on epidemiological studies showing fairly consistent associations between exposure and disease, but where there are perceived shortcomings in the available evidence or some evidence to the contrary, which precludes a more definite judgement. Shortcomings in the evidence may be any of the following: insufficient duration of trials (or studies); insufficient trials (or studies) available; inadequate sample sizes; incomplete follow-up. Laboratory evidence is usually supportive. Again, the association should be biologically plausible.	**Moderate:** We are moderately confident in the evidence supporting the recommendation. Further research could have an important impact, which may change the estimates of effect.	**Moderate:** Evidence base shows fairly consistent findings, but there are some shortcomings in extent, quality and directness
Possible evidence: Evidence based mainly on findings from case-control and cross-sectional studies. Insufficient randomised controlled trials, observational studies or non-randomised	**Low:** We have only low confidence in the evidence supporting the recommendation. Further research is very likely to have an important impact, which is likely to change the estimate of effect.	**Weak but suggestive:** Limited number of high or moderate quality studies, but consistent findings among those studies or among high number of lower quality

controlled trials are available. Evidence based on non-epidemiological studies, such as clinical and laboratory investigations, is supportive. More trials are required to support the tentative associations, which should also be biologically plausible.		studies. Evidence may be indirect
Insufficient evidence: Evidence based on findings of a few studies which are suggestive but are insufficient to establish an association between exposure and disease. Limited or no evidence is available from randomised controlled trials. More well-designed research is required to support the tentative associations.	**Very low:** Any estimate of effect is very uncertain.	**Insufficient:** Very limited evidence base in terms of number of studies, quality, and directness

The rating for the overall theme was chosen based on the rating of the majority of the studies. For example, if the majority of the studies were rated very low, then the overall GRADE rating/WHO rating given would be very low/insufficient evidence.

3. FINDINGS

In this section we summarise the evidence base, and related evidence gaps, relevant to the priority research questions on FHS. All relevant studies identified under the research areas are summarised here, along with a description of the quality of these studies. In total, data was extracted from 192 studies.

Full details of all studies (including the study type, methodology, findings, key themes, strengths/limitations reported, relevant outcomes, and study quality with comments) will be presented in individual summary tables (see Appendix 4).

3.1 Risks posed to people with FHS by new/novel foods and/or processes

Overall evidence base is **insufficient** due to:

- Lack of robust experimental studies for most of the themes.
- Most studies being food/protein analysis studies about sensitivity to or allergenicity of new foods/processes, which have limited generalisability due to focus on a specific type of novel protein.
- Few primary research-based studies on risk assessments and protocols to monitor risk, with most being reviews/systematic reviews:
    - There is one study on risk assessment (Garino et al., 2020), which is rated ‘low’ due to reliance on secondary data.
- Lack of data on likelihood of allergenic materials migrating into food from bio-based packaging.

The following table presents the evidence base divided into six thematic areas: Knowledge/Opinions on Novel Foods/Processes; Impact of Thermal Processing on Allergenicity of Foods; Methods to Detect New/Novel Foods; Sensitivity to New/Novel Foods; Allergenicity of New/Novel Foods & Processes, and Novel Food Processes. Please refer to Appendix 2 for a more detailed quality assessment.

Risks posed to people with FHS by new/novel foods and/or processes 13 studies: • **Very low – 6 studies** • **Low – 4 studies** • **Moderate – 1 study** • **High – 2 studies**			
Theme & Number of studies; Overall Quality Assessment (QA)	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: Knowledge/Opinions on Novel Foods/Processes **Number of studies**: 3 **QA:** GRADE rating: **Very Low** **QA comment:** Studies are based on surveys/ questionnaires. As such, they are based on self-reported data, which is subject to a high risk of bias.	Generally, consumers with FHS are comfortable with the introduction of novel foods. However, the impacts are difficult to summarise given the difference in novel foods being used in the studies.	**1a. Qualitative study in the UK** (n=16) using semi-structured interviews to gather opinions from stakeholders (food chain actors and consumers with FHS) on novel hypoallergenic foods (van Putten et al., 2010). **1b. Cross-sectional study in Poland** (n=251) which distributed questionnaires to food technology	**1a. The UK qualitative study** found that stakeholders support the introduction of novel hypoallergenic foods (although support is not universal) if they are acceptable to consumers with FHS and regulators. **1b. The Polish cross-sectional study** found that soy preparations contain immunoreactive proteins

The sample sizes are also limited for these two studies. The US study is also funded by a food biotechnology company, which is subject to potential funding bias.		students/graduates to capture awareness of risk of soy preparations (Jędrusek-Golińska et al., 2019). **1c. Pre-post study in the US** (n=576) where participants completed a test, then completed training which was followed by a post-test. (Santerre & Machtmes, 2002).	that may be the source of hidden allergens, even though they are not recognised as dangerous by well-educated respondents. **1c. The US pre-post study** found prior to training, only 25% believed that biotechnology was unlikely to add new allergens to food supply which increased to 63% after training.

Theme 2: Impact of Thermal Processing on Allergenicity of Foods **Number of studies:** 2 **QA:** GRADE rating: **Low** **QA comment:** There were limitations in the methodology that might overestimate the results. Neither studies use allergic reaction as an outcome measure to test for allergenicity. However, there is consistency in results as both studies arrive at the same conclusion, although testing different proteins.	Although different proteins (wheat in Polish study, lentil and chickpea in Spanish study) are being tested, thermal processing could reduce the allergenicity of foods either through lower immunoreactive potential or reduction in Ig-E binding to lentil and chickpeas. However, there is variability in how factors such as temperatures, time of thermal processing, and condition impact on the way thermal processing affects allergenicity	**2a. Protein analysis study in Poland** (no sample size specified) modified peptides with thermal processing, which were then used to modify wheat flour and the immunoreactivity of the modified wheat was tested (Brzozowski, 2018). **2b. Protein analysis study in Spain** (n = 49 individual sera) analysed SDS-PAGE and Ig-E-immunoblotting patterns of chickpeas and lentils before and after boiling (up to 60 min) and autoclaving (1.2 and 2.6 atm, up to 30 min) (Cuadrado, 2009).	**2a. The Polish protein analysis** study found enzymatic pre-modification of proteins during dough fermentation decreases their immunoreactive potential, such that fewer peptides recognised by R5 antibodies are released during digestion of bread matrix. **2b. The Spanish protein analysis study** found some of these treatments reduce Ig-E binding to lentil and chickpea, especially harsh autoclaving.

Theme 3: Sensitivity to New/Novel Foods **Number of studies**: 2 **QA:** GRADE rating: **Very Low** **QA comment:** Due to small sample sizes, unclear selection criteria of participants, and how representative they are of the population.	Consumers with FHS could experience sensitisation to new/novel foods; however, the studies look at different novel foods.	**3a. Cross-sectional study in France** (n=36) evaluated specific Ig-E to dun pea and cross-reactivity to peanut allergens for patients with legume and/or peanut allergy (Richard et al., 2015). **3b. Retrospective study in the UK** (n=1004) conducted a telephone survey of British consumers on adverse reactions to a meat substitute product (Jacobson, 2003).	**3a. The French cross-sectional study** observed cross-reactivity between sIg-E to peanut and dun pea, and 96% of peanut-allergic patients with legume sensitization or allergy had sIg-E to Ara h 1. **3b. The UK retrospective study** found that sensitivity to the meat substitute was at least as common as other allergens and 67% of consumers who consumed the product had experienced vomiting.

Theme 4: Allergenicity of New/Novel Foods & Processes Number of studies: 4 **QA:** GRADE rating: **Very Low** **QA comment:** Inherent limitations in methodology, 1 study on allergenicity mealworms based on secondary data, and study on soy protein funded by private meat substitute company.	There could be allergenicity in new/novel foods but as studies all look at different foods, more research is needed for those individual novel proteins.	**4a. Protein analysis study in Israel** (no sample size specified) assessed allergens present in proteins extracted from seaweed using computer-simulated methods (Polikovsky et al., 2019). **4b. Protein analysis study in Poland** (n=277) analysed the composition of bake-of/ready-to-bake breads (Rudnicka et al., 2017). **4c. Protein analysis study in the US** (n = 3 leghemoglobin protein samples) investigated the potential allergenicity of a new of soy leghemoglobin protein preparation and its associated Pichia proteins (Reyes et al., 2021). **4d. Quantitative risk study in Germany** (n=15) used stochastic quantitative food allergenicity risk assessment (FARA) to describe present and future scenarios of exposure to	**4a. The Israel protein analysis study** identified known and additional potential food allergens in macroalgae protein. **4b. The Polish protein analysis study** found 84.8% of bake-off products used a combination of 29 food additives. The researchers note that food additives can be a potential food allergen **4c. The US protein analysis study** found seven Pichia proteins, each representing ≥1% of total protein content, showed no significant sequence matches to any known allergens except for one **4d. The German quantitative risk assessment** found mealworm-based food products are a major risk of symptoms for individuals

		foods containing yellow mealworm (Garino et al., 2020).	allergic to crustaceans after the consumption of a dose less than a serving size.
Theme 5: Novel food process **Number of studies**: 2 **QA**: Moderate. Both studies only used samples from one supermarket which lowers quality of studies. Both types of novel processes offer a promising alternative tool to decrease the allergenicity of peanut, however in vivo studies are needed to verify the allergic reduction.	Both studies are focusing on different novel processes, which makes it difficult to formulate an overall impact. However, both studies found that their novel process reduces allergenicity in food product(s) tested.	**5a. Experimental study** evaluating the impacts of the high-intensity ultrasound processing (0, 5, 10, 15, 20 min, at room temperature) on the physiochemical and allergenic properties of shrimp samples. (Dong et al., 2020) **5b. Experimental study in Ireland** investigating the efficacy of cold plasma on major peanut allergens. (Venkataratnam et al., 2020)	**5a. The experimental study** found that the high-intensity ultrasound as a novel non-thermal processing technique exhibits potential in reducing the allergenicity of food products. **5b. The Irish study** concluded that cold plasma processing reduces peanut allergenicity.

3.2 Improving traceability of allergens in the food supply chain

Overall evidence base is **insufficient** due to:

- Limited studies of 'moderate/'high' quality with only 2 studies of 'very low' quality found.
- Both are qualitative interviews, which consists of self-reported data and thus, could be affected by different biases such as recall bias or social desirability bias.
- Small sample sizes with n = 70 participants in total across both studies, which limits generalisability.

The following table presents the evidence base divided into two thematic areas: Beyond Allergan Labelling and Difference in Communication Needs. Please refer to Appendix 2 for a more detailed quality assessment.

Improving traceability of allergens in the food supply chain

2 studies:

- **Very low – 2 studies**
- **Low – 0 studies**
- **Moderate – 0 studies**
- **High – 0 studies**

Theme & Number of studies; Overall QA	Overall Impacts	Type of study and sample sizes	Findings
Theme 1: Beyond allergy labelling	Fact sheets are preferred educational material among consumers and experts	**1a. Qualitative study in US** interviewed food and health experts (n=25) and caregivers (n=32) on knowledge of food	**1a. The US qualitative study** found both experts and caregivers identified fact sheets as preferred information delivery, these fact

Number of studies: 1 **QA:** GRADE rating: **Very Low** **QA comment:** Due to subjective nature of data collected and limited sample size.	and these effectively increased food allergy knowledge of consumers.	allergies and preference of information delivery to inform the development of educational campaign materials. Follow-up interviews and a pre-post-test of knowledge was conducted with caregivers to assess usefulness of material developed. (Maurer et al., 2007)	sheets were advised to have more symbols, graphs, pictures and be multilingual. Caregivers found the fact sheets to be readable and comprehensive. Mean knowledge post-test scores increased significantly (4.77 versus 5.00, $p < 0.001$).
Theme 2: Difference in communication needs **Number of studies**: 1 **QA:** GRADE rating: **Very low** **QA comment:** Only 1 study of very low quality was identified due to subjective nature of data, limited sample	There are different communication needs depending on who the target audience is.	**2a. Qualitative study in the UK** conducted stakeholder consultations (n=45) with the food industry, consumers, health professionals, and regulators on their communication needs. (Miles et al., 2006)	**2a. The UK qualitative study** found consumers and health professionals preferred information on symptoms, treatment, and prevention. The food industry preferred clear guidelines on allergen labelling practices and regulators need information from risk assessors regarding issues key to the implementation of an effective regulatory framework.

sizes, and unbalanced sampling.			

3.3 Risks posed due to shared production of foods, and how can these be mitigated

Overall evidence base is **weak but suggestive** due to:

- Most studies on this topic are of 'low' or 'very low' quality:
  - There is limited generalisability beyond the environments in which the samples were retrieved from (ie pizzerias in Italy, grocery shops and health food shops in Sweden etc).
  - There are limitations in methodology for most studies which lowers quality of studies.
- However, there are consistent findings among two studies of 'moderate' quality that appropriate wet cleaning methods should be used together with monitoring/quantifying cleaning efficiencies.

The following table presents the evidence base divided into three thematic areas: cross-contamination during food production; cross-contamination in food preparation environments (kitchens) and effectiveness of cleaning strategies. Please refer to Appendix 2 for a more detailed quality assessment.

Risks posed due to shared production of foods, and how can these be mitigated

14 studies:

- **Very low – 3 studies**
- **Low – 9 studies**
- **Moderate – 2 studies**
- **High – 0 studies**

Theme & Number of studies; Overall QA	Overall Impacts	Type of study and sample sizes	Findings
Theme 1: Cross-contamination during food production **Number of studies**: 4 **QA**: GRADE rating: **Very Low** **QA comment**: There is limited generalisability as samples only came from grocery shops/supermarkets in the area where the study was conducted.	3 of 4 studies focused on gluten contamination. Higher price. gluten-free labelled products, and less processed food are less likely to be contaminated. One study on peanut contamination found predicted number of allergy reactions from residual peanut oil is extremely low.	**1a. Food sampling study in Italy** (n=200) involved randomly tested gluten-free products from supermarkets in Ancona, Italy, to investigate correlation between cost and contamination (used a R5 ELISA Kit). (Verma et al., 2017) **1b. Food sampling study in Canada** (n=640) testing for gluten contamination in naturally gluten-free flours and starches from 8 Canadian cities and internet. (Koerner et al., 2013) **1c. Food sampling study** in **Sweden** (n=110) testing for gluten contamination oat products and	**1a. The Italian study** found a correlation between price of food products and quality control for gluten contamination. Higher cost, certified gluten-free products were less likely to be contaminated. While naturally gluten-free products and lower priced foods were at higher risk of contamination. Gluten contamination at levels of >20 ppm was found in 18 lower priced products (9% of the sample) but contamination was very low. **1b. The Canadian study** found that 9.5% of samples were contaminated >20 ppm (61/ 640 samples) with a range of 5–7,995 ppm. Naturally gluten free (GF) flours and starches were more likely to be contaminated and gluten-free labelled products less likely. For products not labelled gluten-free, higher fibre ingredients were likely to be the source of contamination. **1c. The Swedish study** found 13% of the oat products had gluten content over 200 mg/kg. Of the products naturally free

		products naturally free from gluten from grocery stores and health food shops in Sweden. (Størsrud et al., 2003) **1d. Food sampling/risk assessment study in multiple countries (Europe)** (n=22) assessing the predicted percentage of objective allergic reactions associated with residual peanut protein in refined non-peanut vegetable oil used in consumer food products. Risk assessment was based on oil samples from the European Vegetable Oil and Protein meal Association, from member companies across Europe and food consumption data from the UK and the Netherlands. (Blom et al, 2017)	from gluten 14% had a gluten content over 200 mg/kg. There was a tendency for higher levels of contamination with increased processing. **1d. The multi-country study** found that the predicted number of allergic reactions from residual refined peanut oil in production of foods was extremely low. All reactions were predicted for peanut protein doses well below the eliciting dose of known most sensitive individuals (2-5%).
Theme 2: Cross-contamination in food preparation environments (kitchens) **Number of studies**: 4	Safe cleaning and cooking procedures can help to reduce the risk of contamination in shared food preparation areas.	**2a. Food sampling study in Italy** (n=5 pizzerias) to assess gluten contamination in GF pizzas cooked with different methods in working pizzerias. The pizzerias used different procedures to either simultaneously or separately cook GF+WB pizzas in shared or separate ovens. (Vincentini et al., 2016)	**2a. The Italian study** found that samples had gluten concentrations below 20 ppm so not contaminated. If procedures are followed, sharing ovens with non-GF products is safe. The study findings are limited due to the small sample, recruitment procedures for restaurants unclear and adherence to procedures will vary.

QA: GRADE rating: **Very Low** **QA comment**: There are limitations surrounding generalisability of findings. There is limited information on the samples / where they came from. The trials were not conducted in controlled test conditions and full methods/ recruitment selection was unclear, so high potential for variable results and bias.		**2b. Food preparation surface sampling study in Spain** (n=621 food-contact surfaces from 50 school canteens) to evaluate allergen residues on food contact surfaces in school canteens (milk, egg, gluten) using a rapid LFIA test followed by ELISA lab test, for the purpose of assessing the adequacy of cleaning procedures. (Ortiz et al., 2018) **2c. Experimental study in the US** (n=10 experiments and 30 food samples) analysing shared domestic kitchenware (wooden spoon, colander, ladle, knife) for gluten contamination. Identifying which of 3 cleaning methods is most effective at preventing cross-contamination. (Studerus et al, 2018) **2d. Experimental study in the US** (n=5 activities) to measure gluten contamination in schools and the efficacy of cleaning methods. 5 experiments measured potential gluten cross-contact in Play-Doh, baking, papier mâché, dry and cooked pasta on sensory table and 3 handwashing methods tested (soap	**2b. The Spanish study** found that cleaning procedures in school canteens are inadequate putting FHS sufferers at risk. There was low contamination of milk (0%-6% depending on test) but higher contamination for egg (15%-24% depending on test) and gluten (45%-57%). **2c. The US experimental trial** of kitchenware found that the cleaning method used did not influence gluten concentrations: all samples contained <10 mg/kg. **2d. The US school study** resulted in rates of gluten transfer >20ppm threshold for paper mâché, baking and cooked pasta. Play-Doh and dry pasta resulted in the least gluten transfer and soap and water was the most effective cleaning method.

		and water, water, wet wipe). Gluten contamination among 30 participants age 2 to 18 was tested. (Weisbrod et al., 2020)	
		2e. Food preparation surface sampling study in the US determined if 3 common food preparation methods lead to gluten contamination: GF food in shared fryer; GF bread in shared toaster; sandwich spread using shared knife. Samples came from restaurants (shared fryer) or home environments (shared toaster and sandwich spread). (Parsons et al., 2020)	**2e. The US food sampling study** found small amounts of gluten cross-contact (6.4% at >20 kg/mg ppm) and sandwich spreads were at highest risk of cross contamination.
		2f. Food preparation surface sampling study in the **US** determined if 3 food preparation methods lead to gluten contamination in shared preparation areas and the efficacy of cleaning methods for kitchenware. The 3 food preparation methods: cooking pasta, toasting bread, and slicing cupcakes. Control samples were also tested. (Weisbrod et al., 2020)	**2f. This US study** detected gluten in GF pasta samples cooked in shared water but rinsing pots with water alone was an effective solution in preventing gluten transfer. Toasting in a shared toaster was not associated with gluten transfer. Only 2 of 28 cupcakes tested >20 ppm. All 3 knife-washing methods were effective in removing gluten.
			2g. The Spanish retrospective study found that of the 530 food allergic

		2g. Retrospective study in Spain (n=530 cases) to provide an overview of the role of hidden allergens in allergic reactions in one public health area of Spain. (Añíbarro et al., 2007)	reactions analysed, 119 (22.4%) were considered to be due to hidden allergens. One source of hidden contamination described was cross-contamination during food preparation such as container or grill contamination.
Theme 3: Effectiveness of cleaning strategies **Number of studies**: 3 **QA**: GRADE rating: **Moderate** **QA comment**: Two out of the three studies had either low sample size or did not specify sample size. Methods also not tested on an industrial scale.	Appropriate wet cleaning methods need to be used. It is necessary to monitor/quantify efficacy of cleaning processes and this can be done with a simple Bradford assay for total protein in combination with ELISA sandwich.	**3a. Wash water sample analysis study in Germany** (n=4) to evaluate the risk of carryover contaminations of peanut and celery contaminations during industrial cleaning procedures (using ELISA and Bradford). (Stephan et al., 2004) **3b. Cross-contamination analysis study** in Germany to investigate effectiveness of different cleaning methods to reduce Hazelnut Cross-Contamination (HNCC) in industrial cookie manufacturing. The extent of HNCC was analyzed by ELISA for each production device and various cleaning procedures (dry and wet cleaning methods) used between products. (Röder et al., 2008)	**3a. The German study** found that the washing water samples collected after the alkaline and acidic wash procedure were all negative. In each of the washing water samples from the prewashing procedure protein contaminations were observed ranging from 2.4 to 12.6 g/mL. In all samples taken after the alkaline and acidic cleaning, no protein contaminations were observed. This indicates that the applied cleaning process was effective. **3b. In the German cross-contamination analysis** the highest HNCC was found after mechanical scraping: Up to 100 mg/kg hazelnut protein was found in the follow-up product after processing. After additional cleaning with hot water, the HNCC decreased regardless of the processing device to levels at or below 1 mg/kg hazelnut protein. The application of an appropriate wet cleaning procedure

However, there is clear explanation of methods and cleaning efficiency was monitored.			(manual scraping plus cleaning with 53 degrees celcius hot water) in combination with quantitative monitoring of the cleaning efficiency reduced the hazelnut protein cross-contamination to a level at which severe hazelnut-related allergic reactions are unlikely to occur.
		3c. Cross-contamination analysis study in Japan that developed a novel enzyme-linked immunosorbent assay system using a rabbit polyclonal antibody against a recombinant orange profilin allergen. This was used with limit of quantification of 2,500 mg/mL, residual orange extract on the cookware surfaces was measured using swabbing tests. Cleaning methods tested was rinse alone and foam and rinse, with no treatment used as control. (Kiyota et al., 2018)	**3c. The Japanese study** found that rinsing with 1 L of water showed a >95% removal efficiency for stainless steel and glass cookware, whereas half the polypropylene plastic and wood cookware required scrubbing with a detergent-containing sponge for complete cleanliness.

3.4 Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe[3]

Overall evidence base is **insufficient** due to:

- Limited number of studies which are all 'very low' quality:
  - The studies are surveys/interviews which are based on self-reported data and have small sample sizes.
- Despite consistent findings on consumers preferring written information/protocol in restaurants, a limited number of studies (three) arrive at this finding.

The following table presents the evidence base divided into three thematic areas: factors influencing effectiveness of FBOs' risk information/communication with consumers who have FHS, preferences of consumers/FBOs in communicating risk, recommendations for improving FBO communication of risk. Please see Appendix 2 for a more detailed quality assessment.

[3] This research topic is on how can FBOs effectively communicate allergen risk to consumers with FHS.

Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe 9 studies: • **Very low – 9 studies** • **Low – 0 studies** • **Moderate – 0 studies** • **High – 0 studies**			
Theme & Number of studies; Overall QA	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: Factors influencing effectiveness of FBOs' risk information/communication with consumers who have FHS. **Number of studies**: 3 **QA**: • WHO rating: **Insufficient evidence**	Communication effectiveness depended on communication from consumers to staff about food allergies and from staff reporting back to kitchens. However, evidence is varied among all 4 studies and there does not seem to be a consensus	**1a. Mixed methods study in the UK** (n=37) on how well the hospitality industry copes with special dietary requests. Methods included survey & structured interviews. (Pratten et al., 2004) **1b. Qualitative study in the UK** (n=32) used	**1a. The mixed methods UK study** reported that communication effectiveness depended on whether staff reported customer requests accurately to the kitchens. Labelling issues (lack of labelling regulations applicable to catering industry packaging) meant that FBOs were not always confident to state that a food was allergen free.

• GRADE rating: **Very Low** **QA comment**: All the studies identified are qualitative interviews or surveys. Hence, they are rated as 'low' or 'very low' as mostly reliant on self-reported data. Sample sizes are also small. There are also only a few studies on this and no RCT studies.		semi-structured interviews to examine the strategies that nut allergic individuals deploy to make safe food choices in addition to a reliance on food labelling. (Barnett et al., 2011) **1c. Qualitative study in New Zealand** (n=21) used ethnographic focus groups and interviews, to examine the factors affecting allergen management practices, particularly pertaining to college foodservices. (Verstappen et al., 2018)	**1b. The UK study** (n=32) found that factors other than safety influenced decision making e.g. product attributes, contextual factors and internal -physiological or psychological - states and the broader life stage. **1c. The ethnographic study in New Zealand** (n=21) found that factors which influence the effectiveness of communication of risk from the perspective of food service managers and staff include: communication from residents and hall management, the availability and friendliness of foodservice staff and the ease of the colleges' systems, college size and residents' attitudes and the level of responsibility they

			took for their special dietary requirements..
Theme 2: Preferences of consumers/FBOs in communicating risk to consumers with FHS. **Number of studies**: 4 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment**: All studies identified are qualitative interview or survey studies and assessed as low quality. Hence, reliant on self-reported data. Sample sizes are also limited. There are also only a few studies on this.	Consumers prefer written information/protocol on food allergies from FBOs, but they also value and trust in good communication with FBO staff.	**2a. Survey study in the US** (n=316) used self-reported online surveys to look at how restaurant staff share food allergy information with and communicate risks to customers with food allergies. (Wen & Kwon, 2019) **2b. Qualitative study in the US** (n=75) used	**2a. The US study** found that participants perceived the 3 most effective communication strategies as: informing customers when the food preparer is unable to provide allergen-free meals, including a statement on the menu to advise customers to notify the server if anyone has a food allergy, and having a written protocol with standard procedures for serving customers with food allergies in place. Including a statement on the menu to advise customers to notify the server if anyone has a food allergy was perceived more positively by servers from chain restaurants than servers from independent restaurants. **2b. The qualitative US study** found that

		semi-structured interviews to explore the allergen-related information delivery preferences of FA/FI populations when eating out or ordering takeaway foods. (Begen et al., 2016) **2c. Mixed methods longitudinal study in the UK** used semi-structured interviews (n=28) and a self-report survey (n=129) investigates the impact of EU FIC legislation on the behaviours, experiences and attitudes of consumers with food allergy when eating out. (Begen et al., 2018) **2d. Survey study in the US** (n=291) used an online survey to: compare the persuasiveness of gain-framed and loss-framed	consumers with FHS preferred FBOs to communicate allergen risk through written information but also valued staff use of simple, proactive face to face strategies to make enquiries and reassure customers. **2c. The UK study** found that since the EU FIC legislation, consumers with FHS continue to prefer written allergen information but also report greater confidence in communicating with eating out staff and in trusting the allergen information that they provided since the legislation. **2d. The US study** found the gain-framed message demonstrated significantly higher level of persuasiveness, effectiveness,

		messages in encouraging food allergy communication; identify and compare factors that influence the relative effectiveness of gain-framed and loss-framed messages; and identify factors that influence customers' intentions to communicate with restaurant staff about their food allergies. (Wen & Lee, 2020)	convincingness, and credibility. Fear, attitudes toward the messages, the perceived effectiveness of the messages, and the severity of one's food allergies were significant predictors of customers' intentions to communicate.
Theme 3: Recommendations for improving communication of risk by FBOs **Number of studies**: 2 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low**	Recommendations should focus on providing training and educational resources to staff and improve communication by having employees be willing to listen carefully to customers.	**3a. Qualitative study in the US** (n=16) used telephone interviews to identify restaurant managers' risk perceptions and operational issues related to communications about food allergy risks. (Wen & Kwon, 2016)	**3a. The US study** reported the theme of food allergy communication including recommendations for training for effective communication: get manager or supervisor involved, establish clear and open communication, ask questions of chef, listen to cue words, be willing to listen. **3b. The US study** reported recommendations

QA comment: There are only 2 studies, using interviews and focus groups. Hence, reliant on subjective data. Sample sizes were also small. Studies were low or very low quality.		**3b. Qualitative US study** used advisory panel (n=25) interviews (n=25) and focus groups (n=3) to examine the information and communication challenges regarding food allergens. To create a fact sheet that depicts the suspect foods and explains specifically how to avoid triggering food allergies in guests. (Abbot et al., 2007)	from the advisory panel including: that the fact sheets should: (1) convey the seriousness of food allergies; (2) provide step-by-step food-handling instructions on how to prevent a food allergic reaction; and (3) educate food-service employees never to guess whether a food is safe for a customer. They further recommended: that the fact sheet contain pictures, symbols, or graphs to help convey the messages and be written in both English and Spanish. Food-service employees should: listen carefully to customer requests, honour customer requests, symptoms of an allergic reaction, what to do in case of an emergency.

3.5 Allergen labelling, including Precautionary Allergen (“may contain”) Labels

Overall evidence base is **weak but suggestive** due to:

- All studies being of ‘low’ or ‘very low’ quality:
  - Most studies are based on self-reported data, potentially have recall biases from retrospective data collection, have small sample populations and indirectness.
- However, there are consistent findings among a high number of lower quality studies on precautionary allergen labelling (PAL):
  - They find there is a preference among consumers for “may contain” statements over other differently worded statements shown to them.

The following table presents evidence base for the topic divided into seven thematic areas including: effectiveness of PAL statements; symbols as an effective way to communicate allergens; specific allergens and their effective communication; effective communication of allergen information requires educating the consumer; improving existing allergen labelling practices; and using Information Communications and Technology (ICT’s) in allergen labelling. Please refer to the Appendix 2 for a more detailed quality assessment.

As some studies have overlapping themes, they've been classified into more than one theme. These studies are indicated with an asterisk.

Allergen labelling, including Precautionary Allergen ("may contain") Labels 30 studies: • **Very low –** 19 **studies** • **Low –** 11 **studies** • **Moderate – 0 studies** • **High – 0 studies**			
Theme & Number of studies, Overall QA	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: Effectiveness of PAL statements **Number of studies**: 13 **QA**[4]:	In general, consumers with allergies prefer "may contain" statement over any other differently worded statements shown to them. There is a need to standardise PAL phrasing	**1a. Control-case study in the US** (n=1,243 for survey; n=4,049 for experiment) determining consumer preferences for allergy statements; to compare these statements	**1a. US control-case study** identified a consumer preference for "Allergy Information: may contain peanut" over "may contain peanuts" or "manufactured on the same equipment as food

[4] The WHO rating given is higher than the GRADE rating given for themes 1 ("Effectiveness of PAL statements") and 2 ("Symbols as an effective way to communicate allergens") due to the large number of cross-sectional studies available for that theme. As GRADE is typically used for clinical studies, themes with a large base of cross-sectional studies and are graded down for bias/inconsistency/indirectness/imprecision/publication bias would have been rated 'very low'. GRADE's 'very low' rating would typically be mapped to WHO's rating of 'insufficient evidence'. However, having a large amount of cross-sectional studies would fall under 'Possible evidence', thus some themes were given both a 'very low' and 'possible evidence' rating. Although both ratings are provided, as these are observational studies, the WHO rating will be more relevant than the GRADE rating for these themes.

• WHO rating: **Possible evidence** • GRADE rating: **Very Low** **QA comment**: Possible evidence as studies are mainly case-control/cross-sectional studies. Rated ‘very low’ due to low sample representativeness of findings and selection bias	across the industry as different statements convey different level of danger as perceived by consumers with allergies. There is also a need to regulate these statements as advisory labelling could contain false information.	and their efficacy by measuring its impact on consumers' decision-making. (Verrill et al., 2009) **1b. Cross-sectional study in Australia** (n=535) aiming to understand parental perception of precautionary allergy labelling. (Zurzolo et al., 2013a)* **1c. Cross-sectional study in the US** (n=625 in 2003 and n=645 in 2006) to determine whether consumers with FHS heed advisory labels and whether products with advisory labelling contain allergens. (Helfe et al., 2007) **1d. Cross-sectional study in North America** (n=6684) assessing consumer perception of PAL labelling. (Marchisotto et al., 2017)	that contain peanut" or "produced in a facility with an allergy control plan. May still contain trace amounts of peanuts". **1b. The Australian study** found the “may be present” statement was viewed as most useful/ taken more seriously. **1c. The US study** found that “may contain” statements are more effective deterrents than ‘‘shared facility’’ statements, and ‘‘shared equipment’’ statements are intermediate in effectiveness. **1d. US PAL study** found that 11% of respondents purchased food with "may contain" labelling, 40% - “manufactured in a facility that also processes.",

		1e. Cross-sectional study in the US (n=3,008) aimed at understanding PAL preferences among food allergy stakeholders. (Gupta et al., 2020) **1f. Mixed methods study in the US** (n=150) to understand factors that contribute to the economic impact of food allergen control practices on the food industry, using focus group and survey data. (Ruchi et al., 2017)	37% of respondents thought PAL was based on the amount of allergen present. **1e. US cross-sectional study** identified that 85.5% of the respondents never buy products with “May contain traces of allergen” label in with a “Good manufacturing practices used to segregate ingredients in a facility that also processes allergen” label that was bought by 35.0%. Top preferences for a PAL statement were “Not suitable for people with ‘blank’ allergy” (29.3%) and “May contain” (22.1%). **1f. US mixed methods study** found that manufacturers use various statements such as ‘‘may contain’’ (30%) being the labelling used most frequently, followed by ‘‘manufactured in’’ (16%), ‘‘manufactured on’’ (10%), and ‘‘other’’ (4%). 78% of the respondents reported that having only a single option for PAL (e.g., ‘‘may contain’’) would

			improve their industry. As such, PAL phrasing should be harmonised to improve effectiveness.
		1g. Food sampling study (n=569) used cookies and chocolates to determine peanut and hazelnut content and compared results with information provided on the product label. (Pele et al., 2007)	**1g. The study** concluded that precautionary labelling can only be an effective deterrent if it identifies an increased chance of allergen contamination. The absence of a precautionary warning should guarantee that cookies and chocolate are nut free.
		1h. US retrospective study compiled labelling information for 101 products tested for gluten content and retrospectively reviewed them for an allergen advisory statement for wheat, gluten or both. (Thompson et al., 2016)	**1h. The US retrospective review** found 86% of products tested for gluten did not include an allergen advisory statement for wheat or gluten on product packaging. Out of this 86%, 15% contained quantifiable gluten at or above 5 ppm, including 5% products that tested at or above 20 ppm. of gluten. For the 14% of products that did include an advisory statement, only 7% contained quantifiable gluten at or above 5 ppm.
		1i. Qualitative study in the UK using observation	

		of food shopping behaviour and semi-structured interviews (n = 32) to understand how peanut and nut allergic adults interpret 'may contain' labelling and how they use this information when purchasing food (Barnett et al., 2011) **1j. Risk assessment study in the UK** using probabilistic techniques (ELISA) that enables the estimation of the residual risk after the consumption of a product that unintentionally contains an allergen. This is used to analyse product categories with and without PAL. (Remington et al., 2015). **1k. Cross-sectional study in Australia** examined n=1355 packed processed goods in a large supermarket for precautionary labelling to	**1i. UK study** found many believed 'may contain' labelling was not reliable or desirable. There were also many that ignored it, but some found it helpful and avoided products with this labelling. **1j. UK risk assessment study** found majority of products that tested positive for an allergen contained a concentration of allergen predicted to cause a reaction in >1% of the allergic population. The concentrations of allergens measured would trigger PAL. This was found for products both with and without PAL. **1k. The Australia study** found overall, 882 products (65%) had a precautionary statement for one or more allergens. The most

		assess prevalence and types of precautionary labelling statements for common food allergens and investigate uptake of the Voluntary Incidental Trace Allergen Labelling (VITAL - a risk management tool to assist with declaring possible presence of allergens in food). (Zurzolo et al., 2013b) **1l. Database study** developed reference doses for precautionary labelling from statistical dose-distribution modeling of individual thresholds of patients in a dataset of over 55 studies of clinical oral food challenges. This precautionary labelling is part of VITAL 2.0. (Allen et al., 2014) **1m. Cross-sectional study** distributed anonymous questionnaire	common allergens listed on precautionary statements were tree nuts (36.2%) and peanuts (34.1%), followed by sesame (27.5%) and egg (22.6%). Of those that had precautionary statements, 'May contain traces of . . .' was the most common type of precautionary label used on 392 products (29.0%). This was followed by 'May be present' (VITAL) on 172 products (12.7%). **1l. The database study** found that the eliciting dose for an allergic reaction in 1% of the population estimated for the following were 0.2 mg of protein for peanut, 0.1 mg for cow's milk, 0.03 mg for egg, and 0.1 mg for hazelnut. These new levels will enable manufacturers to apply credible PAL and improve consumer confidence in their reliability.

		to (n = 184) parents of children with nut allergies to assess attitude on allergen labelling. Diagnosed nut allergy [previous reaction to a peanut/tree nut or/ with a positive peanut/tree nut skin prick test (SPT) equal to or larger than a 10% histamine control] (Noimark et al., 2009)	**1m. In the cross-sectional study** 80% of parents would not purchase a product labelled 'not suitable for nut allergy sufferers' or 'may contain nuts'. However, other labels including 'this product does not contain any nuts but is made in a factory that uses nuts', 'cannot guarantee is nut free' and 'may contain traces of nuts' were avoided by only around 50% of parents
Theme 2: Symbols as an effective way to communicate allergens on food labelling **Number of studies**: 7 **QA**: • WHO rating: **Possible evidence** • GRADE rating: **Very Low** **QA comment**: Possible evidence as most are cross-	There is a clear preference for internationally recognised and standardised usage of symbols for communication of allergen information.	**2a. Observational study in Europe** (n=40) to evaluate whether labelling practices are perceived as adequate by consumers with FHS and if changes are needed. Participants observed during food selection and interviewed afterwards. (Cornelisse-Vermaat et al., 2008)* **2b. European cross-sectional study** (n=287) to examine preferences of food labelling among consumers with FHS. (Voordouw et al., 2011)*	**2a. European observational study** proposes using universally recognisable symbols for allergens. **2b. The European cross-sectional study** found that consumers prefer universally recognised symbols for allergens on packets.

sectional studies. Studies are based on secondary data, self-reported allergies, indirectness between findings and conclusions, and convenience sampling (resulting in selection bias). Most studies have small sample sizes and offer limited generalisability.		**2c. Cross-sectional study in Australia** (n=535) analysing informative PAL (Zurzolo et al., 2017)* **2d. Another European cross-sectional study** (n=62) examining consumer preferences for different information delivery formats. (Voordouw et al., 2012)* **2e. Experimental study in Canada** (n=1,100) to examine allergic/ anaphylaxis consumer preferences in food labelling. (Marra et al., 2017) **2f. Cross-sectional study in Europe** (n=1,560) examining how consumers make decisions based on PAL using questionnaire. (DunnGalvin et al., 2019)	**2c. The Australian cross-sectional study** identified consumer preference for symbols, mobile apps and a toll-free helpline. **2d. The European cross-sectional study** identified a need to harmonise international symbolic allergen strategy. **2e. The Canadian study** identified preference for using allergen symbols on packets. **2f. The European cross-sectional study** found a preference for symbols with one- or two-word safety statements.

		2g. Mixed methods Greek & Dutch study had interviewed and observed purchasing behaviour of participants (n=40) to understand whether labelling practices meets the need of food allergic consumers. (Voordouw et al., 2009)*	**2g. The Greek & Dutch mixed methods study** found that Both Greek and Dutch consumers favoured symbolic labelling of allergens.
Theme 3: Specific allergens and their effective communication **Number of studies**: 3 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment**: There is insufficient evidence as there are only a few studies. The few studies identified are of 'very low' quality due to	Current food labelling practices do not adequately specify the sources for specific ingredients (eg. protein extracted from pea) which either endangers consumers with allergies or limits their diets.	**3a. Food sampling study in Europe** (n=20) that evaluates whether glycose syrup is dangerous for consumers with CD. (Dostálek et al., 2009) **3b. Cross-sectional study in the US** (n=20,241 food products) to determine the frequency and language used in voluntary advisory labels among commercially available products and to identify labelling ambiguities affecting consumers with FHS. (Pieretti et al., 2009)	**3a. The European food sampling study** found that coeliac disease sufferers do not need to avoid glycose syrup containing foods. Wheat starch-based glycose syrups are exempt from gluten labelling requirement. **3b. The US cross-sectional study** found that nonspecific ingredients eg. ''natural flavours'' or ''spices'' were found on 65% of products and 83% were not linked to specific ingredients. Additional ambiguities included unclear sources of soy (lecithin vs protein), nondisclosure of sources of gelatine and lecithin, and simultaneous disclosure of

selection bias and indirectness (theme is only part of the overall focus of studies).		**3c. Retrospective study in the US** (n=4482) to describe use of labels among consumers with FHS. (Vierk et al., 2007)	‘‘contains’’ and ‘‘may contain’’ for the same allergen. Further regulations regarding soy, such as specifying ‘‘this product contains soy as lecithin only’’ or not including ‘‘contains soy’’ if soy oil is the only soy ingredient, could expand the products available to consumers with FHS. **3c. The US cross-sectional study** concluded a need to address generic ingredient names that do not specify the source (eg. spices and flavours), the use of different words for allergenic foods on different products, and overly technical terms on ingredient lists.
Theme 4: Effective communication of allergen information requires educating the consumer **Number of studies**: 4 **QA**:	There is a need for simplified labelling, but to minimise the risk of accidental exposures, consumers need to be educated about allergen labelling as well because many fail to properly read the labels or recognise allergens.	**4a. Retrospective study in Canada** (n=1454) examining risk factors of accidental allergen exposures (including inappropriate labelling and ignoring precautionary statements). (Sheth et al., 2010)	**4a. Canadian study** found that 47% of consumers with FHS attributed at least one allergen exposure to manufacturer error. Clear and consistent labelling should increase consumer confidence, widen food choices for allergy sufferers and decrease the risk of accidental exposure. However, consumers

• WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment**: Insufficient evidence as only one cross-sectional study. Few studies identified, which are of very low quality due to indirectness and selection bias.		**4b. Cross-sectional study in Australia** (n=535) analysing informative PAL. (Zurzolo et al., 2017)* **4c. Review exercise in the US** (n=91) to determine accuracy of label reading among parents of food-allergic children. (Joshi et al., 2002) **4d. Evaluation study in the US** carrying cost-benefit and regulatory analysis. (FDA, 2005)	need to be educated about labelling. **4b. The Australian cross-sectional study** identified a preference for symbols, mobile apps and a toll-free number on package foods. Consumers could benefit from these labelling methods alongside consumer education regarding the VITAL process for packaged goods* **4c. The US review exercise** concluded that most parents are unable to identify common allergenic food ingredients. These results suggest a need for improved and simplified labelling with allergen warnings and improved label reading education. **4d. The US evaluation study** concluded that no exceptions should be made in terms of excluding products that contain gluten with more than 20 ppm produced by the small entities

			from the shelves as this would jeopardise trust in "gluten-free" labels.
Theme 5: Improving existing allergen labelling practices for more effective communication **Number of studies**: 7 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment**: Insufficient evidence as 7 studies were identified, and only 3 are cross-sectional. Most studies are of 'low' or 'very low' quality due to indirectness, small sample sizes and self-reported nature of data.	Standardised allergen labelling is required including font size and colour, warning statement, front label, etc. Using objects, such as square, circle and triangle will help individuals with impaired sight to understand labelling better. There are, however, contradictory findings on whether harmonisation of the labelling practices across Europe is feasible.	**5a. Cross-sectional study in South Korea** (n=543) exploring consumer preferences in food allergy labelling practices. (Ju et al., 2015) **5b. Observational study in Europe** (n=40) to evaluate whether labelling practices are perceived as adequate by consumers with FHS and if changes are needed. Participants observed during food selection and interviewed afterwards. (Cornelisse-Vermaat et al., 2008)* **5c. Cross-sectional study in Europe** (n=287)	**5a. South Korean study** found that the following labelling features will help consumers with FHS: bold font, font colour, box frame, warning statement, front label, and addition of potential allergens. **5b. The European observational study** recommendations: ○ Introduce regulations around minimum thresholds for font sizes and contrasts of information on packaging. Barcodes could help provide relevant information. ○ Determine a standard location for allergen information. ○ Harmonise EU labelling practices*

		exploring consumer preferences in food allergy labelling practices. (Voordouw et al., 2011)*	**5c. The European cross-sectional study** recommendations: ○ Mandatory safety warning for allergy ingredients with no exceptions for the size of the product or secondary packaging. ○ Adoption of ICT approach to address language issues. However, pan-European approaches will incur significant costs for the food industry as standardisation of traceability would be required across the retail industry*
		5d. Cross-sectional study in the UK (n=1,000) to explore characteristics and buying behaviour of consumers with FHS. (Cochrane et al., 2013)	**5d. The UK cross-sectional study** found that only 1 in 3 consumers with FHS read labels on every occasion – therefore food producers should flag new allergens on the front of packets to alert consumers with FHS of changes.
		5e. Field observation study in Portugal to create universal and inclusive food allergen	**5e. The Portuguese field observation** concluded that triangle, circle and square are

		symbols for consumers with sight impairment. (Mesquita et al., 2016) **5f. Mixed methods Greek & Dutch study** (n=40) investigating whether information provided through current labelling practices meets the need of food allergic consumers. (Voordouw et al., 2009)* **5g. Mixed methods study in the Netherlands** analysed product labels (n = 288) of several food products. Effectiveness of communication was assessed evaluating readability and findability of information on allergens using principles of Gestalt and Cognitive Load theories. (Blom et al., 2021)	easy forms to recognise for individuals with impaired sight which should be used for allergen labelling. **5f. The Greek & Dutch study** concluded that inappropriate use of fonts, colours and languages, application of precautionary labelling and lack of harmonization in labelling practices across countries can cause (un)necessary dietary restrictions for food allergic consumers. **5g. The Netherlands study** found part of the products displayed an icon at different locations of the label. Label background, a lack of cohesion and variation in location of topics hamper the identification of relevant information on allergens by (allergic) consumers. Recommendations include a standardization of mandatory and voluntary topics on the label and a separate allergen information section

Theme 6: Using ICT's in allergen labelling **Number of studies**: 3 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment**: Insufficient evidence as only 3 studies were identified, and these are of low or very low quality due to indirectness and small sample and self-reported nature of data.	Since the allergen information is ever increasing and it becomes complex to display all relevant information on a small label, usage of ICT technologies, such as barcode or electronic scanner, can help to provide all relevant information and address language challenges. However, one study suggests this should only be a supplementary tool.	**6a. Observational study in Europe** (n=40) to evaluate whether labelling practices are perceived as adequate by consumers with FHS and if changes are needed. Participants observed during food selection and interviewed afterwards. (Cornelisse-Vermaat et al., 2008)* **6b. Cross-sectional study in Europe** (n=287) exploring consumer preferences in food allergy labelling practices. (Voordouw et al., 2011)* **6c. European cross-sectional study** (n=62) about consumer preferences for different information delivery formats (Voordouw et al., 2012)*	**6a. The observational study in Europe** concluded that new ICTs, like barcoding, could provide all relevant information rather than including full details on packaging* **6b. Cross-sectional study in Europe** concluded that ICT methods can only serve as supplementary information to support food labelling. Recommendations for effective communication include adoption of ICT approach which can help address language challenges* **6c. The European cross-sectional study** found that the consumers with FHS preferred clear and unambiguous labelling on product packaging, although the functionality of the electronic scanner was appreciated. While the use of allergen labelling of

			food products remains an important consumer priority, additional information provision through the application of novel ICTs is also needed*

*As some studies have overlapping themes, they've been classified into more than one theme. These studies are indicated with an asterisk

3.6 Informing the FSA as to incidents involving FHS

Overall evidence base is **insufficient** due to:

- Only two studies of 'low' and 'very low' quality found on this topic:
  - There are small sample sizes and indirectness as effectiveness of reporting system is not the focus of the research study.
- Lack of evidence on obstacles that hinder reporting.

The following table presents the evidence base which only has one theme: reporting systems for allergic reactions. Please refer to Appendix 2 for a more detailed quality assessment.

Informing the FSA as to incidents involving FHS

2 studies:

- **Very low – 1 study**
- **Low – 1 study**
- **Moderate – 0 studies**

• **High – 0 studies**			
Theme & Number of studies; Overall QA	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: Reporting systems for allergic reactions **Number of studies:** 2 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Only two studies identified which is of low/very low quality. The first study is low due to a small sample, selection bias (all recruited through clinics/charities) and gender bias in	Both patients and clinicians can have access to the reporting system, where each accident is logged and its severity can be rated by the clinician. National reporting systems reveal food safety problems, although there is a high level of underreporting and physicians need to be prompted to report reactions.	**1a. Cross-sectional survey study in the UK** (n=39) to develop and evaluate eHealth methods on reporting allergic reactions. (Munro et al., 2015) **1b. Retrospective review in Norway** of 300 cases recorded in the national reporting system and register of severe food allergic reactions (Løvik et al., 2009).	**1a. The UK qualitative study** found that stakeholders support the introduction of novel hypoallergenic foods (although support is not universal) if they are acceptable to consumers with FHS and regulators. **1b. The Norway study** reported on cases in the national system. They found the register food safety problems in relation to allergy that probably could be discovered only with the help of a systematic, nation-wide registration of cases.

validation (90% are female). The second study is very low due to it being a review of results from the register and not on effectiveness of reporting system.			

3.7 Impact of co-factors on reaction severity

Overall evidence base is **weak but suggestive** due to:

- Most studies are of 'low' or 'very low' quality:
  - Mainly population-based studies using self-reported questionnaires and retrospective studies (which are subject to recall bias).
- Fairly consistent associations between exercise, sleep deprivation and reaction severity but only one RCT on this (Dua et al., 2019).
- Majority of studies found and excluded (c.18) were case studies/case reports on patients who suffered food dependent exercise-induced anaphylaxis (FDEIA) to certain foods.
- Lack of evidence on communicating risk of co-factors on reaction severity.

The following table presents the evidence base divided into four thematic areas: the association between exercise and food allergies (FDEIA); co-factors which increase severity of reaction; genetic factors on severity of food allergy; and frequency of reaction severity in peanut allergy sufferers compared to cashew allergy sufferers. Please refer to Appendix 2 for a more detailed quality assessment.

Impact of co-factors on reaction severity 12 studies: • **Very low – 6 studies** • **Low – 5 studies** • **Moderate – 1 study** • **High – 0 studies**			
Theme & Number of studies; Overall QA	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: Association between exercise and food allergies (including FDEIA) **Number of studies:** 2 **QA**: GRADE rating: **Low** **QA comment:** Only 1 RCT and 1 cross-section study of sufficient quality to be	Exercise and sleep deprivation potentially impact on the level of sensitivity of reaction for FHS sufferers.	**1a. RCT in the UK** on the effect of sleep deprivation and exercise on reaction threshold in adults with peanut allergy. Baseline challenges performed with 126 participants, 100 were randomized, and 81 completed at least 1 further challenge. (Dua et al., 2019) **1b. Cross-sectional study in Japan** (n=12) to understand effect of aspirin on FDEIA through administered SPT and	**1a. The UK study** found that the mean (SD) threshold was 214 mg (330mg) for non-intervention challenges and this was reduced by 45% (95% confidence interval 21,61 p=0.001) and 45% (22,62 p=0.001) for exercise and sleep deprivation, respectively. Exercise and sleep deprivation each significantly reduce the threshold of reactivity in people with peanut allergy, putting them at greater risk of a reaction. **1b. The Japanese study** found that Skin Prick Test reaction was enhanced by oral aspirin pre-treatment in 62.5% of patients and aspirin provoked symptoms in 71% of patients.

included in the review. Majority of studies identified are case studies of individual patients and case series of 2-3 patients, so these are excluded due to very low sample size.		provocation tests on patients with history of FDEIA. (Aihara et al., 2002)	
Theme 2: Co-factors which increase severity of reaction **Number of studies:** 6 **QA**: GRADE rating: **Very Low** **QA comment:** The few studies identified in searches were of low quality and limited by data quality, retrospective or self-	Studies have identified a range of co-factors which potentially influence severity of reaction. However, one study found that severity of DBPCFCs and accidental reactions to food is largely unpredictable.	**2a. Population study in Australia** (n=9,663) looked at factors increasing risk of severe reaction for young adolescents (age 10 to 14) using self-reported student questionnaire. (McWilliam et al., 2018) **2b. Cohort study in the USA, Australia, New Zealand** (n=295) examining the factors influencing severe gluten reactions from an open-label gluten food challenge. (Tye-Din et al., 2020)	**2a. The Australian study** found that those with nut allergy were most at risk of severe reactions (aOR, 2.9 [95% CI, 1.1-4.4]) and did not show that those with asthma were at significantly increased risk for severe reactions (aOR, 0.8 [95% CI, 0.3-2.2]. **2b. The multi-country study** found no association between patient characteristics (age, gender, height, weight) and clinical severity of reaction but patient age/age of diagnosis associated with elevation in serum IL-2.

reported nature of studies.		**2c. Retrospective study in Spain** (n=74) assessing co-factors for food allergy assessed by skin-prick tests, specific Ig-E and oral challenges. (Cardona et al., 2012) **2d. Retrospective database study** in the **Netherlands** (n=496) using a self-reported questionnaire to understand frequency of exposure to cofactors and association with severe symptoms. (Versluis, 2016) **2e. Prospective cohort study in the Netherlands** (n=147) using patient questionnaires over 1 year on accidental food allergic reactions to examine cofactors in accidental food allergic reactions in adults (influence on severity and occurrence). (Versluis et al., 2019)	**2c. The Spanish study** found that NSAIDs were involved in 58% of cases, exercise in 52.7% and alcohol in 12.2%. **2d. The Dutch retrospective study** found that 13% reported severe symptoms after participating in one or more of the cofactors: physical exercise (10%), alcohol consumption (5%), and use of analgesics (0.6%) – PE and alcohol were the most widely reported cofactors (still less than 10% of patients). **2e. The Dutch prospective cohort study** found no significant difference in the presence of factors (tiredness, alcohol intake, stress, symptoms of pollinosis, symptoms of asthma, sickness/flu, physical exercise and use of analgesics) between mild, moderate and severe reactions.

		2f. Retrospective database study in the Netherlands analysed a database of children (n = 734) with DBPCFC-confirmed FA to milk, egg, peanut, cashew and/or hazelnut; to identify predictors of reaction severity. Two scoring systems used to determine severity of reactions. (Pettersson et al., 2018)	**2f. The retrospective database study** found independent predictors for the severity of the DBPCFC reaction were age (B = 0.04, P = .001), skin prick test ratio (B = 0.30, P < .001), eliciting dose (B = -0.09, P < .001), level of specific Ig-E (B = 0.15, P < .001), reaction time during the DBPCFC (B =-0.01, P = .004), and severity of accidental reaction (B = 0.08, P = .015). The total explained variance of this model was 23.5%, and the eliciting dose only contributed 4.4% to the model.
Theme 3: Genetic factors on severity of food allergy[5] **Number of studies:** 3 **QA**: GRADE rating: **Very Low** **QA comment:** Few studies were identified, and these	Some evidence of genetic factors influencing severity of CD and food allergy symptoms, but evidence is limited.	**3a. Population-based candidate gene study in the US** (n=84) of Coeliac Disease patients and control group (n=102) who underwent high-resolution class 2 HLA genotyping, to understand contribution of DQA & DQB alleles to risk and severity of Coeliac Disease. Typing methodology is PCR with sequence-specific primers, low resolution and high resolution. (Murray et al., 2007)	**3a. The US study** found no relation between HLA DQ gene dosage and severity of Coeliac Disease.

[5] The search terms used were not specialised to look for genetic markers that influence severity. Thus, the genetic markers mentioned in the theme may not be the complete list of genetic markers that have been studied.

were of low quality and limited by sample size and retrospective or self-reported nature of studies. Blind genotyping was not used, and Hardy Weinberg Equilibrium not measured for		**3b. Retrospective candidate genes study in Japan** (n=187) to understand the effect of single nucleotide polymorphism (SNP) and environmental factors on severity of food allergy in children, using clinical records and questionnaires. SNPs studied are IL-4, FCER1B, STAT6, and IL-10 (Negoro et al, 2006) **3c. Population-based candidate gene study in Finland** (n=144) to understand impact of DQB gene dosage on severity of Coeliac Disease performed HLA genotyping on patients with biopsy-proven CD. Subjects and data originally from a genome-wide scan study. Typing methodology is PCR with sequence-specific primers. Other data collected by biopsies and questionnaires. (Karinen et al., 2006)	**3b. The Japanese study** found that while no single SNP selected in the study determined severity, but combination of the SNP with environmental factors influenced severity. **3c. The Finnish study** found that DQB allele associated with a more severe form of CD and slows down rate of recovery of villous atrophy after a year of GFD.

Theme 4: Frequency of reaction severity in peanut allergy sufferers compared to cashew allergy sufferers **Number of studies:** 3 **QA**: GRADE rating: **Very Low** **QA comment:** Only one study identified which is of very low quality due to allergies not tested using DBPCFC and small sample size.	Frequency of severe clinical reactions is higher in cashew compared with peanut allergy sufferers but only 1 study found on this.	**4a. Retrospective case-matching study** in the **UK** (n=47 cashew / 94 peanut allergy sufferers) comparing reaction severity between cashew and peanut in children using Skin Prick Test. (Clark et al., 2007)	**4a. In the UK retrospective case-matching study,** wheezing and cardiovascular symptoms were reported more frequently during cashew reactions than peanut reactions. Cashew group received adrenaline more frequently and severe reactions reported more frequently in cashew group (22%) compared to peanut group (1%).

3.8 Impact of socioeconomic factors (including race/ethnicity) on FHS

Overall evidence base is **weak but suggestive** due to:

- All studies being of ‘low’ or ‘extremely low’ quality:

- Most of the data collected are through surveys and databases/records, as well as largely retrospective studies (recall biases). The self-reported data collected from these studies could be less robust and subject to different biases. Potential confounding is also largely not considered for most studies.

- However, there are consistent findings among a high number of lower quality studies on racial differences in prevalence of FHS:
  - They find that there is higher prevalence of FA (based on sensitisation data for most studies) among non-White ethnic groups (especially non-Hispanic black groups) compared to White ethnic groups but higher prevalence of CD among White ethnic groups for both adults and children.

The following table presents evidence base for the topic divided into seven themes such as adherence to GF diet; racial differences in prevalence of FHS in children / adults; socioeconomic differences in prevalence of FHS in children / adults; impact of socioeconomic differences on affordability/ accessibility/ availability to appropriate foods for those with FHS; socioeconomic differences and management of FHS; gender and experiences of CD; and management of FA among adolescents. Please refer to Appendix 2 for a more detailed quality assessment.

Impact of socioeconomic factors (including race/ethnicity) on FHS

37 studies:

- **Very low – 28 studies**
- **Low – 9 studies**
- **Moderate – 0 studies**
- **High – 0 studies**

Theme & Number of studies; Overall QA	Overall Impacts	Type of study and sample sizes	Findings
Theme 1: Adherence to GF diet **Number of studies:** 4 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Few studies were identified, and they were all of very low quality due to small samples and very low response rates. Also due to selection bias that results in unbalanced or not representative population, recall bias as data was collected retrospectively and	Caucasian patients are more likely to adhere to GF free diet than South Asian coeliac patients. This is because South Asian patients reported having difficulties in understanding food labelling. It is unclear whether this is due to difference in health literacy or language barriers.	**1a. UK cohort study** examining adherence to gluten-free diet in Caucasian and South Asian coeliac patients (n=146), data was collected through the NHS trust's database and a follow-up visit after 1 year. (Adam et al., 2019) **1b. UK cross-sectional survey** examining difference in adherence to a GF diet between Caucasian and South Asian adults (n=375), participants filled a survey on diet, allergy details, and adherence to GF diet. (Muhammad et al., 2017) **1c. US prospective population study** describing CD in African Americans (n=9). (Brar et al., 2006)	**1a. The UK cohort study** found larger proportion of Caucasian patients being fully adherent to gluten-free diet compared to South Asian patients (64.6% versus 12.1%, P < 0.001). **1b. The UK cross-sectional study** found adherence to gluten-free diet the same for both groups (53%). However, a higher proportion of South Asian patients, compared with Caucasians, reported difficulties understanding what they can eat (76% versus 5%; p < 0.001) and understanding of food labels (53% versus 4%; p < 0.001). **1c. The US case series** identified that 4 from 9 African American participants adhered to GF diet.

all studies used self-reported data on adherence to diet.		**1d. Another UK cross-sectional study** identifying factors of compliance with a GF diet among Caucasian & South Asian patients (n=87), questionnaire included symptoms, advice given and adherence to GF diet. (Butterworth et al., 2004)	**1d. The UK cross-sectional study** found that higher proportions of Caucasian patients reported never ingesting gluten or did so less than once a month. (P=0:04 and 0.03, respectively). Also, they found factors associated with adhering to a gluten-free diet for Caucasian patients included understanding labelling and following up with a dietician; which was not related to adhering to a gluten-free diet for South Asian patients.
Theme 2: Racial differences in prevalence of FHS in children **Number of studies:** 8 **QA**: • WHO rating: **Insufficient evidence**	These studies found that in general non-Caucasian children (including African, Hispanic, African American and Mexican American) have a higher risk of being sensitised than Caucasian children.	**2a. US retrospective chart review** aiming to determine prevalence and characteristics of food allergy in a low-income minority population of children (n=9,184), data was collected through the extraction of medical records. (Taylor-Black & Wang, 2012)	**2a. The US retrospective chart review** found overall prevalence of food allergy was significantly higher in Black children than other races (4.7% vs 2.7%, p<0.0001). Also, black children had significantly higher rates of peanut, shellfish, and tree nut allergy;

• GRADE rating: **Very Low** **QA comment:** All studies identified were of very low quality due to unclear selection process or selection bias, measurement of food allergens was not through DBPCFC/oral food challenge, and high risk of confounders not accounted for.		**2b. US cohort study** examining variation of risk of food-allergen sensitization between self-identified race in childhood (n=1,104), data was collected through the extraction of medical records and a post-natal questionnaire. (Kumar et al, 2011) **2c. Prospective observational study** examining variation in ethnicity in FHS (n=76) of children with Ig-E-mediated food allergy from a particular NHS trust in the UK. (Dias et al., 2008) **2d. Prospective population-based cohort** study in the **Netherlands** identifying ethnic differences in Coeliac Disease Autoimmunity (CDA) in 6-year olds and explaining the socioeconomic factors	as well as higher rates of multiple allergies. **2b. The US cohort study** found self-reported black race (OR: 2.34 [95% CI: 1.24 – 4.44]) and African ancestry (OR: 1.07 [95% CI: 1.02–1.14]) were associated with food sensitization and with a high number of food sensitizations. **2c. The UK prospective study** found that average number of food allergies per child in the non-Caucasian group was 2.05 vs.1.22 in the Caucasian group, which is significant. **2d. The Dutch prospective cohort study** found being raised in the Netherlands (including those with Dutch, European, Indonesian, American, and Oceanian

		behind them (n=4,442). The researchers obtained serum from children and socioeconomic data was collected through questionnaires. (Jansen et al., 2017) **2e. US retrospective cohort study** identifying racial differences in FA and health care utilization among children (n=817). (Mahdavinia et al., 2017)	heritage) was positively associated with TG2A - proxy for CDA - positivity (adjusted odds ratio (aOR) 1.94; 95% CI 1.02 to 3.70) compared to groups not raised in the Netherlands (who were of non-Western heritage including Turkish, Moroccan, Cape Verdean, Antillean, Surinamese). This could partly be explained by high socioeconomic position and day-care attendance. The study used the term 'western ethnicity' to describe those who had grown up in the Netherlands regardless of their heritage and ethnic background. **2e. The US retrospective cohort study** found when compared with non-Hispanic white children, African American and Hispanic children had significantly higher odds of allergy to wheat, soy, corn, fish, and shellfish (P < .01). Also, they

		2f. Retrospective study in the **US** determining whether there were racial/ethnic and socioeconomic differences in the relationship between sensitization to common foods and self-reported food allergy (n=2,763). Data on food allergies, socioeconomic status and race were analysed from the National Health and Nutrition Examination Survey (NHANES). (McGowan et al., 2016) **2g. US birth cohort study** to understand racial differences in Ig-E-mediated food allergy (n=590). Serologic and demographic data was obtained from the Wayne County Health, Environment, Allergy, and Asthma Longitudinal Study	had a shorter duration of follow-up with an allergy specialist and higher rates of food-related anaphylaxis and emergency department visits (P < .01). **2f. The US retrospective study** found sensitization to foods was significantly higher among black than white or Mexican American children and self-reported food allergy was significantly less common among black and Mexican American children than white children. **2g. The US retrospective birth cohort study** found no statistically significant racial/ethnic differences in Ig-E-mediated food allergy. However, sensitization (serum specific Ig-E >0.35

		(WHEALS) study. (Joseph et al., 2016) **2h. Population based study** in the **US** aimed to characterize asthma and food allergy reporting and management in Chicago Public Schools (n=22,000). (Gupta et al., 2014)	IU/mL) to the food allergens was significantly higher for African American children compared with non-African American children. **2h. The US study of children** only in Chicago schools found that Black students have higher chances of having food allergies while Hispanic students are less likely to.
Theme 3: Racial differences in prevalence of FHS in adults **Number of studies:** 6 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** The studies identified are of low/very low	Non-Hispanic Black population are at higher risk of food sensitisation, while non-Hispanic White population are at higher risk of developing CD.	**3a. Swedish retrospective cohort study** examining influence of genetic versus ethnicity factors on incidence of childhood CD. (Ji et al., 2011) **3b. Retrospective cohort study** to understand prevalence and demographic risk factors for FA in the US. Data was	**3a. The Swedish study** identified decreased incidence of CD (Standard Incidence Ratios= 0.89, 95% CI 0.84-0.94) among second generation immigrations and adoptees from Eastern Asia which suggests that ethnic differences in genes may contribute to the worldwide variation of CD. **3b. US study** found that Risk of Possible/Likely Food Allergy was increased in non-Hispanic blacks ((OR) 3.06; 95% (CI) 2.14-4.36), males

quality, most studies do not account for any confounders, absence of robust diagnosis of CD/FA and retrospective data collection		obtained from a National survey (n=8,203) to derive population-based estimates of FA and identify high risk populations. (Liu et al., 2010) **3c. Retrospective US study** to estimate of the prevalence of CD by race/ethnic origin (n=19,591) in the US. Data on food allergies and race were analysed from the National Health and Nutrition Examination Survey (NHANES). (Mardini et al., 2015) **3d. US prospective pre-birth cohort** study to examine racial, ethnic and socioeconomic differences in adolescent FA. Serologic data and data on race and socioeconomic factors of participants (n=1,114) were collected from a different study. (Coulson et al., 2020)	(1.87; 1.32-2.66), and children (2.04; 1.42-2.93). This implies that non-Hispanic Blacks and males are possible risk factors for FA. **3c. The US study** concluded that prevalence of CD is 4–8 times higher among non-Hispanic white compared with other races. Non-Hispanic white were more likely to be positive for tissue transglutaminase (tTG) and endomysial (EMA) IgA antibodies compared to other races. **3d. The US study** argues that there are racial and socioeconomic disparities in food sensitisation among adolescents as there are higher rates of food sensitisation among non-Hispanic Blacks and lower socioeconomic homes. **3e. The Canadian study** identified that 10 out 14

		3e. Canadian retrospective record review describing CD in Asian-Canadians. Asian patients with biopsy-proven coeliac (n=14) were identified from a prospectively generated database, medical records were extracted. (Freeman et al., 2003) **3f. Retrospective population study** in the **US** (n= 97,482) determining the prevalence of food allergy and intolerance documented in the electronic health records allergy module. (Acker et al., 2017)	Asian-Canadians with CD are of Punjabi descent and that abdominal pain is the most frequent symptom. **3f. The US study** found that females and Asians are more likely to have food allergies and intolerance.
Theme 4: Socioeconomic differences in prevalence of FHS in children **Number of studies:** 5 **QA**:	Low socioeconomic group is a potential risk factor for developing FHS among children. However, there is one study using sales of infant hypoallergenic formula and EpiPens as proxy for food allergies that found higher sales of these	**4a. Welsh cohort study** determining whether socioeconomic deprivation increases or reduces Coeliac disease development (n=232) (Whyte et al., 2014)	**4a. The Welsh study** found that there is a higher prevalence of CD among children in low deprivation area (rate = 1.16) than high deprivation area (0.49).

• WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** The few studies identified are of low and very low quality due to self-reported data and recall bias, sampling bias and no food challenges used.	products for those with greater socioeconomic advantage.	**4b. Cross-sectional survey** to understand relation between food purchase location and food allergen related risks and food-induced anaphylaxis from caregivers' perspective (n=172) in the US. (Alayna et al., 2019) **4c. Prospective cohort study** to understand relation between socioeconomic status and allergic diseases in Swedish children (n=4089), data was collected through questionnaires and blood samples. (Almqvist et al., 2005) **4d. Prospective cohort study** to understand the relationship between socioeconomic factors and coeliac disease among children. 16,286 Swedish mothers consented and answered questionnaires on socioeconomic factors and	**4b. The US study** identified that those who report higher food insecurity also have higher perceived risk of food allergen risk and anaphylaxis. **4c. The Swedish study** found that the risk of sensitization to food allergens decreased with increasing socioeconomic status; OR 0.65 (0.41-1.02) in the highest socioeconomic group & OR 0.78 (0.57-1.03) for second lowest socioeconomic group. **4d. The Swedish study** determined that CD is less common among children with mothers who worked < 3 months during pregnancy, adjusted for confounders (R = 0.28; 95% CI: 0.09-0.92;).

		CD was confirmed by biopsy. (Ludvigsson et al., 2005) **4e. Retrospective review study in Australia** used sales of infant hypoallergenic formulae (IHF) and EpiPens for children ages 0-4 and hospital anaphylaxis admission rates for children and adults were used as proxies for food allergy and anaphylaxis. These were matched with data on socioeconomic status and geographic remoteness. (Mullins et al., 2010)	**4e. Australian study** found annual IHF sales rates are higher for those with greater socio-economic advantages (47 830 vs. 21 384 tins/100 000 population; P < 0.001). EpiPen sales were also higher in those with greatest socio-economic advantages most marked in those aged 0–4 (1713 vs. 669/100 000; P = 0.002) and 5–14 years (1628 vs. 600/100 000; P = 0.001). While anaphylaxis admission rates were higher in those with the greatest compared with the least socio-economic advantage in children aged 0–4 years (129 vs. 92/100 000 population/year; P = 0.03), the opposite was observed in older age groups (e.g. aged 25–64 years: 43 vs. 76, P = 0.01). No association between geographic

			remoteness and anaphylaxis admissions.

Theme 5: Socioeconomic differences in prevalence of FHS in adults **Number of studies:** 6 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** The studies identified are of low and very low quality due to largely relying on self-reported data. Other limitations include small sample sizes and confounders were not considered.	These studies present somewhat contradictory findings on whether higher/lower socioeconomic status is a risk factor for developing FHS.	**5a. Matched case control study** to examine relation of socioeconomic status and education to coeliac disease in Sweden (n=29,096), data was collected from biopsy records and government agency. (Olén et al., 2012) **5b. Cross-sectional survey** to estimate prevalence of food allergy among vulnerable populations in **Canada**, data was collected from randomly selected households completing surveys. (Soller et al., 2015) **5c. Canadian case-control study** to evaluate the association between the most common food allergies and sociodemographic	**5a. The Swedish case control study** identified that diagnosed CD was slightly less common in individuals with low socioeconomic position (adjusted OR = 0.89; 95% CI = 0.84–0.94) but not associated with educational level. **5b. The Canadian survey** found that food allergy was less common among adults without postsecondary education versus those with postsecondary education (6.4% [95% CI, 5.5%-7.3%] vs 8.9% [95% CI, 7.7%-10%]) and new Canadians versus those born in Canada (3.2% [95% CI, 2.2%-4.3%] vs 8.2% [95% CI, 7.4%-9.1%]). No difference for income and Aboriginal identity. **5c. The Canadian study** found that high household income associated with higher risk of probable allergy.

		characteristics and lifestyle habits using random national telephone survey (n=5734). (Ben-Shoshan et al., 2015) **5d. US retrospective cohort study** to examine association between socioeconomic status and symptoms at diagnosis of CD (n=872). (Roy et al., 2016) **5e. Secondary analysis study** in the **UK** based on FSA's Food and You survey (n=12,965) on demographics of those with food allergies versus those without. (NatCen, 2017) **5f. Prospective survey study** to assess the relationships between income, symptoms, and perceived burden of CD (n=341) (Oza et al., 2016)	**5d. The US study** concluded that patients with nonclassical symptoms of CD are less likely to be diagnosed if they are of lower socioeconomic status. **5e. The UK secondary analysis study** found socioeconomic factors such as household size, presence of children, working status, educational level and country of residence are not related with impact on health or risks associated with FHS. **5f. The prospective survey study** found that higher income predicted better overall health, better CD related health, and fewer symptoms while low income was associated with greater

			CD symptoms (odds ratio=6.04, P=0.002).

Theme 6: Impact of socioeconomic differences on affordability/ accessibility/ availability to appropriate foods for those with FHS **Number of studies:** 5 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** The studies identified are of low or very low quality due to low generalisability, indirectness of findings, small samples, and measurement errors.	GF foods are less accessible/available/affordable to lower socioeconomic group of consumers with FHS.	**6a. UK cross-sectional survey** of GF foods to understand costs and availability of GF foods. (Hanci & Jeans, 2019) **6b. Canadian cross-sectional surveys** to explore intersectional stigma between food allergies and poverty (n=23), all participants took part in semi-structured interviews. (Minaker et al., 2015) **6c. Another UK survey** to research cost and availability of GF food in UK.(Burden et al., 2015) **6d. US cross-sectional survey** to compare costs borne by families of food-allergic children by socioeconomic groups	**6a. The UK cross-sectional survey** found that accessibility of GF foods is lower in budget and convenience stores which could restrict access for those with lower SES, poorer literacy, rural communities. **6b. The Canadian surveys** found that low-income participants perceived difficulty in procuring safe foods and felt insufficiently trained/education on FHS management. **6c. The UK survey** identified that poor availability of GF foods in budget supermarkets and added cost is likely to impact on adherence in deprived groups. **6d. The US study** found that African American caregivers spent the least on out-of-pocket costs, which includes accessing specialty foods.

		(n=1643). (Bilaver et al., 2016) **6e. US observational study** to examine availability and cost differentials of GF food in the public. (Lee et al., 2007)	**6e. The US study** found that every gluten-free product was more expensive than their wheat-based counterpart (P = 0.05). Another finding is that regular grocery stores carried 36%, while upscale markets carried 41%, and health food stores 94%, compared with 100% availability on the internet. This suggests that GF foods are less readily available and more expensive.
Theme 7: Socioeconomic differences and management of FHS **Number of studies: 1** **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low**	Schools in area with >20% low-income families are less likely to have appropriate medications for children with severe food allergies.	**7a. Canadian cross-sectional survey** to understand relationship between the proportion of low-income households in Toronto neighbourhoods and the adequacy of anaphylaxis management plans in primary schools (n=50). (Frost & Chalin, 2005)	**7a. The Canadian study** found that for children with severe reported food allergies attending schools in area with >20% low-income families there is less likely to be medication in school than those in areas with <20% low-income households.

QA comment: The study identified is of very low quality due to small sample sizes, low generalisability and confounders not accounted for.			
Theme 8: Gender and experiences of CD **Number of studies: 1** **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Insufficient evidence as based only one study that mainly used qualitative methods and has a small sample size. All data is also self-reported, including FA diagnosis.	Although both gender experience similar consequences of dilemma, there is difference in food preparation responsibilities, with women shouldering that burden more	**8a. Mixed methods study** in **Sweden** that uses semi-structured interviews and quantitative questionnaires to assess consequences of dilemmas of CD on everyday life (n = 76). (Sverker et al., 2009)	**8a. In the mixed methods study in Sweden**, women and men experienced similar consequences of dilemma of CD on everyday life (e.g. daily concerns of gluten and constant preparation of gluten-free food, social exclusion, and emotional pressure). However, men and women reported having different responsibilities in relation to food preparation etc as that burden mainly falls on women.

Theme 9: Management of FA among adolescents **Number of studies: 1** **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Insufficient evidence as based only one study that mainly used qualitative methods and has a small sample size. All data is also self-reported, including FA diagnosis.	There is risk taking behaviour among youth but education on FA management can potentially reduce that	**9a. Cross-sectional study in the US**, which distributed survey to participants aged 13-21 (n=174) on risk taking behaviours and coping strategies. Participants recruited through allergy websites. (Sampson et al., 2006)	**9a. In the cross-sectional US study**, a significant number of adolescents and young adults with FA admit taking risks that vary by social circumstances. Education could reduce this risk taking behaviour.

3.9 Impact of environmental exposures on the risk of developing FHS

The evidence base is **insufficient** due to:

- Most of the studies being of ‘low’ or ‘very low’ quality:

    - They are reliant on self-reported data, have unclear participant selection methods, and evidence base is largely retrospective studies.
- There are inconsistent findings across two ‘moderate’ quality RCTs which focus on gluten intake on coeliac development:
    - One study found that gluten intake was associated with reduced CD prevalence while the other found no association between gluten intake and CD.

The following table presents the evidence base divided to these 16 thematic areas:

- Caesarean delivery as a risk factor for developing FHS;
- Birth season as a risk factor for developing FHS;
- Vitamin D status and intake as risk factors for developing FHS;
- Antibiotics intake as a risk factor for developing FHS;
- Infant dietary patterns as risk factors for developing FHS;
- Exposure to pollutants as a risk factor for developing FHS;
- Alcohol consumption among elderly as a risk factor for developing FHS;
- Intrauterine environment as a risk factor for developing FHS;
- Low birthweight as a risk factor for developing FHS;
- Household factors and risk for developing FHS;
- Maternal atopy as a risk factor for developing FHS;
- Prenatal phthalate exposure as a risk factor for developing FHS;
- Influenza as a risk factor for developing FHS;
- Exposure to smoking as a risk factor for developing FHS;
- Maternal age at the time of delivery as a risk factor for developing FHS;
- and Other (multiple factors).

Please refer to Appendix 2 for a more detailed quality assessment. As some studies have overlapping themes, they have been classified into more than one theme. These studies are indicated with an asterisk.

Impact of environmental exposures on the risk of developing FHS

34 studies:

- **Very low – 17 studies**
- **Low – 16 studies**
- **Moderate – 1 study**
- **High – 0 studies**

Theme & Number of studies; Overall QA	Overall Impacts	Type of study and sample sizes	Findings
Theme 1: Caesarean delivery as a risk factor for developing FHS **Number of studies:** 3 **QA**: GRADE rating: **Very Low** **QA comment:** Few studies identified are of low quality due to confounding bias, self-	Caesarean delivery is a risk factor for developing FHS later in life.	**1a. Prospective birth cohort study in Norway** (n=2,803) examining whether caesarean delivery and the use of antibiotics were associated with subsequent food allergy. (Eggesbø et al., 2003) **1b. Swedish case control study** examining caesarean delivery as risk factor for the development of CD (11,749 individuals with CD and 53,887 controls were included	**1a. The Norwegian cohort study** found that children who are predisposed to food allergies (the mothers have allergies) have a higher risk of development of food allergies if they were delivered by caesarean section. **1b. Swedish case control** concluded that elective caesarean delivery is positively associated with later CD.

reported data, and lack of DBPCFC/oral food challenge used.		in the study). (Mårild et al., 2012) **1c. German prospective cohort study** (n=865) investigating the effect of caesarean section on sensitisation to nutritional allergens in infants. (Laubereau et al., 2004)	**1c. The German study** found that infants born by caesarean section (147/865, 17%) had a greater risk of sensitisation to food allergens, adjusted (ORadj 2.06, 95% CI 1.123 to 3.80).
Theme 2: Birth season as a risk factor for developing FHS **Number of studies:** 5 **QA**: GRADE rating: **Very Low** **QA comment:** Few studies identified are of 'low' quality due to potential confounders, secondary data, no DBPCFC/oral food challenge to confirm allergies. Overall quality of evidence is 'very	Findings are contradictory as different studies identify different birth seasons as risk factors.	**2a. Swedish retrospective cohort-based study** (n=2,151) that aimed to analyse if the risk for coeliac disease varies with month of birth as a proxy for a seasonal pattern for possible causal environmental exposure(s) using secondary data. (Ivarsson et al., 2003) **2b. Australian cohort study** (n=835) aiming to examine the relationship between low Vitamin D and food allergies pathogenesis. (Mullins et al., 2011)* **2c. Swedish prospective cohort study** (n=6,596)	**2a. The Swedish study** found that children born in the summer have a higher risk of developing CD compared to those born in the winter. **2b. The Australian study** found that people who are born in autumn/winter are more likely to have food allergies compared to those born in spring/summer **2c. The Swedish study** found CD risk was higher for

low' partly due to findings being inconsistent.		examining season of birth and risk for the development of CD. (Namatovu et al., 2016)	children born during spring, summer and autumn as compared with children born during winter: adjusted HR for spring 1.08 (95% CI 1.01 to 1.16), summer 1.10 (95% CI 1.03 to 1.18) and autumn 1.10 (95% CI 1.02 to 1.18).
		2d. South Korean prospective birth-cohort study (n=1,177) examining the incidence of food allergy in Korean infants and identifying risk factors associated with this. (Kim et al., 2011)	**2d. The South Korean study** found that children who were born during autumn had a higher prevalence of FA than those born during spring (p = 0.005).
		2e. Cohort study in **Denmark** (n = 206,900) examined 2 cohorts exposed or not exposed to extra vitamin D from the Danish Mandatory Vitamin D Fortification Policy. Birth season was also examined as there could be fluctuations in Vitamin D levels. Cohorts were created with a washout period of 15 months. Records were reviewed over a 30-year	**2e. In the cohort study in Denmark** there was a statistically significant season effect particularly for children born in autumn (OR 1.6 95% CI 1.16; 2.21) and born in summer (OR 1.5 95% CI 1.1; 2.1) when compared to children born in winter.

		period for CD development. (Moos et al., 2020)*	
Theme 3: Vitamin D status and intake as risk factors for developing FHS **Number of studies:** 6 **QA**: GRADE rating: **Very Low** **QA comment:** Few studies identified are of low quality due to confounding bias and potential misclassification of vitamin D exposure in some studies. Studies are also all observational studies, which means overall evidence starts as 'low'.	Lower status of Vitamin D is associated with an increased risk of allergic disease, except for one Danish study that found no association. Also, supplementation of Vitamin D in water-soluble form is likely to increase the risk of allergic disease compared with supplementation in peanut oil.	**3a. Swedish prospective birth cohort study** (n=4,089) that explored the association between early life supplementation of vitamins A and D in water-soluble form or in peanut oil and allergic diseases up to 4 years of age. (Kull et al., 2006) **3b. US cohort study** (n=649) aimed to examine whether deficiency in Vitamin D contributes to the development of food allergies. (Liu et al., 2011) **3c. Australian cohort study** (n=835) aiming to examine the relationship between low Vitamin D and food allergies pathogenesis. (Mullins et al., 2011)* **3d. Nordic prospective population study** (n=144) examining dietary patterns	**3a. The Swedish cohort study** found that supplementation of vitamins A and D in water-soluble form seems to increase the risk of allergic disease up to the age of 4 years compared with supplementation with the same vitamins given in peanut oil. **3b. The US study** found that Vitamin D deficiency may increase the risk of food sensitisation among individuals with certain genotypes. **3c. The Australian study** found that higher ultraviolet light exposure/Vitamin D status decreases risk of FA* **3d. The Nordic study** found that vitamin D supplement at 6 years decreased the odds of

		and vitamin D levels in infants and their risk of sensitisation to food allergens. (Thorisdottir et al., 2019)	Ig-E-sensitization, OR = 0.2 (95%, CI = 0.1–0.98).
		3e. Birth cohort study in **Australia** (n=5,276) investigating the role of vitamin D status in infantile food allergy. (Allen et al., 2013) **3f. Cohort study** in **Denmark** (n = 206,900) examined 2 cohorts exposed or not exposed to extra vitamin D from the Danish Mandatory Vitamin D Fortification Policy. Cohorts were created with a washout period of 15 months. Records were reviewed over a 30-year period for CD development. (Moos et al., 2020)*	**3e. The Australian study** concluded that Vitamin D sufficiency may be an important protective factor for food allergy in the first year of life. **3f. The Danish study** found the odds ratio for developing CD was 0.81 (95% CI 0.66; 1.00 p = 0.054), comparing those with fetal exposure to mandatory vitamin D fortification policy to those without after adjusting for gender and season of birth. No evidence to support prenatal exposure to small extra amounts of vitamin D affects development of CD.
Theme 4: Antibiotics intake as a risk factor for developing FHS	Antibiotics can be a risk factor for the development of FA and CD.	**4a. Canadian case-control epidemiological survey** (n=322) determining whether nine variables are associated	**4a. The Canadian survey** found positive association between early life exposure to antibiotics and CD.

Number of studies: 5 **QA**: GRADE rating: **Very Low** **QA comment:** Few studies identified. Overall quality is 'very low' due to potential confounding not considered and selection bias.		with CD in children. (Bittker & Bell, 2019) **4b. US retrospective cohort study** (n=18,160) investigating the extent to which antibiotic exposure in the first 2 years of life is associated with the risk of immunological health conditions with childhood onset. (Aversa et al., 2020) **4c. Danish & Norwegian retrospective observational cohort study** (n=3,346) exploring the association between exposure to a systemic antibiotic in the first year of life and risk of diagnosed CD. (Sander et al., 2019) **4d. US cohort study** examining the impact of exposure to antibiotics early in life on time to development of food allergy (nb. no full text). (Li et al., 2019)	**4b. The US study** found significant association between early life antibiotic exposure and CD. **4c. The Danish and Norwegian cohort study** found that childhood exposure to systemic antibiotics could be a risk factor for CD. **4d. The US study** concluded that compared with antibiotic nonusers, children with antibiotic prescription had an increased risk of food allergy.

		4e. Lithuanian cohort study (n=1,558) examining environmental factors that increase the risk of IgE-mediated food allergy at 6 and 12 months of age. (Dubakiene et al., 2012)	**4e. The Lithuanian study** found that antibiotics are not identified as significant factor that can impact on the early sensitisation to food allergens.
Theme 5: Infant dietary patterns as risk factors for developing FHS **Number of studies:** 3 **QA**: GRADE rating: **Very Low** **QA comment:** There is potential confounding bias, self-reported allergies which lowers accuracy of participants actually having FAs, and only 3 studies found on this.	Different dietary patterns of infants may have different impact on the development of FHS in infants.	**5a. Swedish retrospective survey study** (n=1,029) examining late introduction of solid foods. (Hicke-Roberts et al., 2020) **5b. French birth cohort study** (n=10,407) that assesses the links between 2-month infant formula use and the incidence of eczema, respiratory symptoms, or food allergies (FA) up to 2 years of age. (Davisse-Paturet et al., 2019) **5c. Nordic prospective population study** (n=144)* examining dietary patterns and vitamin D levels in infants and their risk of sensitisation	**5a. The Swedish retrospective survey** study found that late introduction of solids into an infant's diet may be one risk factor for developing food allergy or intolerance. **5b. The French study** found that partially hydrolysed formulas area associated with higher risk of food allergies. **5c. The Nordic study** found that introduction of solid foods prior to 4 months increased the odds of Ig-E-sensitization, OR = 4.9 (95%, CI = 1.4–16.6)*

		to food allergens. (Thorisdottir et al., 2019)	
Theme 6: Exposure to pollutants as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Only 1 study of 'very low' quality due to very small sample; prevalence of female participants problematises comparing female and male odds of CD; low generalisability as mostly non-Hispanic white participants.	Dichlorodiphenyldichloroethylene is associated with an increased risk of CD (study lacks precision).	**6a.US pilot study** (n=88) which aims to elucidate the association between persistent organic pollutants ("organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes") and CD. (Gaylord et al., 2020)	**6a. The US study** found that increased odds of CD are associated with specific persistent organic pollutants, and in particular p,p'-dichlorodiphenyldichloroethylene, although these estimates lacked precision.
Theme 7: Alcohol consumption among elderly as a risk factor for developing FHS	Elderly individuals with chronic alcohol consumption are more likely to have sensitisation to food allergens.	**7a. Hungarian cross-sectional study** (n=109) examining the prevalence and risk factors for sensitizations in elderly who are living in a	**7a. The Hungarian study** concluded that a risk factor for sensitisation to food allergen across elderly population is chronic alcohol consumption.

Number of studies: 1 **QA**: GRADE rating: **Very Low** **QA comment:** Only one study identified is of very low quality due to indirectness, confounding bias and small sample. Overall quality is 'very low' due to only one study found.		geriatric nursing home. (Bakos et al., 2006)	
Theme 8: Neonatal infection as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Only one study identified is of 'low' quality due to reliance on secondary data. Overall quality is 'very low' due to only one study found.	Neonatal infection increases the risk of developing CD.	**8a. Swedish retrospective cohort study** (n=3,482) which aims to investigate whether factors in the foetal or neonatal period influence the risk of later development of coeliac disease. (Sandberg-Bennich et al., 2002)*	**8a. The Swedish study** concluded that one of the most evident risk factors for developing CD: is being exposed to neonatal infections (OR = 1.52, confidence limits 1.19; 1.95)

Theme 9: Low birthweight as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Only one study identified is of 'low' quality due to reliance on secondary data. Overall quality is 'very low' due to only one study found.	Low birthweight is the risk factor for developing CD.	**9a. Swedish retrospective cohort study** (n=3,482)* which aims to investigate whether factors in the fetal or neonatal period influence the risk of later development of coeliac disease. (Sandberg-Bennich et al., 2002)	**9a. The Swedish study** found that being small for gestational age (OR = 1.45, confidence limits 1.20; 1.75) is the risk factor for developing CD.
Theme 10: Household factors and risk for developing FHS **Number of studies:** 4 **QA**: GRADE rating: **Low** **QA comment:** Few studies identified are of 'low' quality due to reliance on secondary	Dog exposure in early life can decrease the risk of developing FHS. Higher household endotoxin is associated with increased odds of milk and egg sensitization.	**10a. Secondary cohort study** (n=1,303) in the Enquiring About Tolerance (EAT) study in England and Wales. (Marrs et al., 2019)* **10b. US retrospective cohort study** (n= 6,963) examining household endotoxin levels and risk for food sensitisation in a cohort of ages 1-84 years. (Tsuang et al., 2020)	**10a. The England and Wales cohort study** found that dog ownership in infancy may prevent food allergy among participants from Wales and England. **10b. The US study** found that higher household endotoxin is associated with increased odds of milk and egg sensitization in all age groups.

data and retrospective data collection.		**10c. Australian retrospective survey** study (n=4,991) investigating the risk factors for current adolescent food allergy using a population-based sample. (Sasaki et al., 2018)* **10d. US cohort study** (n=285) determine the effects of pet exposure and genotype on immunologic development and the incidence of atopic markers and diseases in the first year of life. (Gern et al., 2004)	**10c. The Australian study** found that dog exposure in early life reduced the risk of FA in 10- to14-year-old adolescents. **10d. The US cohort study** concluded that exposure to dogs was associated with reduced food allergen sensitization (19% vs 33%, P=.020).
Theme 11: Maternal atopy as a risk factor for developing FHS **Number of studies:** 2 **QA**: GRADE rating: **Very Low**	Inconsistent findings as Lithuanian study finds that maternal atopy can be a risk factor for sensitisation to egg in children but US study found that there is no association between maternal asthma and child food allergies.	**11a. Lithuanian cohort study** (n=1,558)* examining environmental factors that increase the risk of IgE-mediated food allergy at 6 and 12 months of age. (Dubakiene et al., 2012) **11b. Pre-birth cohort study** in the US assessing the associations between maternal history of asthma and the	**11a. The Lithuanian study** concluded that children of atopic mothers are more likely to be sensitized to egg (37.5%) compared to children of non-atopic mothers (17.3%). **11b. The US pre-birth cohort study** concluded that there is no association between maternal asthma and child food allergies.

QA comment: Findings are inconsistent and only 2 studies founds on this topic.		development of respiratory and allergic diseases in offspring, n=1410. (Venter et al., 2020)	
Theme 12: Prenatal phthalate exposure as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Study identified is of 'very low' quality due to selection bias and small sample. Overall quality is 'very low' partly due to only one study found.	Higher urine concentrations of monobenzyl phthalate in mothers during pregnancy is associated with the risk of food allergy in children.	**12a. Polish prospective cohort study** (n=1,300) examining whether maternal prenatal and children urine metabolite concentration of phthalates would be associated with food allergy and early eczema among inner-city children. (Stelmach et al., 2015)	**12a. The Polish cohort study** found that that higher urine concentrations of monobenzyl phthalate in mothers during pregnancy increased the risk of food allergy in children during the first 2 years of life (odds ratio 4.17 [95% confidence interval, 1.17–17.89]).
Theme 13: Influenza as a risk factor for developing FHS **Number of studies:** 1	Influenza diagnosis can be a risk factor for the later development of CD.	**13a. Norwegian retrospective cohort study** (n= 7321) determining the risk of CD after influenza in a cohort of 2.6 million people. (Kårhus et al., 2018)	**13a. The Norwegian study** found positive association with influenza diagnosis is consistent with the hypothesis that infections may play a role in CD development.

QA: GRADE rating: **Very Low** **QA comment:** Study identified is of 'very low' quality due to indirectness of outcome measurement and high risk of confounding bias. Overall quality is 'very low' partly due to only one study found			
Theme 14: Exposure to smoking as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Study identified is of 'low' quality due to bias in measurement of outcomes. Overall quality is	Smoking exposure in infancy increases the risk of sensitisation to food allergens.	**14a. Swedish cohort study** (n=4,089) examining whether exposure to smoking prenatally/postnatally is associated with Ig-E sensitisation in children of 4 years old. This was done by analysing for Ig-E antibodies to common food allergens (not specified what food allergens were tested) in blood collected at 4 years old. (Lannerö et al., 2008)	**14a.** The Swedish study found that smoking exposure in infancy increases the risk of sensitisation to food allergens**.**

'very low' partly due to only one study found			
Theme 15: Maternal age at the time of delivery as a risk factor for developing FHS **Number of studies:** 1 **QA**: GRADE rating: **Very Low** **QA comment:** Potential selection bias due to unclear participation selection methods. Only 1 study identified.	Mothers of children with a food allergy have greater odds of being older at time of delivery.	**15a. US case-control study** (n=81,020) evaluate whether maternal age at the time of delivery is associated with a food allergy in children. (Dioun et al., 2003)	**15a. The US study** found that mothers of children with a food allergy had about three times greater odds of being aged 30 or over at the time of delivery.
Theme 16: Other (multiple factors) **Number of studies:** 3 **QA**: GRADE rating: **Low**	Certain genetic and ethnic factors and previous illness history can increase the risk of FA.	**16a. Australian retrospective survey study** (n=4,991)* investigating the risk factors for current adolescent food allergy using a population-based sample. (Sasaki et al., 2018)* **16b. Cohort study** in **Sweden** examining	**16a. The Australian study** found that early-onset eczema, Asian background, and family history of allergic disease were associated with an increased risk of food allergy. **16b. The Swedish cohort study** concluded that the risk

QA comment: No clinical studies. High risk of bias across two out of the three studies due to retrospective data collection, potential confounding, and not using DBPCFC/oral food challenges.		environmental factors that can increase risk of CD (n= 792,401). (Wingren et al., 2012) **16c. European birth cohort study** assessing the risk factors, particularly eczema, for hen's egg allergy (n=86). (Grimshaw et al., 2020)	of CD among second-generation immigrants seems to be conditioned by maternal length of stay in Sweden before delivery. **16c. The European study** concluded that eczema was strongly associated with egg allergy development and the association increased with increasing eczema severity. The age of introduction of dietary egg was not a risk factor.

* As some studies have overlapping themes, they've been classified into more than one theme. These studies are indicated with an asterisk.

3.10 Current knowledge of FHS amongst the general public

Overall evidence base is **weak but suggestive** due to:

- All studies are of ‘low’ or ‘very low’ quality:
  - There is reliance on self-reported data from surveys/qualitative interviews, which may be less robust. Most studies could also have selection bias as consumers are either selected from allergy groups/events and selection methods of FBO staff are unclear.
- However, there are consistent findings among a high number of lower quality studies on knowledge and attitudes of FBO staff:
  - The studies find that the most common misbelief among FBO staff that drinking water can dilute the allergen and staff are unable to identify major official allergens, especially soy, seafoods (including fish and crustacean), and egg.

The following table presents the evidence base divided to these five research areas such as FHS knowledge, attitude, and management among consumers with FHS; FHS knowledge, attitude, and training among FBOs; FHS knowledge and management among healthcare providers; FHS knowledge and preparedness childcare providers; and FHS knowledge and preparedness among children with FHS. Please refer to the Appendix 2 for a more detailed quality assessment.

Current knowledge of FHS amongst the general public 39 studies: • **Very low – 34 studies** • **Low – 5 studies** • **Moderate – 0 studies** • **High – 0 studies**			
Theme & Number of studies; Overall QA	**Overall Impacts**	**Type of study and sample sizes**	**Findings**
Theme 1: FHS knowledge, attitude, and management among consumers with FHS **Number of studies:** 9	Most of the studies are related to Coeliac Disease (rather than FHS more widely) except one related to dining out	**1a. Cross-sectional study** in the **UK** (n=252) administered questionnaires at three major Free Form events. Consumers with FHS, or those who are carers to individuals with FHS and those interested in Free From food products were invited to participate in the study. (Soon, 2019)	**1a. The UK cross-sectional survey** found consumers demonstrated very good understanding on the severity of allergic reactions, prevention method and hidden egg ingredients. They were also motivated in personal allergy avoidance. However, both knowledge and attitude did not translate into food allergy management practices.

QA[6]: • WHO rating: **Possible evidence** • GRADE rating: **Very Low** **QA comment:** These are voluntary surveys/questionnaires which are subject to several biases, especially the online ones where participants can search the internet for answers. Selection of participants is also subject to bias as most	habits and another on food allergy management among college students. There is generally a good adherence to a Gluten-Free diet among Coeliac patients. However, there is a gap in knowledge of a gluten-free diet and identifying foods (although	**1b.** Another **cross-sectional study** in the **UK** (n=100) recruited participants through support groups and a Free Form event, with questions asked on knowledge of Gluten-Free food. (Laheri & Soon, 2018) **1c. Cross-sectional study** in **Canada** (n=68) surveyed participants which were a convenience sample of community-dwelling adults following a Gluten-Free diet for the past for months. Questions asked on adherence, food label and ingredient knowledge. (Jamieson & Gougeon, 2019) **1d. Another Canadian cohort study** assessed knowledge and adherence to a Gluten-Free	**1b. The cross-sectional UK survey** found most had good understanding of a Gluten-Free diet. However, a more recent diagnosis was linked with a poorer understanding of a Gluten-Free diet and lower consumption rates and awareness of alternative grains. **1c. The Canadian cross-sectional survey** found 62% reported not receiving Gluten-Free diet advice from a health professional. Respondents with higher frequency of intentional consumption of gluten were more likely to have fewer correct answers to a food label quiz. 75% made at least one error in identifying gluten-free and gluten-containing foods. **1d. The Canadian cohort study** possible knowledge gaps in people with CD identifying

[6] The WHO rating given is higher than the GRADE rating given for the some themes due to the large number of cross-sectional studies available for that theme. As GRADE is typically used for clinical studies, themes with a large base of cross-sectional studies and are graded down for bias/inconsistency/indirectness/imprecision/publication bias would have been rated 'very low'. GRADE's 'very low' rating would typically be mapped to WHO's rating of 'insufficient evidence'. However, having a large amount of cross-sectional studies would fall under 'Possible evidence', thus some themes were given both a 'very low' and 'possible evidence' rating. Although both ratings are provided, as these are observational studies, the WHO rating will be more relevant than the GRADE rating for these themes.

recruited through allergy-focused events and groups. Diagnosis of allergy are also based on self-reported data. Sample sizes are generally limited, except for one study (Halmos et al., 2018).	evidence on this is limited).	diet. Participants (n=144) were asked to determine whether 25 food items were gluten-free based on labelling information. Diet adherence was assessed using the Coeliac Diet Assessment Tool (CDAT) and the Gluten-Free Eating Assessment Tool (GF-EA). Study follow-up at 6, 12, and 24 months after diagnosis. (Gutowski et al., 2020) **1e. Cross-sectional study** in **Poland** recruited participants (n=278) through a free Coeliac Disease (CD) screening. Questions asked on definition, aetiology, symptoms, and treatment of CD. (Drabinksa et al., 2017) **1f. Cross-sectional study** in **the US** (n=82) recruited participants through support groups. Participants completed a questionnaire with items related to Gluten-Free diet information sources, gluten	GF foods correctly. However, diet adherence was generally good. **1e. The cross-sectional survey in Poland** found 94% correctly defined CD as gluten intolerance. This myth of CD being a childhood disease continues to be deeply maintained. Regarding symptoms, gastrointestinal problems were easily associated with CD (87%), whereas atypical symptoms were not always seen as signs of CD. Most correctly selected a GFD as the method of treating CD. **1f. The US cross-sectional survey** found 55% reported strict adherence. No participant identified correctly the gluten content of all 17 foods; only 30% identified at least 14 foods correctly. The median score on the Gluten-Free Diet Knowledge Scale (GFD-KS) was 11.5

		content of 17 common foods (food to avoid, food allowed, and food to question), and adherence. (Silvester et al., 2016) **1g. Cross-sectional study** in **Australia and New Zealand** (n=7,393) involved patients with coeliac disease completing an online survey comprising the validated Coeliac Dietary Adherence Test in addition to data on details of diagnosis and management and assessment of diet knowledge. (Halmos et al., 2018) **1h. Mixed methods study** in **the US** (n=320) used cross-sectional surveys and focus groups to assess participants' dining out experience and knowledge. Participants were either FHS sufferers or carers of children with FHS. (Kwon et al., 2020)	(interquartile ratio, 10–13), which puts them at risk. **1g. The cross-sectional survey in Australia & New Zealand** found 61% were adherent to a gluten-free diet. Respondents who considered themselves to have poor food knowledge were more likely to incorrectly identify gluten-free foods, but could still recognise gluten-containing foods. **1h. The US mixed methods study** found the average knowledge score of participants was 24.7 out of 30 (82.3%), and they recognized typical causes of food allergy reactions in restaurants (i.e., hidden allergens, cross-contacts, and restaurant employees' lack of knowledge, care, and communication about food allergies). Customers with food allergies took a variety of actions to prevent food allergy reactions before or during their visits to restaurants.

		1i. Cross-sectional study in **US** recruited participants from a larger nationwide study. Questionnaires on their food allergy(s), symptoms, and management were distributed to those with food allergies. They and a control group without food allergies completed a measure of food allergy knowledge. (McLaughlin et al., 2020) N = 51 students with food allergies, N = 50 for control	**1i. The US study** found food allergy knowledge accounted for an additional 20% of variance in students' allergy management behaviours. No statistically significant difference in knowledge between participants with food allergy and matched controls. (McLaughlin et al., 2020)
Theme 2: FHS knowledge, attitude, and training among FBOs **Number of studies:** 19 **QA**: •WHO rating: **Possible evidence** •GRADE rating: **Very Low**	The most common misbeliefs among restaurant staff is that an individual experiencing a reaction should drink water to dilute the allergen and that consumers can safely ingest small amounts of	**2.**There are **17 Cross-sectional studies** and **1 qualitative study** administering online/telephone surveys to various restaurant staff in FBOs assessing them on their knowledge and attitude on FHS. Individual methods are not described here because the methods were similar across all studies. See appendix for detailed methods of each study.	**2a. Cross-sectional study in Ireland** (n=689) found only 16% of respondents could list each of the 14 named allergens. 28% of all respondents claimed 'never' to have received any food safety training. High levels of knowledge & training were reported among staff working in canteens. While 79% of respondents identified milk as an allergen, only 57% included crustacean and 66% egg. (Gruenfeldova et al., 2019) **2b. Cross-sectional study in Germany** (n=295) found only 18.3% of participants were unable to name any correct food allergen. At least 80% of the participants provided correct answers to four of the five questions assessing general food allergy knowledge. Most common

QA comment: These are voluntary surveys/questionnaires which are subject to several biases, especially the online ones where participants can search the internet for answers. Sample sizes are also relatively small for most of these studies.	allergens. Also, there is a gap in being able to identify major official allergens, especially soy, seafoods (including fish and crustacean), and egg. There is a high reported of confidence in being able to provide a safe meal, with conflicting data on percentage of those who had received training.		misconception is that water should be drunk after an allergic reaction. (Loerbroks et al., 2019) **2c. Telephone cross-sectional study in France** (n=100) found only 4% reported to be not confident in in providing a safe meal to a food-allergic customer. Most common misconception is believing an individual experiencing a reaction should drink water to dilute the allergen. Chefs and waiters seemed to have greater knowledge of food allergies compared to owners or managers. (Lefèvre et al., 2016) **2d. US online cross-sectional study** (n=332) found among the eight major food allergens, a significant number of participants failed to identify fish (n = 161, 50.9%), soy (n = 144, 45.6%), and egg (n = 120, 38.0%) as the major food allergens. Only 21 respondents (6.6%) correctly recognized all eight major food allergens. Most respondents (n = 222, 70.3%) were not aware that asthma can be a possible symptom of food allergy reaction. (Wen & Kwon, 2017) **2e. Cross-sectional study in New Zealand** (n=125) found 13% of participants were unaware of coeliac disease, all of whom were

			non-European and worked at an ethnic restaurant which did not have gluten-free policies in place. (Schultz et al., 2017) **2f. Cross-sectional study in Turkey** (n=351) found only 17.1% had food allergy training. Most common misconception (45%) is that it is appropriate to serve water to customers who had a reaction to dilute it. (Sogut et al., 2015) **2g. Cross-sectional study in the US** (n=229) found almost 40% of the participants were not able to identify soy and fish as major allergens. 72.9% participants were unable to identify “arachis oil” as an indicator of the presence of peanuts in food items. About 29% believed that removing food allergens could prevent an allergic reaction. (Lee & Sozen, 2016) **2h. Cross-sectional study in US** (n=110) found 77% perceived customers should be responsible to request special meals. 69% participants have provided employee food allergy training. Employee lack of commitment and time constrains were identified as barriers to provide training. (Lee & Xu, 2015) **2i. Cross-sectional study in US** (n=187) found no restaurant employee was able to name all seven “best practices” to reduce the risk of food

			allergy adverse events in restaurants, with majority only being able to name zero or one. 24.1% thought water would dilute an allergic reaction and 11.7% thought customers with food allergies can safely consume a small amount of that food. (Dupuis et al., 2016) **2j. Cross-sectional study in Canada** (n=209) found almost all (99.5 %) participants understood that food allergies can be serious and potentially life-threatening. Also, 94.7 % knew that touching a food allergen can trigger an allergic reaction, and 93.3 % recognized that removing an allergen from a prepared meal is not an appropriate approach to mitigating food allergy risks. However, more than 21.2% incorrectly suggested that individuals with food allergies could safely ingest small amounts of food allergens. (McAdams et al., 2018) **2k. Cross-sectional US study** (n=278) found more than 10% of managers and staff believed that a person with a food allergy can safely consume a small amount of that allergen. Managers and staff also had lower confidence in their restaurant's ability to properly respond to a food allergy emergency. (Radke et al., 2016)

			2l. Cross-sectional study in the UK (n=28) found a third of the takeaways' staff were uncertain that hands could transfer allergens. 43% would mistakenly offer water to dilute a food allergen to stop the reaction. Experienced staff and managers/owners reported more positive attitude and higher frequency of good food allergen management practices. (Soon, 2018) **2m. Cross-sectional study in US** (n=65) using food regulatory ratings found mean ratings indicate a lack of awareness of food safety risks associated with products and how to mitigate those risks, lack of capital for training, lack of understanding of laws that pertain to them, and lack of knowledge of food allergens and mandatory labelling among owner/operators with whom they work. (Harrison et al., 2016) **2n. Cross-sectional study in Italy** (n=20) found 30% erroneously stated that CD patients can introduce small amounts of gluten with diet, and only 75% is aware that gluten is not removed by cooking foods. 20% did not know that GF food should be stored in clearly identified and separated areas. Only 25% knew that equipment (i.e. oven, deep fryer, plates, etc.) and utensils (i.e. cookware, tableware,

			etc.) should be used exclusively for GF food preparation. (Tamburro et al., 2020) **2o. Cross-sectional study in US** (n=100) found 42% of respondents reported they had training. 72% were 'very' or 'somewhat' comfortable about providing a safe meal, and 47% about managing a food allergy emergency. In the knowledge questions, 24% thought eating a small amount of allergen would be safe. More than 80% recognised peanut, milk and seafood as major allergens and 61% recognised egg. (Sicherer, 2007) **2p. UK cross-sectional study found** (n=322) chefs were less likely to have heard of Coeliac Disease compared to the (n=513) public (17.1% (55/322) versus 44.2% (227/513), respectively, P<0.0001). (Karajeh et al., 2005) **2q. A pre-publication UK qualitative study** reported that managers and staff (n=18) lacked knowledge about the presence of allergens and their effect. Overall, knowledge of allergens and of the 2014 European food legislation was poor, particularly in independent takeaways, especially where clear communication in the English language is difficult. Gluten and nut allergens were most often mentioned and known to be associated with serious health

			consequences. There was minimum awareness of many other allergens. (Shashoua & Barnett, 2020) **2r. Cross-sectional study in UK** of 90 participants (restaurant staff in Brighton) found that there are certain gaps in staff's knowledge of food allergies which calls for more rigorous training. Restaurant staff had some false believes about food allergies that in a case of allergic reaction of a customer can pose as a risk. There is lack of understanding of signs, management and severity of food allergy emergency. (Bailey et al., 2011)
Theme 3: FHS knowledge and management among healthcare providers **Number of studies:** 6 **QA**: • WHO rating: **Possible evidence** • GRADE rating: **Very Low**	Three out of the five studies focused on Coeliac Disease. Most of the studies showed that participants rated their knowledge quite highly. Despite this, there are knowledge gaps among healthcare	**3a. Cross-sectional study** in **Turkey** (n=125) surveyed dietitians and dietetics students on their knowledge and attitudes regarding the symptoms, severity, triggers, hidden food allergens, and of food allergies. (Giniş et al., 2016) **3b. Cross-sectional study** in **the US** (n=405) administered a survey to registered dietitian nutritionists on Coeliac Disease knowledge. (Geiger et al., 2017)	**3a. The Turkish cross-sectional survey** found 58.5% defined their knowledge on food allergy and managing the dietary needs of patients with Food allergies as “moderate.” About 40% of respondents did not recognize that food allergens could be transmitted by means of tools used for service such as knives and spoons. About 60% of respondents also thought that touching the food never causes allergic reactions. **3b. The US cross-sectional survey** to dietitian nutritionists found most RDNs reported either moderate or high levels of knowledge for all seven self-reported knowledge topics. Over

QA comment: These are voluntary surveys/questionnaires which are subject to several biases, especially the online ones where participants can search the internet for answers. Sample sizes are also relatively small for most of these studies. However, most are cross-sectional studies which categorises it as possible evidence.	providers, especially in recognising symptoms and management of food allergies.	**3c. Cross-sectional study** in **Finland** (n=80) administered an online questionnaire to nurses and general practitioners on their knowledge, attitudes, and perceptions of food allergies. (Yrjänä et al., 2018) **3d. Cross-sectional survey in the US** (n=418) administered to pharmacists on knowledge of Coeliac Disease. (Avena-Woods et al., 2018) **3e. Qualitative study in the Netherlands** (n=7) interviewed GPs on diagnosis, treatment, and follow-up of Coeliac Disease. (Gils et al., 2018)	85% of RDNs selected correct answers for five Coeliac Disease knowledge questions. **3c. The Finnish cross-sectional study** found the median overall knowledge score was 77% and significantly higher among the general practitioners than among the nurses (p=0.004). However, only 35% of all the professionals recognized either severe airway or cardiovascular symptoms as potential food allergy-related symptoms. **3d. The US cross-sectional survey** to pharmacists showed only 27% of all respondents who reported their understanding of CD to be basic or advanced correctly defined CD as both an autoimmune and a chronic lifelong disease. Approximately 59% of respondents considered their level of understanding to be basic or advanced, while 41% of respondents considered their level to be limited or poor. **3e. The qualitative Netherlands study** found inconsistency and possible gaps in GP knowledge of symptoms of Coeliac Disease and how it should be managed (practice is not always in line with guidance).

		3f. Cross-sectional study in the **US** (n=1,130) administered survey to a random sample of paediatricians to assess food allergy diagnosis and management. (Krugman et al., 2006)	**3f. The US cross-sectional survey** found most paediatricians (70%) did not recognize that a 30-minute observation period after anaphylaxis was too short. Although most paediatricians seem to have some knowledge of food-induced anaphylaxis, a substantial proportion has knowledge deficits that may hinder their ability to provide optimal care to children with food-induced anaphylaxis.
Theme 4: FHS knowledge and preparedness among childcare providers **Number of studies:** 2 **QA**: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Both studies are surveys which rely on self-reported data, data is	Despite high level of reported confidence in managing food allergies in children, there is lack of training and awareness of proper risk-management procedures among childcare providers in Australia.	**4. 2 x Australian cross-sectional surveys** administered to early childhood and education and care staff to assess knowledge and management of food allergies, with n=494 respondents for the first survey and n=53 respondents for the second survey.	**4a. The first Australian cross-sectional survey** (n=494) found that 9.5% ECEC services did not require staff to undertake anaphylaxis training. Staff felt confident in managing FA and anaphylaxis, regardless of their level of training. Against recommendations, 37% of participating ECEC services stored adrenaline autoinjectors (AAI) in a locked location. Only 51.4% of ECEC services reported having an AAI trainer device. (Hua et al., 2020) **4b. The second Australian cross-sectional survey** (n=53) found that 7% of ECEC services did not require staff to undertake anaphylaxis training. All services felt confident they had access to trained staff who could appropriately respond to anaphylaxis. Against recommendations, 36% of participating ECEC services stored adrenaline autoinjectors (AAI) in a locked location. Only 51.4% of ECEC

not as robustness. Sample sizes are also limited. There are also only 2 studies which makes the evidence insufficient. Both findings are also only focused on Australia, which makes them less generalisable. However, there is consistency of evidence between both surveys with roughly similar percentages.			services reported having an AAI trainer device. (Jacobsen et al., 2018)
Theme 5: FHS knowledge and preparedness among children/parents of children with FHS **Number of studies:** 3	There are different challenging aspects to managing child food allergy, with a need for both parents and children to be	**5a. 1 Australian qualitative study** interviewed 6 children with medically diagnosed food allergies about their food allergy and starting school. (Sanagavarapu et al., 2017) **5b. 1 Australian mixed methods study** administered cross-sectional surveys to	**5a. The Australian qualitative study** found a child's knowledge of food allergy, their self-control to resist temptation and their ability to communicate the need for help may help them to stay safe at school, and therefore are vital in their transition to school. **5b. The Australian mixed methods study** found 44.1% of parents hesitated to use an adrenaline auto-injector and may be influenced

QA: • WHO rating: **Insufficient evidence** • GRADE rating: **Very Low** **QA comment:** Studies are based on surveys/qualitative interviews, which consists of self-reported data that can be subject to different biases. Generally small sample sizes for the studies and only 3 studies on this, which means there could be insufficient evidence.	knowledgeable about its management and diet, and this affects their schooling life.	children with food allergy or parents of children with food allergy (n=306) and conducted focus groups with these parents. (Stockhammer et al., 2020) **5c. Australian qualitative study** interviewed parents of children with food allergy (n=84) on their needs. (Hu et al., 2007)	by a classification system where symptom severity is not universally understood. Allergen labelling and community acceptance continue to be the most challenging aspects of managing a food allergy, and 50% of parents reported that food allergy played a role in choosing a preschool or primary school. **5c. The Australian qualitative study** administered to parents found parents described knowledge needs on the reasoning behind the doctor's judgments about their child's allergy, including the likelihood of anaphylaxis, and the recommended management. They also wanted to know what they should feed their child, as distinct from what they should avoid.

4. DISCUSSION

4.1 Evidence gaps

This section will provide the main evidence gaps for each research area alongside with further research recommendations.

Please note that the use of a food systems approach may provide a useful interdisciplinary conceptual framework for research and policy aimed at sustainable solutions for safe food in FHS. This approach analyses the relationships between the different parts of the food system and the outcomes of activities within the system. Feedback loops are a distinguishing factor in systems thinking: they occur between parts of the food chain (production, processing, distribution and consumption) and from the socio-economic and environmental outcomes of food production and consumption (such as food security, safety, risk perception) back to that of production and consumption. This sheds light on non-linear processes in the food system, and on possible trade-offs between policy objectives. Thus, it could provide a framework that could allow for concurrent evaluation of several of the research areas below.

4.1.1 Risks posed to people with FHS by new/novel foods and/or processes

Evidence gaps:

1. Absence of studies researching the likelihood of allergenic materials migrating into food from bio-based packaging.
2. Absence of primary research-based studies on risk assessments and protocols to monitor risk.
3. Wide range of novel foods studied but there are limited studies on each novel food.

Further research recommendations:

- This research area needs robust experimental studies conducted on each novel foods to support the tentative conclusions.
- This research area needs food sampling studies to test for presence of allergenic materials from bio-based packaging in food.

- This research area needs risk assessments with an explicit problem formulation to identify relevant information.

4.1.2 Improving traceability of allergens in the food supply chain

Evidence gaps:

1. Lack of studies researching communication of allergen information to:
    a. Improve consumer confidence in allergen information provided.
    b. reduction of the incidence of unintended allergen exposure.

Further research recommendations:

- This research area needs more studies (preferably well-designed high-quality studies), with an explicit problem formulation, to be conducted to generate direct evidence relevant to the UK context and population.
- High-quality studies of how to improve consumer confidence would ideally have an intervention design with an appropriate length of follow-up and include both quantitative and qualitative methods
- High-quality studies of how to reduce the incidence of allergen exposure would address primary prevention, which seeks to prevent the onset of IgE /non-IgE sensitization; secondary prevention, to interrupt the development of FHS sensitized children; and tertiary prevention, which seeks to reduce the expression of end-organ disease.

4.1.3 Risks posed due to shared production of foods, and how can these be mitigated

Evidence gaps:

1. Studies focus on cross-contamination only in food production or in kitchen environments.
2. Absence of studies on cross-contamination of allergens as most are about gluten.
3. Only three studies were conducted on the effectiveness of cleaning methods in production.

Further research recommendations:

- Robust evidence needed with larger samples and higher quality study designs
    - For example, outcomes could include the presence of detectable food proteins in different exposure locations, how and if these proteins are transferred or eliminated, and the clinical implications of exposures to food proteins under these different scenarios.
    - Studies needed on cross-contamination in settings other than kitchen and manufacturing and on other allergens (not just gluten) and including both cross-contact of food proteins and environmental food protein exposures.
- Confirmatory studies are needed for the cleaning methods, including monitoring effects over time.

4.1.4 Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe

Evidence gaps:

1. Only three studies were conducted on the UK consumer behaviour.
2. Most of the studies use only qualitative research tools.

Further research recommendations:

- Robust evidence needed using high-quality study designs with UK population(s).
    - High-quality study designs ideally with an intervention design and appropriate length of follow-up and to include both quantitative and qualitative methods to examine actual consumer practices and changes in these rather than just reported behaviours to reduce reporting bias. Sample needs to capture the range of practices across different FHS groups.
    - Research could include observational studies to validate results from self-reported practices and provide more accurate information. Real data and parameters from literature could be combined to design realistic scenarios demonstrating the potential effects (benefits and costs) of different types of risk communication over short and longer time periods for different population groups in the UK.
    - Establishing a set of standard food safety questions that can be compared between future surveys would contribute to a comprehensive baseline against which future food safety interventions could be measured

4.1.5 Allergen labelling, including Precautionary Allergen ("may contain") Labels

Evidence gaps:

1. Only three studies were conducted in exclusively UK context.
2. Only one case-control study.

Further research recommendations:

- Robust evidence needed using high quality study designs with UK population(s) to support the tentative conclusions.
    - Ideally, there could be intervention designs with an appropriate length of follow-up and to include both quantitative and qualitative methods to examine actual consumer practices and changes in these rather than just reported behaviours to reduce reporting bias. Sample needs to capture the range of practices across different FHS groups.
    - Real data (including intervention) and parameters from literature could be combined to design realistic scenarios demonstrating the potential effects (benefits and costs) of different types of risk communication over short and longer time periods for different population groups and evaluation of how these how these might related to clinical outcomes in the UK.
    - The testing of relevant risk hypotheses in support of risk assessment should strive to be as rigorous as hypothesis testing in any other branch of science; it needs to comply with quality standards to increase confidence in the results and add certainty to the conclusions.

4.1.6 Informing the FSA as to incidents involving FHS

Evidence gaps:

1. Absence of studies on obstacles that hinder reporting of allergic reactions.
2. Lack of studies that research the effectiveness of reporting systems.

Further research recommendations:

- This research area needs more well-designed high-quality research, firstly identifying what reporting systems are out there and then comparing their potential effectiveness in a UK context.
- Studies that survey stakeholders (hospitals, FBOs, consumers) on why they might not report reactions. Methods could include both quantitative and qualitative methods. A better understanding of the interrelationships between antecedents and behavioural consequences of changes in consumer confidence in food safety over time will improve understanding of the effectiveness of public policy, and allow the development of best practice in risk communication and risk management.

4.1.7 Impact of co-factors on reaction severity

Evidence gaps:

1. Methodological limitations and shortcomings of study design in the available evidence preclude a more definite judgement.
2. Insufficient RCTs available.
3. No studies on communicating risk of co-factors to consumers with FHS.

Further research recommendations:

- More well-designed research studies (in particular RCTs) are required to support the tentative findings. The testing of relevant risk hypotheses in support of risk assessment should strive to be as rigorous as possible and needs to comply with quality standards to increase confidence in the results and add certainty to the conclusions
- This research area needs more research on the risk communication with an explicit problem formulation to identify relevant information.

4.1.8 Impact of socioeconomic factors (including race/ethnicity) on FHS

Evidence gaps:

1. Only seven studies conducted in exclusively UK context.

2. Lack of compelling evidence on the micro and macro-economic impact of FHS.

Further research recommendations:

- Robust evidence needed using high quality study designs with UK population(s).
- Cost of illness studies using a validated measure of FA are needed, along with measures to translate Quality of Life into economic terms.

4.1.9 Impact of environmental exposures on the risk of developing FHS

Evidence gaps:

1. Insufficient RCTs available.
2. Most studies focus on CD, studies that research other types of FAs do not differentiate between them (ie Ig-E mediated or non-Ig-E mediated).
3. Broad range of environmental exposures but limited studies on most of them (ie Only one study found on pollutant exposure and risk of developing FHS). However, most are birth cohort studies which can still provide valuable information.

Further research recommendations:

- Prospective and longitudinal studies needed, particularly for FA. Specifically, for the birth cohort studies, following up on these cohorts at adulthood to examine if more allergies developed and the circumstances surrounding it.
- Robust evidence needed using high quality study designs to further explore tentative findings on the risk factors that were only explored by a single study.

4.1.10 Current knowledge of FHS amongst the general public

Evidence gaps:

1. Absence of studies on attitudes and behaviours of the general public as most focus on the FBOs.

2. Only six studies conducted in exclusively UK context.

Further research recommendations:

- Robust evidence needed using high quality observational study designs with UK population(s).
- Studies that assess general public knowledge across FHS's needed.
- Assessment of knowledge of the general public on FHS vs other chronic diseases to provide comparison for level of knowledge in the chronic disease landscape
- Larger studies using cluster sampling methods are needed to verify key knowledge gaps and misconceptions around FHS, across different population groups in the UK. This would provide a baseline to allow for targeted interventions aimed specifically at these knowledge gaps and population groups to help improve the health and lives of children and families with FHS.

4.2 Common research

Across the research areas, there are areas which could be jointly covered by one research study as illustrated in the figures below.

Figure 3: Improving traceability of allergens in the food supply chain + Risks posed to people with FHS by new/novel foods and/or processes

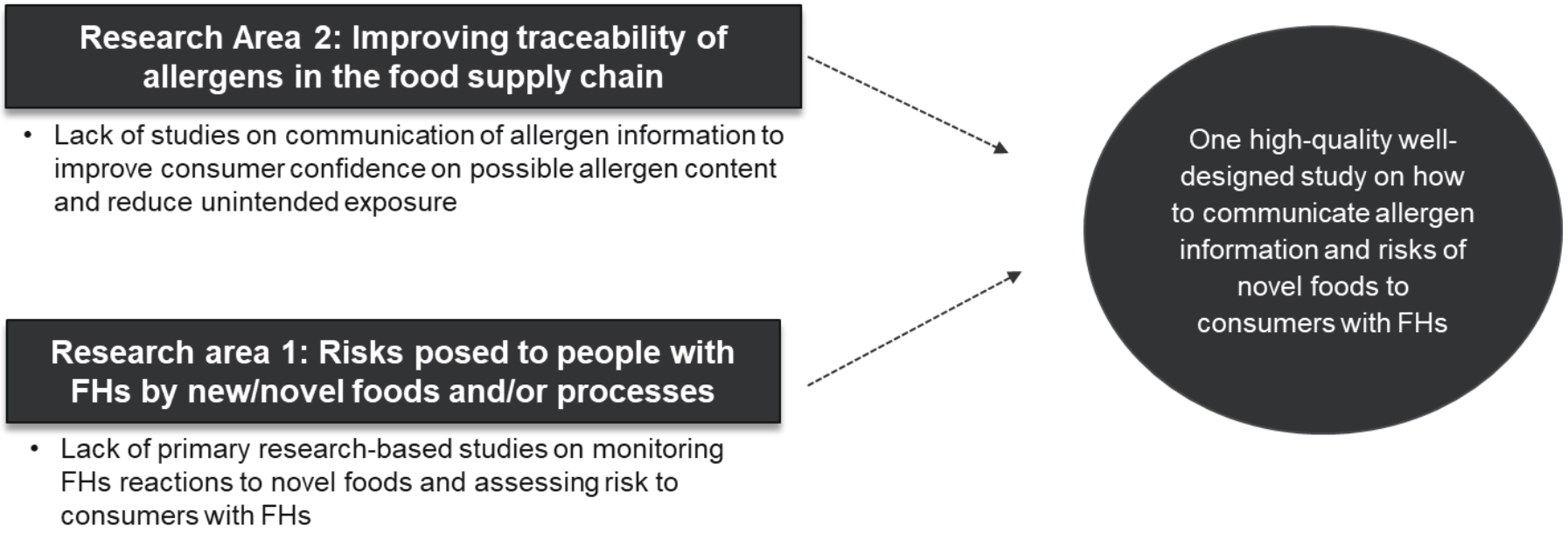
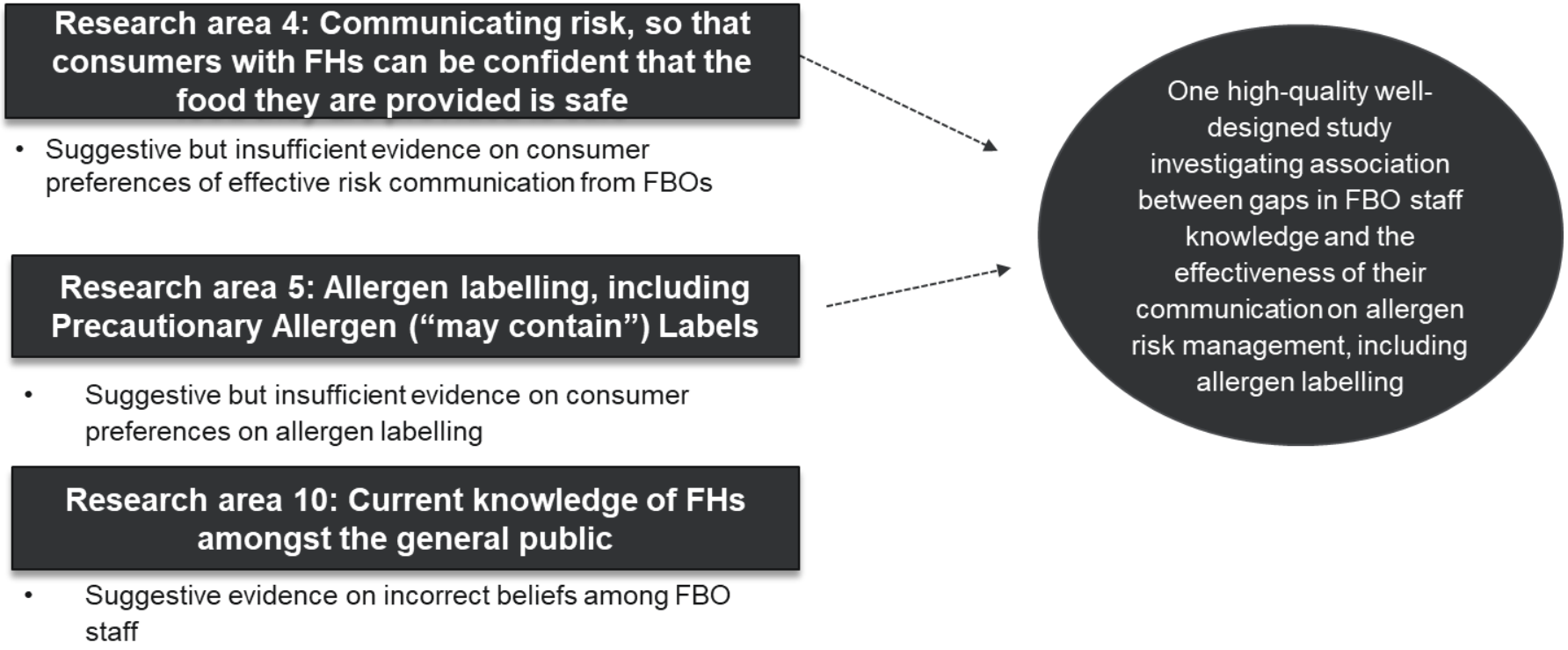


Figure 4: Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe + Allergen labelling, including Precautionary Allergen ("may contain") Labels

Figure 5: Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe + Allergen labelling, including Precautionary Allergen ("may contain") Labels + Current knowledge of FHS amongst the general public



5. CONCLUSIONS

The table below summarises the overall findings, evidence gaps, and recommendations for further research for each research area. The recommendations are based on the evidence gaps identified and will help the FSA prioritise their research funding to the most critical areas.

Research area	Key Findings	Evidence gaps	Recommendations for further research
1. Risks posed to people with FHS by new/novel foods and/or processes	• None as there is a wide range of novel foods studied across the topics, which makes it difficult to generalise findings	• Absence of studies researching the likelihood of allergenic materials migrating into food from bio-based packaging. • Absence of primary research-based studies on risk assessments and protocols to monitor risk. • Wide range of novel foods studied but with limited studies on each novel food	• This research area needs robust experimental studies conducted on each novel foods to support the tentative conclusions. • Need for possibly food sampling studies to test for presence of allergenic materials from bio-based packaging in food, to start building up evidence base
2. Improving traceability of allergens in the food supply chain	• No findings due to the paucity of evidence base, thus findings cannot be generalised	• Insufficient evidence as there are only 2 studies	• Needs more research in this area (preferably well-designed high-quality studies) to be conducted

3. Risks posed due to shared production of foods, and how can these be mitigated	• Safe cleaning and cooking procedures play an important role in reducing the risk of contamination in shared preparation areas. • Appropriate wet cleaning methods should be used but quantitative monitoring of their efficacy is required	• Absence of studies on cross-contamination of allergens as most are about gluten • Absence of studies on cross-contamination in settings other than kitchen and manufacturing • Only 3 studies on efficacy of different cleaning methods in food production	• Robust evidence needed with larger samples and higher quality study designs. • Studies needed on cross-contamination in settings other than kitchen and manufacturing and in allergens other than gluten • Confirmatory studies are needed for the cleaning methods, including monitoring effects over time
4. Communicating risk, so that consumers with FHS can be confident that the food they are provided is safe	• Communication from consumers to staff about food allergies and from staff reporting back to kitchens is important • Consumers prefer written information/protocol on food allergies from FBOs • Recommendations to improve communication include provision of training and educational resources to staff and communication skills of staff	• Only three studies were conducted on consumer behaviour among the UK population • Most of the studies use only qualitative research tools	• Robust evidence needed using high quality study designs with UK population(s) and from consumer viewpoint • Intervention studies needed to show effect over short- and longer time periods
5. Allergen labelling, including	• Consumers prefer “may contain” labels over other labels shown	• Only three studies were conducted in exclusively UK context.	• Well-designed high-quality research with UK

Precautionary Allergen ("may contain") Labels	• FA consumers want indicators on labels that give clear direction on whether the product has undergone a risk assessment and may contain an allergen	• Lack of robust studies with only one case-control study	population(s) is required to provide robust evidence • Intervention studies needed to show effect on risk and safety over longer time periods
6. Informing the FSA as to incidents involving FHS	• No findings due to the paucity of evidence base, thus findings cannot be generalised	• Absence of studies on obstacles that hinder reporting of allergic reactions • Lack of studies that research the effectiveness of reporting systems	• Needs more research in this area, firstly identifying reporting systems that exist • Well-designed high-quality research on reporting systems, their effectiveness, and obstacles hindering reporting is required • Need studies that survey stakeholders (hospitals, FBOs, consumers) on why they might not report
7. Impact of co-factors on reaction severity	• Exercise and sleep deprivation potentially put peanut allergy sufferers at greater risk of reaction by reducing threshold dose of reactivity	• Methodological limitations and shortcomings of study design in the available evidence preclude a more definite judgement • Insufficient randomised controlled trials available	• More well-designed research (in particular RCT's) is required to support the tentative findings • This research area needs more research on the risk communication

		• No studies on communicating risk of co-factors on reaction severity	
8. Impact of socioeconomic factors (including race/ethnicity) on FHS	• Non-Caucasians (especially non-Hispanic Blacks) have a higher risk of being sensitised/developing FA while non-Hispanic Whites are at higher risk of developing CD, for both children and adults	• Only seven studies conducted in exclusively UK context. • Lack of compelling evidence on the micro and macro-economic impact of FHS	• Robust evidence needed using high quality study designs with UK population(s) • Cost of illness studies using a validated measure of FA are needed, along with measures to translate Quality of Life into economic terms
9. Impact of environmental exposures on the risk of developing FHS	• Gluten consumption can be a risk factor for developing CD later in life, however, findings are somewhat contradictory	• Insufficient randomised controlled trials available. • Most studies focus on CD and omit differentiating between different types of FAs researched. • Limited number of studies for a broad range of environmental exposures	• Prospective and longitudinal studies needed, particularly for FA. • Robust evidence needed using high quality study designs to further explore tentative findings on the risk factors that were only explored by a single study. • Robust evidence needed using high quality study designs to confirm the findings on gluten intake

10. Current knowledge of FHS amongst the general public	• Common misbeliefs among FBO staff are that an individual having a reaction should drink water to dilute the allergen and consumers can safely ingest small amounts of allergens • FBO staff are unable to identify major official allergens, especially soy, seafoods, and egg	• Absence of studies on attitudes and behaviours of the general public as most focus on the FBOs. • Only six studies conducted in exclusively UK context	• Robust evidence needed using high quality study designs with UK population(s). • Studies that assess general public knowledge across FHS's needed. • Assessment of knowledge of general public on FHS vs other chronic diseases to provide comparison for level of knowledge in the chronic disease landscape

ACKNOWLEDGMENTS

We would like to thank our colleagues who made a significant contribution to the project, particularly Jenny Irwin, Kerry Daff, Nicole Chan, Sofia Reva and Lorna Rouse at RSM.

We also thank our advisors, Audrey Dunn-Galvin from University College Cork and Alizon Draper from the University of Westminster, for their valuable direction and guidance. We would also like to thank Donna Ó Doibhlin from University College Cork for their completing the database searches in collaboration with RSM.

We would also like to thank the Food Standards Agency and Science Council team for their support and guidance throughout the project, particularly Chun-Han Chan, Manisha Hartigan, Paul Nunn, Ayah Wafi, Ross Yarham, Paul Turner and John O'Brien.

REFERENCES

Studies included in the review:

Abbot, J. M., Byrd-Bredbenner, C., & Grasso, D. (2007). “Know before You Serve”: Developing a Food-Allergy Fact Sheet. Cornell Hotel and Restaurant Administration Quarterly, 48(3), pp. 274–283.

Adam, U. U., Melgies, M., Kadir, S., Henriksen, L., & Lynch, D. (2019). Coeliac disease in Caucasian and South Asian patients in the North West of England. *Journal of human nutrition and dietetics : the official journal of the British Dietetic Association*, 32(4), pp. 525–530.

Aihara, M., Miyazawa, M., Osuna, H., Tsubaki, K., Ikebe, T., Aihara, Y., & Ikezawa, Z. (2002). Food-dependent exercise-induced anaphylaxis: influence of concurrent aspirin administration on skin testing and provocation. *The British journal of dermatology*, 146(3), pp. 466–472.

Acker, W. W., Plasek, J. M., Blumenthal, K. G., Lai, K. H., Topaz, M., Seger, D. L., Goss, F. R., Slight, S. P., Bates, D. W., & Zhou, L. (2017). Prevalence of food allergies and intolerances documented in electronic health records. *The Journal of allergy and clinical immunology*, 140(6), pp. 1587–1591.

Allen, K. J., Koplin, J. J., Ponsonby, A. L., Gurrin, L. C., Wake, M., Vuillermin, P., Martin, P., Matheson, M., Lowe, A., Robinson, M., Tey, D., Osborne, N. J., Dang, T., Tina Tan, H. T., Thiele, L., Anderson, D., Czech, H., Sanjeevan, J., Zurzolo, G., Dwyer, T., Tang, M.L., Hill, D., & Dharmage, S. C. (2013). Vitamin D insufficiency is associated with challenge-proven food allergy in infants. *The Journal of allergy and clinical immunology*, *131*(4), pp. 1109–1116.

Allen, K. J., Remington, B. C., Baumert, J. L., Crevel, R. W., Houben, G. F., Brooke-Taylor, S., Kruizinga, A. G., & Taylor, S. L. (2014). Allergen reference doses for precautionary labeling (VITAL 2.0): clinical implications. *The Journal of allergy and clinical immunology*, 133(1), pp. 156–164.

Almqvist, C., Pershagen, G., & Wickman, M. (2005). Low socioeconomic status as a risk factor for asthma, rhinitis and sensitization at 4 years in a birth cohort. *Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology*, 35(5), pp. 612–618.

Añíbarro, B., Seoane, F. J., & Múgica, M. V. (2007). Involvement of hidden allergens in food allergic reactions. *Journal of investigational allergology & clinical immunology*, *17*(3), pp. 168–172.

Avena-Woods, C., Mangione, R. A., & Wu, W. K. (2018). Exploring the Community Pharmacist's Knowledge of Coeliac Disease. *American journal of pharmaceutical education*, *82*(2), 6353.

Aversa, Z., Atkinson, E. J., Schafer, M. J., Theiler, R. N., Rocca, W. A., Blaser, M. J., & LeBrasseur, N. K. (2021). Association of Infant Antibiotic Exposure With Childhood Health Outcomes. *Mayo Clinic proceedings*, *96*(1), pp. 66–77.

Bailey, S., Albardiaz, R., Frew, A. J., & Smith, H. (2011). Restaurant staff's knowledge of anaphylaxis and dietary care of people with allergies. *Clinical and experimental allergy: journal of the British Society for Allergy and Clinical Immunology*, 41(5), pp. 713–717.

Bakos, N., Schöll, I., Szalai, K., Kundi, M., Untersmayr, E., & Jensen-Jarolim, E. (2006). Risk assessment in elderly for sensitization to food and respiratory allergens. *Immunology letters*, *107*(1), pp. 15–21.

Barnett, J., Leftwich, J., Muncer, K., Grimshaw, K., Shepherd, R., Raats, M. M., Gowland, M. H., & Lucas, J. S. (2011). How do peanut and nut-allergic consumers use information on the packaging to avoid allergens?. *Allergy*, *66*(7), pp. 969–978.

Barnett, J., Muncer, K., Leftwich, J., Shepherd, R., Raats, M.M., Gowland, M.H., Grimshaw, K., & Lucas, J.S. (2011). Using 'may contain' labelling to inform food choice: a qualitative study of nut allergic consumers. *BMC Public Health,* 11, 734.

Begen, F. M., Barnett, J., Payne, R., Gowland, M. H., DunnGalvin, A., & Lucas, J. S. (2018). Eating out with a food allergy in the UK: Change in the eating out practices of consumers with food allergy following introduction of allergen information legislation. *Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology*, *48*(3), pp. 317–324.

Begen FM, Barnett J, Payne R, Roy D, Gowland MH, Lucas JS (2016) Consumer Preferences for Written and Oral Information about Allergens When Eating Out. *PLoS ONE*, 11(5).

Ben-Shoshan, M., Soller, L., Harrington, D. W., Knoll, M., La Vieille, S., Fragapane, J., Joseph, L., St Pierre, Y., Wilson, K., Elliott, S. J., & Clarke, A. E. (2015). Eczema in early childhood, sociodemographic factors and lifestyle habits are associated with food allergy: a nested case-control study. *International archives of allergy and immunology*, 166(3), pp. 199–207.

Bilaver, L. A., Kester, K. M., Smith, B. M., & Gupta, R. S. (2016). Socioeconomic Disparities in the Economic Impact of Childhood Food Allergy. *Pediatrics,* 137(5).

Bittker, S. S., & Bell, K. R. (2019). Potential risk factors for coeliac disease in childhood: a case-control epidemiological survey. *Clinical and experimental gastroenterology*, *12*, pp. 303–319.

Blom, W. M., Kruizinga, A. G., Rubingh, C. M., Remington, B. C., Crevel, R., & Houben, G. F. (2017). Assessing food allergy risks from residual peanut protein in highly refined vegetable oil. *Food and chemical toxicology : an international journal published for the British Industrial Biological Research Association*, *106*(Pt A), pp. 306–313.

Blom, W.M., van Dijk, L.M., Michelsen-Huisman, A., Houben, G.F., Knulst, A.C., Linders, Y.F.M., Verhoeckx, K.C.M., Holleman, B.C. and Lentz, L.R. (2021), Allergen labelling: Current practice and improvement from a communication perspective. *Clin Exp Allergy,* p. 1-11.

Brar, P., Lee, A. R., Lewis, S. K., Bhagat, G., & Green, P. H. (2006). Coeliac disease in African-Americans. *Digestive diseases and sciences*, 51(5), pp. 1012–1015.

Brzozowski B. (2018). Impact of food processing and simulated gastrointestinal digestion on gliadin immunoreactivity in rolls. *Journal of the Science of Food and Agriculture*, 98(9), pp. 3363-3375

Burden, M., Mooney, P. D., Blanshard, R. J., White, W. L., Cambray-Deakin, D. R., & Sanders, D. S. (2015). Cost and availability of gluten-free food in the UK: in store and online. *Postgraduate medical journal*, 91(1081), pp. 622–626.

Butterworth, J. R., Banfield, L. M., Iqbal, T. H., & Cooper, B. T. (2004). Factors relating to compliance with a gluten-free diet in patients with coeliac disease: comparison of white Caucasian and South Asian patients. *Clinical nutrition (Edinburgh, Scotland)*, 23(5), pp. 1127–1134.

Cardona, V., Luengo, O., Garriga, T., Labrador-Horrillo, M., Sala-Cunill, A., Izquierdo, A., Soto, L., & Guilarte, M. (2012). Co-factor-enhanced food allergy. *Allergy*, 67(10), pp. 1316–1318.

Cochrane, S. A., Gowland, M. H., Sheffield, D., & Crevel, R. W. (2013). Characteristics and purchasing behaviours of food-allergic consumers and those who buy food for them in Great Britain. *Clinical and translational allergy*, *3*(1), pp. 31.

Cornelisse-Vermaat, J. R., Voordouw, J., Yiakoumaki, V., Theodoridis, G., & Frewer, L. J. (2008). Food-allergic consumers' labelling preferences: a cross-cultural comparison. *European journal of public health*, 18(2), pp. 115–120.

Clark, A. T., Anagnostou, K., & Ewan, P. W. (2007). Cashew nut causes more severe reactions than peanut: case-matched comparison in 141 children. *Allergy*, 62(8), pp. 913–916.

Coulson, E., Rifas-Shiman, S. L., Sordillo, J., Bunyavanich, S., Camargo, C. A., Jr, Platts-Mills, T., Coull, B. A., Luttmann-Gibson, H., Oken, E., Gold, D. R., & Rice, M. B. (2020). Racial, ethnic, and socioeconomic differences in adolescent food allergy. *The journal of allergy and clinical immunology. In practice*, 8(1), pp. 336–338.

Cuadrado, C., Cabanillas, B., Pedrosa, M.M., Varela, A., Guillamón, E., Muzquiz, M., Crespo, J.F., Rodriguez, J. and Burbano, C. (2009), Influence of thermal processing on IgE reactivity to lentil and chickpea proteins. *Mol. Nutr. Food Res*., 53, pp. 1462-1468.

Davisse-Paturet, C., Raherison, C., Adel-Patient, K., Divaret-Chauveau, A., Bois, C., Dufourg, M. N., Lioret, S., Charles, M. A., & de Lauzon-Guillain, B. (2019). Use of partially hydrolysed formula in infancy and incidence of eczema, respiratory symptoms or food allergies in toddlers from the ELFE cohort. *Pediatric allergy and immunology : official publication of the European Society of Pediatric Allergy and Immunology*, *30*(6), pp. 614–623.

Dias, R. P., Summerfield, A., & Khakoo, G. A. (2008). Food hypersensitivity among Caucasian and non-Caucasian children. *Pediatric allergy and immunology*, 19(1), pp. 86–89.

Dioun, A. F., Harris, S. K., & Hibberd, P. L. (2003). Is maternal age at delivery related to childhood food allergy?. *Pediatric allergy and immunology : official publication of the European Society of Pediatric Allergy and Immunology*, *14*(4), pp. 307–311.

Dong, X., Wang, J. & Raghavan, V. (2020). Effects of high-intensity ultrasound processing on the physiochemical and allergenic properties of shrimp*. Innovative Food Science & Emerging Technologies,* 65.

Dostalek P, Gabrovská D, Rysová J, Mena MC, Hernando A, Méndez E, Chmelík J, Šalplachta J (2009) Determination of gluten in glucose syrups. *Journal of Food Composition and Analysis,* 22 (7–8), pp. 762–765

Drabińska, N., Bączek, N., & Krupa-Kozak, U. (2017). Knowledge about coeliac disease: Results of survey conducted among persons screened using a self-administered transglutaminase-based test, *Acta Alimentaria Acta Alimentaria*, *46*(3), pp. 283-289.

Dua, S., Ruiz-Garcia, M., Bond, S., Durham, S. R., Kimber, I., Mills, C., Roberts, G., Skypala, I., Wason, J., Ewan, P., Boyle, R., & Clark, A. (2019). Effect of sleep deprivation and exercise on reaction threshold in adults with peanut allergy: A randomized controlled study. *The Journal of allergy and clinical immunology*, *144*(6), pp. 1584–1594.

Dubakiene, R., Rudzeviciene, O., Butiene, I., Sezaite, I., Petronyte, M., Vaicekauskaite, D., & Zvirbliene, A. (2012). Studies on early allergic sensitization in the Lithuanian birth cohort. *TheScientificWorldJournal*, *2012*, 909524.

DunnGalvin, A., Roberts, G., Regent, L., Austin, M., Kenna, F., Schnadt, S., Sanchez-Sanz, A., Hernandez, P., Hjorth, B., Fernandez-Rivas, M., Taylor, S., Baumert, J., Sheikh, A., Astley, S., Crevel, R., & Mills, C. (2019). Understanding how consumers with food allergies make decisions based on precautionary labelling. *Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology*, *49*(11), pp. 1446–1454.

Dupuis, R., Meisel, Z., Grande, D., Strupp, E., Kounaves, S., Graves, A., Frasso, R., & Cannuscio, C. C. (2016). Food allergy management among restaurant workers in a large U.S. city. *Food control, 63*, pp. 147-157.

Dydensborg Sander, S., Nybo Andersen, A. M., Murray, J. A., Karlstad, Ø., Husby, S., & Størdal, K. (2019). Association Between Antibiotics in the First Year of Life and Coeliac Disease. *Gastroenterology*, *156*(8), pp. 2217–2229.

Eggesbø, M., Botten, G., Stigum, H., Nafstad, P., & Magnus, P. (2003). Is delivery by cesarean section a risk factor for food allergy?. *The Journal of allergy and clinical immunology*, *112*(2), pp. 420–426.

FDA (2005). Food Labeling; Gluten-Free Labeling of Foods. *Final Regulatory Impact Analysis.*

Freeman H. J. (2003). Biopsy-defined adult coeliac disease in Asian-Canadians. *Canadian journal of gastroenterology = Journal canadien de gastroenterologie*, 17(7), pp. 433–436.

Frost, D. W., & Chalin, C. G. (2005). The effect of income on anaphylaxis preparation and management plans in Toronto primary schools. *Canadian journal of public health = Revue canadienne de sante publique*, 96(4), pp. 250–253.

Gaylord, A., Trasande, L., Kannan, K., Thomas, K. M., Lee, S., Liu, M., & Levine, J. (2020). Persistent organic pollutant exposure and coeliac disease: A pilot study. *Environmental research*, *186*, 109439.

Garino, C., Mielke, H., Knüppel, S., Selhorst, T., Broll, H., & Braeuning, A. (2020). Quantitative allergenicity risk assessment of food products containing yellow mealworm (Tenebrio molitor*). Food and chemical toxicology : an international journal published for the British Industrial Biological Research Association*, 142, 111460.

Geiger, J. , Rhee, Y. , Stastny, S. N. , Brunt, A. , & Salafia, E. B. (2017). Coeliac Disease and the Gluten-free Diet: Registered Dietitian Nutritionists' Self-reported Knowledge Varies. *International Journal of Coeliac Disease*, *5*(2),pp. 56-61.

Gern, J. E., Reardon, C. L., Hoffjan, S., Nicolae, D., Li, Z., Roberg, K. A., Neaville, W. A., Carlson-Dakes, K., Adler, K., Hamilton, R., Anderson, E., Gilbertson-White, S., Tisler, C., Dasilva, D., Anklam, K., Mikus, L. D., Rosenthal, L. A., Ober,

C., Gangnon, R., & Lemanske, R. F., Jr (2004). Effects of dog ownership and genotype on immune development and atopy in infancy. *The Journal of allergy and clinical immunology*, *113*(2), pp. 307–314.

Giniş, T., Koç, N., Güvenir, H., Çetin, C., Toyran, M., Civelek, E., & Kocabaş, C. N. (2016). The level of knowledge of dietitians about dietary management of children with food allergy. *Asim, Allerji, Immunoloji*, *14*(2), pp. 81–87.

Grimshaw, K., Roberts, G., Selby, A., Reich, A., Butiene, I., Clausen, M., Dubakiene, R., Fiandor, A., Fiocchi, A., Grabenhenrich, L. B., Larco, J. I., Kowalski, M. L., Rudzeviciene, O., Papadopoulos, N. G., Rosenfeld, L., Sigurdardottir, S. T., Sprikkelman, A. B., Schoemaker, A. A., Xepapadaki, P., Mills, E., Keil., T., & Beyer, K. (2020). Risk Factors for Hen's Egg Allergy in Europe: EuroPrevall Birth Cohort. *The journal of allergy and clinical immunology. In practice*, *8*(4), pp. 1341–1348.

Gruenfeldova J., Domijan K. & Walsh C. (2019). A study of food safety knowledge, practice and training among food handlers in Ireland. *Food Control*, 105, pp. 131-140.

Gupta, R., Kanaley, M., Negris, O., Roach, A., & Bilaver, L. (2021). Understanding Precautionary Allergen Labeling (PAL) Preferences Among Food Allergy Stakeholders. *Journal of Allergy and Clinical Immunology: In Practice*, 9(1), pp. 254-264.

Gupta, R. S., Rivkina, V., DeSantiago-Cardenas, L., Smith, B., Harvey-Gintoft, B., & Whyte, S. A. (2014). Asthma and food allergy management in Chicago Public Schools. *Pediatrics*, 134(4), pp. 729–736.

Gupta, R. S., Taylor, S. L., Baumert, J. L., Kao, L. M., Schuster, E., & Smith, B. M. (2017). Economic Factors Impacting Food Allergen Management: Perspectives from the Food Industry. *Journal of food protection*, 80(10), pp. 1719–1725.

Gutowski, E. D., Weiten, D., Green, K. H., Rigaux, L. N., Bernstein, C. N., Graff, L. A., Walker, J. R., Duerksen, D. R., & Silvester, J. A. (2020). Can individuals with coeliac disease identify gluten-free foods correctly?. *Clinical nutrition ESPEN*, *36*, pp. 82–90.

Halmos, E. P., Deng, M., Knowles, S. R., Sainsbury, K., Mullan, B., & Tye-Din, J. A. (2018). Food knowledge and psychological state predict adherence to a gluten-free diet in a survey of 5310 Australians and New Zealanders with coeliac disease. *Alimentary pharmacology & therapeutics*, *48*(1), pp. 78–86.

Hanci O., Jeanes Y. M. (2019). Are gluten-free food staples accessible to all patients with coeliac disease? *Frontline Gastroenterology,*10, pp. 222-228.

Harrison J. A., Critzer F. J., and Harrison M. A. (2016). Regulatory and food safety knowledge gaps associated with small and very small food businesses as identified by regulators and food safety educators - implications for food safety training. *Food Protection Trends*, 36(6), pp. 420-427.

Hefle, S. L., Furlong, T. J., Niemann, L., Lemon-Mule, H., Sicherer, S., & Taylor, S. L. (2007). Consumer attitudes and risks associated with packaged foods having advisory labeling regarding the presence of peanuts. *The Journal of allergy and clinical immunology*, 120(1), pp. 171–176.

Hicke-Roberts, A., Wennergren, G., & Hesselmar, B. (2020). Late introduction of solids into infants' diets may increase the risk of food allergy development. *BMC pediatrics*, *20*(1), pp. 273.

Hua, T., Sambell, R., Wallace, R., Vale, S., & Devine, A. (2020). Food allergy management in Early Childhood Education and Care Services in Australia. *Journal of paediatrics and child health*, *56*(3), pp. 394–399.

Hu, W., Grbich, C., & Kemp, A. (2007). Parental food allergy information needs: a qualitative study. *Archives of disease in childhood*, *92*(9), pp. 771–775.

Ivarsson, A., Hernell, O., Nyström, L., & Persson, L. A. (2003). Children born in the summer have increased risk for coeliac disease. *Journal of epidemiology and community health*, *57*(1), pp. 36–39.

Jackson, L. S., Al-Taher, F. M., Moorman, M., DeVries, J. W., Tippett, R., Swanson, K. M., Fu, T. J., Salter, R., Dunaif, G., Estes, S., Albillos, S., & Gendel, S. M. (2008). Cleaning and other control and validation strategies to prevent allergen cross-contact in food-processing operations. *Journal of food protection*, *71*(2), pp. 445–458.

Jacobsen, K. H., Sambell, R., Devine, A., & Vale, S. (2018). Food Allergy Readiness and Anaphylaxis Management in Early Childhood Education and Care in Western Australia. *Australasian Journal of Early Childhood*, 43(4), pp. 43–47.

Jacobson M. F. (2003). Adverse reactions to a new food ingredient. *The American journal of medicine*, 115(4), pp. 334.

Jamieson, J. A., & Gougeon, L. (2019). Adults following a gluten-free diet report little dietary guidance in a pilot survey exploring relationships between dietary knowledge, management, and adherence in Nova Scotia, Canada. *Nutrition research (New York, N.Y.)*, *66*, pp. 107–114.

Jansen, M., Beth, S. A., van den Heuvel, D., Kiefte-de Jong, J. C., Raat, H., Jaddoe, V., van Zelm, M. C., & Moll, H. A. (2017). Ethnic differences in coeliac disease autoimmunity in childhood: the Generation R Study. *Archives of disease in childhood*, 102(6), pp. 529–534.

Jędrusek-Golińska, A., Piasecka-Kwiatkowska, D., Zielińska, P., Zielińska-Dawidziak, M., Szymandera-Buszka, K., & Hęś, M. (2019). Soy Preparations Are Potentially Dangerous Factors in the Course of a Food Allergy. *Foods (Basel, Switzerland)*, 8(12), pp. 665.

Joseph, C. L., Zoratti, E. M., Ownby, D. R., Havstad, S., Nicholas, C., Nageotte, C., Misiak, R., Enberg, R., Ezell, J., & Johnson, C. C. (2016). Exploring racial differences in IgE-mediated food allergy in the WHEALS birth cohort. *Annals of allergy, asthma & immunology*, 116(3), pp. 219–224.

Joshi, P., Mofidi, S., & Sicherer, S. H. (2002). Interpretation of commercial food ingredient labels by parents of food-allergic children. *The Journal of allergy and clinical immunology*, *109*(6), pp. 1019–1021.

Ji, J., Ludvigsson, J. F., Sundquist, K., Sundquist, J., & Hemminki, K. (2011). Incidence of coeliac disease among second-generation immigrants and adoptees from abroad in Sweden: evidence for ethnic differences in susceptibility. *Scandinavian journal of gastroenterology*, 46(7-8), pp. 844–848.

Ju, S. Y., Park, J. H., Kwak, T. K., & Kim, K. E. (2015). Attitudes and preferences of consumers toward food allergy labeling practices by diagnosis of food allergies. *Nutrition research and practice*, *9*(5), pp. 517–522.

Karajeh, M. A., Hurlstone, D. P., Patel, T. M., & Sanders, D. S. (2005). Chefs' knowledge of coeliac disease (compared to the public): a questionnaire survey from the United Kingdom. *Clinical nutrition (Edinburgh, Scotland)*, *24*(2), pp. 206–210.

Kårhus, L. L., Gunnes, N., Størdal, K., Bakken, I. J., Tapia, G., Stene, L. C., Håberg, S. E., & Mårild, K. (2018). Influenza and risk of later coeliac disease: a cohort study of 2.6 million people. *Scandinavian journal of gastroenterology*, *53*(1), pp. 15–23.

Karinen, H., Kärkkäinen, P., Pihlajamäki, J., Janatuinen, E., Heikkinen, M., Julkunen, R., Kosma, V. M., Naukkarinen, A., & Laakso, M. (2006). Gene dose effect of the DQB1*0201 allele contributes to severity of coeliac disease. *Scandinavian journal of gastroenterology*, 41(2), pp. 191–199.

Kim, J., Chang, E., Han, Y., Ahn, K., & Lee, S. I. (2011). The incidence and risk factors of immediate type food allergy during the first year of life in Korean infants: a birth cohort study. *Pediatric allergy and immunology*, *22*(7), pp. 715–719.

Kiyota, K., Sakata, J., Satsuki-Murakami, T., Yoshimitsu, M., Akutsu, K., Ki, M., Hashimoto, H., Kajimura, K., & Yamano, T. (2018). Evaluation of cleaning methods for residual orange extract on different cookware materials using ELISA with profilin allergen indicator. *J Food Process Eng,* 41.

Koerner, T. B., Cleroux, C., Poirier, C., Cantin, I., La Vieille, S., Hayward, S., & Dubois, S. (2013). Gluten contamination of naturally gluten-free flours and starches used by Canadians with coeliac disease. *Food additives & contaminants. Part A, Chemistry, analysis, control, exposure & risk assessment*, *30*(12), pp. 2017–2021.

Krugman, S. D., Chiaramonte, D. R., & Matsui, E. C. (2006). Diagnosis and management of food-induced anaphylaxis: a national survey of pediatricians. *Pediatrics*, *118*(3), pp. 554–560.

Kull, I., Bergström, A., Melén, E., Lilja, G., van Hage, M., Pershagen, G., & Wickman, M. (2006). Early-life supplementation of vitamins A and D, in water-soluble form or in peanut oil, and allergic diseases during childhood. *The Journal of allergy and clinical immunology*, *118*(6), pp. 1299–1304.

Kumar, R., Tsai, H. J., Hong, X., Liu, X., Wang, G., Pearson, C., Ortiz, K., Fu, M., Pongracic, J. A., Bauchner, H., & Wang, X. (2011). Race, ancestry, and development of food-allergen sensitization in early childhood. *Pediatrics*, 128(4), pp. 821–829.

Kwon, J., Lee, Y. Ming, & Wen, H. (2020). Knowledge, attitudes, and behaviors about dining out with food allergies: A cross-sectional survey of restaurant customers in the United States. *Food control, 107.*

Laheri, Z., & Soon, J. M. (2018) Awareness of alternative gluten-free grains for individuals with coealiac disease. *British Food Journal*, 120 (12). pp. 2793-2803.

Lannerö, E., Wickman, M., van Hage, M., Bergström, A., Pershagen, G., & Nordvall, L. (2008). Exposure to environmental tobacco smoke and sensitisation in children. *Thorax*, *63*(2), pp. 172–176.

Laubereau, B., Filipiak-Pittroff, B., von Berg, A., Grübl, A., Reinhardt, D., Wichmann, H. E., Koletzko, S., & GINI Study Group (2004). Caesarean section and gastrointestinal symptoms, atopic dermatitis, and sensitisation during the first year of life. *Archives of disease in childhood*, *89*(11), pp. 993–997.

Lee, A. R., Ng, D. L., Zivin, J., & Green, P. H. (2007*). Economic burden of a gluten-free diet. Journal of human nutrition and dietetics*, 20(5), pp. 423–430.

Lee Y.M., Sozen E. (2016). Food allergy knowledge and training among restaurant employees. *International Journal of Hospitality Management, 57,* pp. 52-59.

Lee, Y. M., & Xu, H. (2015). Food allergy knowledge, attitudes, and preparedness among restaurant managerial staff. *Journal of Foodservice Business Research*, 18(5), pp. 454-469.

Lefèvre, S., Abitan, L., Goetz, C., Frey, M., Ott, M., & de Blay, F. (2019(Multicenter survey of restaurant staff's knowledge of food allergy in eastern France. *Allergo Journal International*, 28, pp. 57–62.

Li, M., Lu, Z. K., Amrol, D. J., Mann, J. R., Hardin, J. W., Yuan, J., Cox, C. L., & Love, B. L. (2019). Antibiotic Exposure and the Risk of Food Allergy: Evidence in the US Medicaid Pediatric Population. *The journal of allergy and clinical immunology. In practice*, *7*(2), pp. 492–499.

Liu, A. H., Jaramillo, R., Sicherer, S. H., Wood, R. A., Bock, S. A., Burks, A. W., Massing, M., Cohn, R. D., & Zeldin, D. C. (2010). National prevalence and risk factors for food allergy and relationship to asthma: results from the National Health and Nutrition Examination Survey 2005-2006. *The Journal of allergy and clinical immunology*, 126(4), pp. 798–806.

Liu, X., Wang, G., Hong, X., Wang, D., Tsai, H. J., Zhang, S., Arguelles, L., Kumar, R., Wang, H., Liu, R., Zhou, Y., Pearson, C., Ortiz, K., Schleimer, R., Holt, P. G., Pongracic, J., Price, H. E., Langman, C., & Wang, X. (2011). Gene-vitamin D interactions on food sensitization: a prospective birth cohort study. *Allergy*, *66*(11), pp. 1442–1448.

Loerbroks, A., Tolksdorf, S. J., Wagenmann, M., & Smith, H. (2019). Food allergy knowledge, attitudes and their determinants among restaurant staff: A cross-sectional study. *PloS one*, *14*(4).

Logan, K., Perkin, M. R., Marrs, T., Radulovic, S., Craven, J., Flohr, C., Bahnson, H. T., & Lack, G. (2020). Early Gluten Introduction and Coeliac Disease in the EAT Study: A Prespecified Analysis of the EAT Randomized Clinical Trial. *JAMA pediatrics*, *174*(11), pp. 1–7.

Løvik, M., Namork, E., Fæste, C., & Egaas, E. (2009). The Norwegian National Reporting System and Register of Severe Allergic Reactions to Food. *Norsk Epidemiologi*, *14*(2).

Ludvigsson, J. F., & ABIS Study Group (2005). Socio-economic characteristics in children with coeliac disease. *Acta paediatrica (Oslo, Norway : 1992)*, 94(1), pp. 107–113.

Mahdavinia, M., Fox, S. R., Smith, B. M., James, C., Palmisano, E. L., Mohammed, A., Zahid, Z., Assa'ad, A. H., Tobin, M. C., & Gupta, R. S. (2017). Racial Differences in Food Allergy Phenotype and Health Care Utilization among US Children. *The journal of allergy and clinical immunology. In practice*, 5(2), pp. 352–357.

Marchisotto, M. J., Harada, L., Kamdar, O., Smith, B. M., Waserman, S., Sicherer, S., Allen, K., Muraro, A., Taylor, S., & Gupta, R. S. (2017). Food Allergen Labeling and Purchasing Habits in the United States and Canada. *Journal of Allergy and Clinical Immunology: In Practice*, 5(2), pp. 345-351.

Mardini, H. E., Westgate, P., & Grigorian, A. Y. (2015). Racial Differences in the Prevalence of Coeliac Disease in the US Population: National Health and Nutrition Examination Survey (NHANES) 2009-2012. Digestive diseases and sciences, 60(6), pp. 1738–1742.

Mårild, K., Stephansson, O., Montgomery, S., Murray, J. A., & Ludvigsson, J. F. (2012). Pregnancy outcome and risk of coeliac disease in offspring: a nationwide case-control study. *Gastroenterology*, *142*(1), pp. 39–45.

Marra, C. A., Harvard, S., Grubisic, M., Galo, J., Clarke, A., Elliott, S., & Lynd, L. D. (2017). Consumer preferences for food allergen labeling. *Allergy, asthma, and clinical immunology : official journal of the Canadian Society of Allergy and Clinical Immunology*, *13*, pp. 19.

Marrs, T., Logan, K., Craven, J., Radulovic, S., McLean, W., Lack, G., Flohr, C., Perkin, M. R., & EAT Study Team (2019). Dog ownership at three months of age is associated with protection against food allergy. *Allergy*, *74*(11), pp. 2212–2219.

Maurer, J., Byrd-Bredbenner, C., & Grasso, D. (2007). “Ask before You Eat”—Development of an Educational Campaign on Food Allergies. *Social Marketing Quarterly*, 13(2), pp. 48–70.

McAdams, B., Deng, A. and MacLaurin, T. (2018), "Food allergy knowledge, attitudes, and resources of restaurant employees".*British Food Journal*, 120(11), pp. 2681-2694.

McGowan, E. C., Matsui, E. C., Peng, R., Salo, P. M., Zeldin, D. C., & Keet, C. A. (2016). Racial/ethnic and socioeconomic differences in self-reported food allergy among food-sensitized children in National Health and Nutrition Examination Survey III. *Annals of allergy, asthma & immunology*, 117(5), pp. 570–572.

McLaughlin, A. M., Macaulay, T., & Peterson, C. C. (2020). College students' knowledge and management of food allergies. *Journal of American college health,* pp. 1–7.

McWilliam, V. L., Koplin, J. J., Field, M. J., Sasaki, M., Dharmage, S. C., Tang, M., Sawyer, S. M., Peters, R. L., Allen, K. J., & SchoolNuts investigators (2018). Self-reported adverse food reactions and anaphylaxis in the SchoolNuts study: A population-based study of adolescents. *The Journal of allergy and clinical immunology*, 141(3), pp. 982–990.

Mesquita J., Silva A., Giesteira B. (2016). Identification of food allergens by using relief pictograms in food packaging. [Conference Paper]. *18th International Conference on Human-Computer Interaction*.

Miles, S., Crevel, R., Chryssochoidis, G., Frewer, L., Grimshaw, K., Riera, A. G., Gowland, H., Knibb, R., Koch, P., Madson, C., Mills, C., Palkonen, S., Pfaff, S., Roccaldo, R., Scholderer, J., Ueland, O., Valovirta, E., & Verbeke, W. (2006). Communication needs and food allergy: an analysis of stakeholder views.

Miles, S., Erkka, V. & Lynn, F. (2006). Communication needs and food allergy: A summary of stakeholder views. *British Food Journal*, 108, pp. 795-802.

Minaker, M. L., Elliott, J. S., & Clarke, A. (2015) Low income, high risk: the overlapping stigmas of food allergy and poverty. *Critical Public Health*, 25(5), pp. 599-614.

Moos, C., Duus, K. S., Frederiksen, P., Heitmann, B. L., & Andersen, V. (2020). Exposure to the Danish Mandatory Vitamin D Fortification Policy in Prenatal Life and the Risk of Developing Coeliac Disease-The Importance of Season: A Semi Ecological Study. *Nutrients*, *12*(5), p. 1243.

Muhammad, H., Reeves, S., Ishaq, S., Mayberry, J., & Jeanes, Y. M. (2017). Adherence to a Gluten Free Diet Is Associated with Receiving Gluten Free Foods on Prescription and Understanding Food Labelling. *Nutrients*, 9(7), pp. 705.

Mullins, R.J., Clark, S. & Camargo, C.A., Jr. (2010). Socio-economic status, geographic remoteness and childhood food allergy and anaphylaxis in Australia. *Clinical & Experimental Allergy*, 40, pp. 1523-1532.

Mullins, R. J., Clark, S., Katelaris, C., Smith, V., Solley, G., & Camargo, C. A., Jr (2011). Season of birth and childhood food allergy in Australia. *Pediatric allergy and immunology*, *22*(6), pp. 583–589.

Munro, C., Semic-Jusufagic, A., Pyrz, K., Couch, P., Dunn-Galvin, A., Peek, N., Themis, M., Mills, C., Buchan, I., Hourihane, J., & Simpson, A. (2015). An eHealth Approach to Reporting Allergic Reactions to Food and Closing the Knowledge Gap. *Studies in health technology and informatics*, *216*, pp. 320–324.

Murray, J. A., Moore, S. B., Van Dyke, C. T., Lahr, B. D., Dierkhising, R. A., Zinsmeister, A. R., Melton, L. J., 3rd, Kroning, C. M., El-Yousseff, M., & Czaja, A. J. (2007). HLA DQ gene dosage and risk and severity of coeliac disease. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*, 5(12), pp. 1406–1412.

Namatovu, F., Lindkvist, M., Olsson, C., Ivarsson, A., & Sandström, O. (2016). Season and region of birth as risk factors for coeliac disease a key to the aetiology?. *Archives of disease in childhood*, *101*(12), pp. 1114–1118.

Natcen for FSA (2017). Profiles and practices of people with food hypersensitivities.

Negoro, T., Orihara, K., Irahara, T., Nishiyama, H., Hagiwara, K., Nishida, R., Takagi, H., Satoh, K., Yamamoto, Y., Shimizu, S., Hagiwara, T., Ishii, M., Tanioka, T., Nakano, Y., Takeda, K., Yoshimura, I., Iikura, Y., & Tobe, T. (2006). Influence of SNPs in cytokine-related genes on the severity of food allergy and atopic eczema in children. *Pediatric allergy and immunology : official publication of the European Society of Pediatric Allergy and Immunology*, 17(8), pp. 583–590.

Noimark, L., Gardner, J., & Warner, J. O. (2009). Parents' attitudes when purchasing products for children with nut allergy: a UK perspective. *Pediatric allergy and immunology: official publication of the European Society of Pediatric Allergy and Immunology*, 20(5), pp. 500–504.

Olén, O., Bihagen, E., Rasmussen, F., & Ludvigsson, J. F. (2012). Socioeconomic position and education in patients with coeliac disease. *Digestive and liver disease : official journal of the Italian Society of Gastroenterology and the Italian Association for the Study of the Liver*, 44(6), pp. 471–476.

Ortiz J.C., Galan-Malo P., Garcia-Galvez M., Mateos A., Ortiz-Ramos M., Razquin P., Mata L. (2018). Survey on the occurrence of allergens on food-contact surfaces from school canteen kitchens. *Food Control*, 84, pp. 449-454.

Oza, S. S., Akbari, M., Kelly, C. P., Hansen, J., Theethira, T., Tariq, S., Dennis, M., & Leffler, D. A. (2016). Socioeconomic Risk Factors for Coeliac Disease Burden and Symptoms. *Journal of clinical gastroenterology*, 50(4), pp. 307–312.

Parsons, K., Brown, L., Clark, H., Allen, E., McCammon, E., Clark, G., Oblad, R., & Kenealey, J. (2020). Gluten cross-contact from common food practices and preparations. *Clinical nutrition (Edinburgh, Scotland)*, S0261-5614(20)30599-9. Advance online publication.

Pele, M., Brohée, M., Anklam, E., & Van Hengel, A. J. (2007). Peanut and hazelnut traces in cookies and chocolates: relationship between analytical results and declaration of food allergens on product labels. *Food additives and contaminants*, 24(12), pp. 1334–1344.

Pettersson, M. E., Koppelman, G. H., Flokstra-de Blok, B., Kollen, B. J., & Dubois, A. (2018). Prediction of the severity of allergic reactions to foods. *Allergy*, 73(7), pp. 1532–1540.

Pieretti, M. M., Chung, D., Pacenza, R., Slotkin, T., & Sicherer, S. H. (2009). Audit of manufactured products: use of allergen advisory labels and identification of labeling ambiguities. The Journal of allergy and clinical immunology, 124(2), pp. 337–341.

Polikovsky, M., Fernand, F., Sack, M., Frey, W., Müller, G., & Golberg, A. (2019). In silico food allergenic risk evaluation of proteins extracted from macroalgae Ulva sp. with pulsed electric fields. *Food chemistry*, 276, pp. 735–744.

Pratten J.D., Towers N. (2004), Food allergies and the UK catering industry: A study of the training needs for the industry to serve those with food allergies. *Journal of European Industrial Training*, 28(6).

Radke, T. J., Brown, L. G., Hoover, E. R., Faw, B. V., Reimann, D., Wong, M. R., Nicholas, D., Barkley, J., & Ripley, D. (2016). Food Allergy Knowledge and Attitudes of Restaurant Managers and Staff: An EHS-Net Study. *Journal of food protection*, *79*(9), pp. 1588–1598.

Remington, B. C., Baumert, J. L., Blom, W. M., Houben, G. F., Taylor, S. L., & Kruizinga, A. G. (2015). Unintended allergens in precautionary labelled and unlabelled products pose significant risks to UK allergic consumers. *Allergy*, *70*(7), pp. 813–819.

Reyes, T. F., Chen, Y., Fraser, R. Z., Chan, T., & Li, X. (2021). Assessment of the potential allergenicity and toxicity of Pichia proteins in a novel leghemoglobin preparation. *Regulatory toxicology and pharmacology* : RTP, 119, 104817.

Richard, C., Jacquenet, S., Sergeant, P., & Moneret-Vautrin, D. A. (2015). Cross-reactivity of a new food ingredient, dun pea, with legumes, and risk of anaphylaxis in legume allergic children. *European annals of allergy and clinical immunology*, 47(4), pp. 118–125.

Roy, A., Mehra, S., Kelly, C. P., Tariq, S., Pallav, K., Dennis, M., Peer, A., Lebwohl, B., Green, P. H., & Leffler, D. A. (2016). The association between socioeconomic status and the symptoms at diagnosis of coeliac disease: a retrospective cohort study. *Therapeutic advances in gastroenterology*, 9(4), pp. 495–502.

Röder, M., Ibach, A., Baltruweit, I., Gruyters, H., Janise, A., Suwelack, C., Matissek, R., Vieths, S., & Holzhauser, T. (2008). Pilot plant investigations on cleaning efficiencies to reduce hazelnut cross-contamination in industrial manufacture of cookies. *Journal of food protection*, 71(11), pp. 2263–2271.

Rudnicka, A., Słowik, M., & Hozyasz, K. (2017). Bread from bake-off technology. Preliminary study of accessibility and composition. *Journal of Paediatrics*, 92(2), pp. 156-163.

Sampson, M. A., Muñoz-Furlong, A., & Sicherer, S. H. (2006). Risk-taking and coping strategies of adolescents and young adults with food allergy. *The Journal of allergy and clinical immunology*, 117(6), pp. 1440–1445.

Sanagavarapu, P., & Huang, Y. (2017). Young children's knowledge of food allergy and transition to school. *Cogent Education*, 4(1).

Sandberg-Bennich, S., Dahlquist, G., & Källén, B. (2002). Coeliac disease is associated with intrauterine growth and neonatal infections. *Acta paediatrica (Oslo, Norway : 1992)*, *91*(1), pp. 30–33.

Sander, D.S., Nybo Andersen, A. M., Murray, J. A., Karlstad, Ø., Husby, S., & Størdal, K. (2019). Association Between Antibiotics in the First Year of Life and Celiac Disease. Gastroenterology, 156(8), pp. 2217–2229.

Santerre, C. R., & Machtmes, K. L. (2002). The impact of consumer food biotechnology training on knowledge and attitude. *Journal of the American College of Nutrition*, 21(3 Suppl), pp. 174S–177S.

Sasaki, M., Peters, R. L., Koplin, J. J., Field, M. J., McWilliam, V., Sawyer, S. M., Vuillermin, P. J., Pezic, A., Gurrin, L. C., Douglass, J. A., Tang, M., Dharmage, S. C., & Allen, K. J. (2018). Risk Factors for Food Allergy in Early Adolescence: The SchoolNuts Study. *The journal of allergy and clinical immunology. In practice*, *6*(2), pp. 496–505.

Shashoua, R., & Barnett, J. (2019). Understanding Food Allergy Knowledge and Practice in Takeaway Restaurants in South Gloucestershire. *University of Bath*, [Unpublished report].

Sheth, S. S., Waserman, S., Kagan, R., Alizadehfar, R., Primeau, M. N., Elliot, S., St Pierre, Y., Wickett, R., Joseph, L., Harada, L., Dufresne, C., Allen, M., Allen, M., Godefroy, S. B., & Clarke, A. E. (2010). Role of food labels in accidental exposures in food-allergic individuals in Canada. *Annals of allergy, asthma & immunology : official publication of the American College of Allergy, Asthma, & Immunology*, *104*(1), pp. 60–65.

Sicherer, A. R. (2007). Deficits in knowledge about allergy among restaurant staff. *Nursing Standard*, 21(44), p. 17.

Silvester, J. A., Weiten, D., Graff, L. A., Walker, J. R., & Duerksen, D. R. (2016). Is it gluten-free? Relationship between self-reported gluten-free diet adherence and knowledge of gluten content of foods. *Nutrition (Burbank, Los Angeles County, Calif.)*, *32*(7-8), pp. 777–783.

Sogut, A., Kavut, A. B., Kartal, İ., Beyhun, E. N., Çayır, A., Mutlu, M., & Özkan, B. (2015). Food allergy knowledge and attitude of restaurant personnel in Turkey. *International forum of allergy & rhinology*, *5*(2), pp. 157–161.

Soller, L., Ben-Shoshan, M., Harrington, D. W., Knoll, M., Fragapane, J., Joseph, L., St Pierre, Y., La Vieille, S., Wilson, K., Elliott, S. J., & Clarke, A. E. (2015). Prevalence and predictors of food allergy in Canada: a focus on vulnerable populations. *The journal of allergy and clinical immunology. In practice*, 3(1), pp. 42–49.

Soon J. M. (2019). Food allergen knowledge, attitude and practices among UK consumers: A structural modelling approach. *Food research international (Ottawa, Ont.)*, *120*, pp. 375–381.

Soon J.M. (2018), 'No nuts please': Food allergen management in takeaways. *Food Control*.

Stelmach, I., Majak, P., Jerzynska, J., Podlecka, D., Stelmach, W., Polańska, K., Ligocka, D., & Hanke, W. (2015). The effect of prenatal exposure to phthalates on food allergy and early eczema in inner-city children. *Allergy and asthma proceedings*, *36*(4), pp. 72–78.

Stephan, O., Weisz, N., Vieths, S., Weiser, T., Rabe, B., & Vatterott, W. (2004). Protein quantification, sandwich ELISA, and real-time PCR used to monitor industrial cleaning procedures for contamination with peanut and celery allergens. *Journal of AOAC International*, *87*(6), pp. 1448–1457.

Stockhammer, D., Katelaris, C. H., Simpson, M. D., & Vanniasinkam, T. (2020). Parent perceptions in managing children with food allergy: An Australian perspective. *The World Allergy Organization journal*, *13*(10), 100468.

Størsrud, S., Malmheden Yman, I. & Lenner, R.A. (2003). Gluten contamination in oat products and products naturally free from gluten. *Eur Food Res Technol,* 217**,** pp. 481–485.

Studerus, D., Hampe, E. I., Fahrer, D., Wilhelmi, M., & Vavricka, S. R. (2018). Cross-Contamination with Gluten by Using Kitchen Utensils: Fact or Fiction?. *Journal of food protection*, *81*(10), pp. 1679–1684.

Sverker, A., Östlund, G., Hallert, C., & Hensing, G. (2009). 'I lose all these hours…'– exploring gender and consequences of dilemmas experienced in everyday life with coeliac disease. *Scandinavian Journal of Caring Sciences*, 23, pp. 342-352.

Tackett, A., Roberts, M. C., Farrow, M., McQuaid, L. E. (2019). Food insecurity and caregiver perceptions of food allergen risk by food purchase location in children with food allergies. *Translational Behavioral Medicine*, 9(3), pp. 404–412.

Tamburro M., Sammarco M.L., Di Eleonora L., Ripabelli G. (2020). Food service operators behavior and knowledge on gluten-free meals and requirements of public canteens. *Italian journal of food science*, 32(2).

Taylor-Black, S., & Wang, J. (2012). The prevalence and characteristics of food allergy in urban minority children. *Annals of allergy, asthma & immunology*, 109(6), pp. 431–437.

Thompson, T., Lyons, T. B., & Jones, A. (2016). Allergen advisory statements for wheat: do they help US consumers with coeliac disease make safe food choices?. *European journal of clinical nutrition*, 70(12), pp. 1341–1347.

Thorisdottir, B., Gunnarsdottir, I., Vidarsdottir, A. G., Sigurdardottir, S., Birgisdottir, B. E., & Thorsdottir, I. (2019). Infant Feeding, Vitamin D and IgE Sensitization to Food Allergens at 6 Years in a Longitudinal Icelandic Cohort. *Nutrients*, *11*(7), pp. 1690.

Tsuang, A., Grishin, A., Grishina, G., Do, A. N., Sordillo, J., Chew, G. L., & Bunyavanich, S. (2020). Endotoxin, food allergen sensitization, and food allergy: A complementary epidemiologic and experimental study. *Allergy*, *75*(3), pp. 625–635.

Tye-Din, J.A., Daveson, A.J.M., Goldstein, K.E. et al. (2020). Patient factors influencing acute gluten reactions and cytokine release in treated coeliac disease. *BMC Med* 18(362).

van Gils, T., Senler, T. G., van der Horst, H. E., Mulder, C., Bouma, G., & de Vries, H. (2018). The daily practice of (suspected) coeliac disease management by general practitioners: A qualitative approach. *The European journal of general practice*, *24*(1), pp. 236–242.

van Putten, M., Frewer, L., Gilissen, L., Bart, G., Peijnenburg, A. and Wichers, H. (2010). Stakeholder and consumer views regarding novel hypoallergenic foods. *British Food Journal*, 112 (9), pp. 949-961.

Venkataratnam, H., Cahill, O., Sarangapani, C., Cullen, P.J., & Barry-Ryan, C. (2020). Impact of cold plasma processing on major peanut allergens. *Sci Rep,* 10.

Venter, C., Palumbo, M.P., Sauder, K.A., Glueck, D.H., Liu, A.H., Yang, I., Abdullah, M.B., Fleischer, D., & Dabelea, D. (2020) Incidence and timing of offspring asthma, wheeze, allergic rhinitis, atopic dermatitis and food allergy and association with maternal history of asthma and allergic rhinitis. *World Allergy Organization Journal.* [Unpublished paper]

Verma, A. K., Gatti, S., Galeazzi, T., Monachesi, C., Padella, L., Baldo, G. D., Annibali, R., Lionetti, E., & Catassi, C. (2017). Gluten Contamination in Naturally or Labeled Gluten-Free Products Marketed in Italy. *Nutrients*, *9*(2), pp. 115.

Verrill, L., & Choinière J, C. (2009) Are Food Allergen Advisory Statements Really Warnings? Variation in Consumer Preferences and Consumption Decisions. *Journal of Food Products Marketing*, 15(2), pp. 139-151

Versluis, A., van Os-Medendorp, H., Kruizinga, A. G., Blom, W. M., Houben, G. F., & Knulst, A. C. (2016). Cofactors in allergic reactions to food: physical exercise and alcohol are the most important. *Immunity, inflammation and disease*, 4(4), pp. 392–400.

Versluis, A., van Os-Medendorp, H., Blom, W. M., Michelsen-Huisman, A. D., Castenmiller, J., Noteborn, H., Houben, G. F., & Knulst, A. C. (2019). Potential cofactors in accidental food allergic reactions are frequently present but may not influence severity and occurrence. *Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology*, 49(2), pp. 207–215.

Verstappen, J., Mirosa, M., & Thomson, C. (2018). Using the Systems-Practice Framework to Understand Food Allergen Management Practices at College Catering Operations: A Qualitative Study. *Journal of the Academy of Nutrition and Dietetics*, *118*(3), pp. 421–430.

Vierk, K. A., Koehler, K. M., Fein, S. B., & Street, D. A. (2007). Prevalence of self-reported food allergy in American adults and use of food labels. *The Journal of allergy and clinical immunology*, *119*(6), pp. 1504–1510.

Vincentini, O., Izzo, M., Maialetti, F., Gonnelli, E., Neuhold, S., & Silano, M. (2016). Risk of Cross-Contact for Gluten-Free Pizzas in Shared-Production Restaurants in Relation to Oven Cooking Procedures. *Journal of food protection*, *79*(9), pp. 1642–1646.

Voordouw, J., Antonides, G., Cornelisse-Vermaat, J. R., Pfaff, S., Niemietz, D., & Frewer, L. J. (2012). Optimising the delivery of food allergy information. An assessment of food allergic consumer preferences for different information delivery formats. *Food Quality and Preference*, *23*(1), pp. 71-78.

Voordouw, J., Cornelisse-Vermaat, J. Ruth, Pfaff, S., Antonides, G., Niemietz, D., Linardakis, M., Kehagia, O., & Frewer, L. J. (2011). Preferred information strategies for food allergic consumers. *A study in Germany, Greece, and The Netherlands. Food quality and preference*, 22, pp. 384-390.

Voordouw, J., Cornelisse-Vermaat, J.R., Yiakoumaki, V., Theodoridis, G., Chryssochoidis, G., & Frewer, L.J. (2009). Food allergic consumers' preferences for labelling practices: a qualitative study in a real shopping environment. *International Journal of Consumer Studies*, 33, pp. 94-102.

Weisbrod, V. M., Silvester, J. A., Raber, C., Suslovic, W., Coburn, S. S., Raber, B., McMahon, J., Damast, A., Kramer, Z., & Kerzner, B. (2020). A Quantitative Assessment of Gluten Cross-contact in the School Environment for Children With Coeliac Disease. *Journal of pediatric gastroenterology and nutrition*, *70*(3), pp. 289–294.

Weisbrod, V. M., Silvester, J. A., Raber, C., McMahon, J., Coburn, S. S., & Kerzner, B. (2020). Preparation of Gluten-Free Foods Alongside Gluten-Containing Food May Not Always Be as Risky for Coeliac Patients as Diet Guides Suggest. *Gastroenterology*, *158*(1), pp. 273–275.

Wen, H., & Kwon, J. (2019) Food allergy information sharing and communication strategies in full-service restaurants in the U.S. *Journal of Foodservice Business Research*, 22(1), pp. 50-65.

Wen, H., & Kwon, J. (2017). Restaurant servers' risk perceptions and risk communication-related behaviors when serving customers with food allergies in the U.S. *International Journal of Hospitality Management,* 64, pp. 11-20.

Wen, H**.**, Kwon, J. (2016). Food Allergy Risk Communication in Restaurants. *Food Protection Trends, 36*(5), pp. 372-383.

Wen, H., Lee, Y. M. (2019). Effects of message framing on food allergy communication: A cross-sectional study of restaurant customers with food allergies. *International Journal of Hospitality Management*.

Wen, H., Kwon, J. (2017). Restaurant servers' risk perceptions and risk communication-related behaviors when serving customers with food allergies in the U.S. *International Journal of Hospitality Management, 64*, pp. 11-20.

Whyte, L. A., Kotecha, S., Watkins, W. J., & Jenkins, H. R. (2014). *Coeliac disease is more common in children with high socio-economic status. Acta paediatrica*, 103(3), pp. 289–294.

Yrjänä, J., Bloigu, R., & Kulmala, P. (2018). Parental confusion may result when primary health care professionals show heterogeneity in their knowledge, attitudes, and perceptions regarding infant nutrition, food allergy, and atopic dermatitis. *Allergologia et immunopathologia*, *46*(4), pp. 326–333.

Zurzolo, G.A., Peters, R.L., Koplin, J.J. et al. (2017). Are food allergic consumers ready for informative precautionary allergen labelling?. *Allergy Asthma Clin Immunol*, 13, p. 42.

Zurzolo, G. A., Koplin, J. J., Mathai, M. L., Tang, M. K., & Allen, K. J. (2013). Perceptions of precautionary labelling among parents of children with food allergy and anaphylaxis. *The Medical journal of Australia*, 198(11), pp. 621–623.

Zurzolo, G. A., Mathai, M. L., Koplin, J. J., & Allen, K. J. (2013). Precautionary allergen labelling following new labelling practice in Australia. *Journal of paediatrics and child health,* 49(4), pp. 306–310.

rsmuk.com