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POSITION PAPER

EAACI Food Allergy and Anaphylaxis Guidelines. Protecting consumers with food allergies: understanding food consumption, meeting regulations and identifying unmet needs

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Abstract

Individuals suffering from IgE-mediated food allergy usually have to practise life-long food allergen avoidance. This document aims to provide an overview of recent evidence-based recommendations for allergen risk assessment and management in the food industry and discusses unmet needs and expectations of the food allergic consumer in that context. There is a general duty of care on the food industry and obligations in European Union legislation to reduce and manage the presence of allergens alongside other food hazards. Current evidence enables quantification of allergen reference doses used to set-up reliable food safety management plans for some foods. However, further work is required to include a wider variety of foods and to understand the impact of the food matrix as well as additional factors which affect the progression and severity of symptoms as a function of dose. Major concerns have been raised by patients, carers and patient groups about the use of precautionary 'may contain' labelling to address the issue of unintended presence of allergens; these therefore need to be reconsidered. New and improved allergen detection methods should be evaluated for their application in food production. There is an urgent requirement for effective communication between healthcare professionals, patient organizations, food industry representatives and regulators to develop a better approach to protecting consumers with food allergies.

Abbreviations
FIR, Food Information Regulation 1169/2011 EC; GMP, good manufacturing practice.

IgE-mediated food allergy is an important chronic disease manifested by a range of symptoms which can sometimes become life-threatening (1, 2). In the absence of a cure, individuals with food allergy usually have to practise life-long food allergen avoidance. Those at risk of severe allergic reactions must be equipped with rescue medication in case they accidentally consume or have contact with the culprit food. As most common allergenic foods provide valuable nutrition and dietary variety, it is neither practical nor desirable to eliminate these from all food products. Therefore, allergens are ubiquitous elements in food manufacturing environments. To support consumers with food allergies in avoiding food allergens, European Union (EU) food legislation requires the labelling of allergenic food components that are used as ingredients (3). It also imposes a general duty of care on the food industry to reduce and manage, control and communicate the presence of allergens alongside other food hazards (Box 1). This requires allergenic ingredients to be managed rather than eliminated completely from the food supply (4). However, the majority of foods are processed on shared equipment, and so-called allergen cross-contact may lead to the unintended presence of allergens. To date, the frequency and extent of cross-contact in commercial food items is generally unknown. As a consequence, precautionary allergen labelling such as 'may contain...' is frequently used. This is partly for product liability reasons, but also to provide additional consumer safety information, even though application of the precautionary labelling may not be evidence-based. In addition, important gaps in knowledge regarding the allergen risk management of manufactured food remain. Proper, improved and novel tools that enable food industry to develop and implement effective allergen management strategies are urgently required. In parallel, efficient training strategies for food manufacturing and catering companies have to be developed. Last, but not least, adequate support for the consumer with food allergy needs to be developed. It is necessary to understand consumer attitudes to allergens in foods and to appreciate who is avoiding which foods and why. This decision depends on each individual's potential severity of symptoms, their age, their understanding and social circumstances. For effective and personalized food allergen avoidance, providing essential information is a key element, as well as adequate training of the patients to understand the labels on pre-packed and allergen information of non-pre-packed foods as well as communicating with food suppliers for further information.

Methods

Clarifying the scope and purpose of this document

The process began in January 2012 with a meeting to discuss the overall approach to guideline development. This included detailed discussions on the main aims of the guidelines, the target conditions, agreeing the intended end-user for the recommendations, agreeing the intended end-user group and ensuring adequate professional and lay representation in the guidelines development process.

Box 1: Key terms

Allergen	Any substance to which IgE may react causing triggering of effector cells via FcERI-cross-linking; usually a protein. For allergen management, this term usually refers to the food
Clinical threshold doses	The lowest dose of an allergenic food to elicit an objective allergic reaction in an individual during a food challenge test
Cofactors	Patient-related circumstances that may cause allergic reactions to be more severe. They are known also as augmentation factors
Cross-contact/Cross-contamination	Unintentional transfer of an allergenic food/ingredient into another food even despite existing GMP. Applies for both, pre-packed and whole foods
Food	Any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of 'food' but does not include cosmetics or tobacco or substances used only as drugs (Codex Alimentarius)
Food label	Any tag, brand, mark, pictorial or other descriptive matter, written, printed or stencilled on the packaging or container of food (46)
Reference dose	The amount of the allergenic food (mg protein) below which adverse reactions are unlikely
Risk assessment	A scientifically based process consisting of four steps: hazard identification, hazard characterization, exposure assessment and risk characterization (46)
Risk communication	The interactive exchange of information and opinions throughout the risk analysis process with regard to hazards and risks, related factors and perceptions among risk assessors, managers, consumers, the academic community and other interested parties (46)
Risk management for food safety	A network of inter-related elements ensuring that food does not cause adverse human health effects. These elements include programmes, plans, policies, processes, methods, controls, responsibilities, documents, records and resources (15)

Ensuring appropriate stakeholder involvement

Participants represented different disciplinary and clinical backgrounds, including medical tertiary, secondary and primary care (Aziz Sheikh) and patient groups (Sabine Schnadt (Germany), Hazel Gowland (UK)).

Formulating recommendations

This document aims to provide an overview of recent evidence-based recommendations for allergen risk assessment and management in the food industry and discusses unmet needs and expectations of the food allergic consumer in that context. Key issues are summarized with regard to food allergens and the food allergic consumer, including the perceived excessive use of precautionary labelling (5), the lack of common standards for risk assessment, current shortfalls in analytical methodology and the communication between consumers at risk, food manufacturers and regulators to establish a common understanding of allergy risk. To build on the current status quo and improve experiences and outcomes for patients and carers, there is a need to agree common standards and develop clear risk-based use of precautionary labelling, which provide a valid and reliable communication of risk, and support the issuing of clear allergen management advice for use in the food manufacturing area. The target audience for this review comprises patients' organizations, regulators, allergists and healthcare professionals as well as food manufacturers, retailers and caterers. The following recommendations are the result of expert opinion consensus following previous systematic reviews of literature on epidemiology, diagnosis and management of food allergy and anaphylaxis (6–9) and an extensive narrative review of the relevant literature. They result also from consultations with all stakeholders involved in management of food allergy and anaphylaxis including primary care physicians and patient organizations. The most important goals are summarized in Box 2.

Editorial independence and managing conflict of interests

The production of this document was funded and supported by EAACI. The funders did not have any influence on the production process, its contents or on the decision to publish. All authors' conflicts of interest statements were taken into account as recommendations were formulated.

Box 2: Major goals

- To identify best practice for allergen risk assessment in food manufacturing and catering.
- To examine the evidence base that underpins allergen management plans and risk communication strategies, including application of precautionary labelling.
- To examine education/training strategies for food manufacturing and catering companies.
- To identify relevant analytical tools and enforcement practices of regulatory authorities.
- To identify best education and training strategies for food allergic consumers to assess the information presented on food labels relevant for their allergic condition to enable them to make informed food choices.

Updating the guideline

We plan to update this document in 2017 unless there are important advances before then.

Risk assessment: towards evidence-based reference doses

Within the last two decades, great efforts have been undertaken in assessing the risk arising from allergenic ingredients in food products for consumers with food allergy. Due to the fact that the range of reactivity to allergens is very wide (up to six orders of magnitude, calculated from controlled food challenge studies (10)), it is evident that the development of an evidence-based risk assessment for food allergens is a challenging task. The overall uncertainty of the risk due to even very small residual amounts of allergen and the consequent effect for a consumer who is highly sensitive with or without cofactors have led to the introduction of precautionary labelling (11).

Recently, the Australian Voluntary Incidental Trace Allergen Labelling (VITAL) initiative and the ILSI Europe Food Allergy Task Force reviewed data sets from previous food challenges with regard to low-dose reactors in different allergenic foods and performed a probabilistic risk assessment approach (11–13). The eliciting dose for inducing an allergic reaction in 1% of the specific allergic population (ED01) was estimated for peanut as 0.2 mg protein, that is 1% of the peanut allergic individuals would still react to a dose of 0.2 mg peanut protein (Table 1). Other ED01 levels were found for cow's milk, hen's egg and hazelnut (11). ED05 values have been identified for wheat, mustard, lupin, cashew, sesame seed, shrimp and fish (12, 13). So far, doses for celery and tree nuts other than hazelnut and cashew are lacking (13). Depending on the allergenic food, doses ranged from 0.03 mg (egg) to 10 mg (shrimp), but some uncertainty remains, and clinical validation of reference doses will be required although these data provide a foundation from which such validation studies can be undertaken. They also provide the means of developing an evidence-based approach for redesigning efficient risk assessment applicable to food production.

The VITAL approach is designed for situations where the unintended allergen is distributed evenly (homogenously) in the product. In cases where allergens are present in a particulate form (e.g. nut pieces, sesame seeds) and not evenly distributed, this approach is not applicable (14). For these cases, the use of precautionary labelling is the only current option when the risk is unacceptable.

Allergen management: part of existing food safety management

The need to set standards and procedures for allergen management and to incorporate them into existing overall food safety assurance strategies in compliance with good

Table 1 Reference doses for allergenic foods (modified from (13). Reprinted from *Food and Chemical Toxicology*, Vol. 63, Taylor et al., 'Establishment of Reference Doses for residues of allergenic foods: Report of the VITAL Expert Panel', Pages 9–17, Copyright 2014, with permission from Elsevier; modified from (11). Reprinted from *Journal of Allergy and Clinical Immunology*, Vol. 133, Allen et al., 'Allergen reference doses for precautionary labeling (VITAL 2.0): Clinical implications', Pages 156–164, Copyright 2014, with permission from Elsevier; modified from (47), 'Food Production and Processing Considerations of Allergenic Food Ingredients: A Review', by Alvarez et al. 2012, licensed under CC–BY 3.0), the respective serving size and the detection limit of cross-contamination as assessed by ELISA

Food	Reference dose (mg protein)	Required sensitivity (mg/kg, ppm) of a method to detect a protein reference dose in a defined amount of a serving size, for example 50 gram
Peanut*	0.2	4
Cow's milk*	0.1	2
Egg*	0.03	0,6
Hazelnut*	0.1	2
Soy†	1.0	20
Wheat†	1.0	20
Cashew	2.0	40
Mustard†	0.05	1
Lupin†	4.0	80
Sesame seed†	0.2	4
Shrimp†	10.0	200
Fish†,‡	0.1	2

*Eliciting doses for 1% of food allergic population (ED01).
†Eliciting doses for 5% of food allergic population (ED05).
‡Provisional data.

manufacturing practices (GMP) is well recognized by the food industry and includes a management plan to identify, prevent and control food safety hazards (HACCP – hazard analysis critical control point).

Recently, FoodDrinkEurope published a guidance document (15) for food producers, to harmonize and disseminate robust and evidence-based information on good practice in risk management of allergenic foods. This guidance document drew on various national guidance documents, as well as research results from the European Commission funded research project EuroPrevall, recommendations from the MoniQA EU Network of Excellence and from ILSI International Life Sciences Institute Europe. Key elements of allergen risk management include: correct training of the personnel involved in the production procedures; complete information on raw materials; adequate production facilities; state-of-the-art manufacturing; and provision of accurate and reliable/trustworthy information for the consumer at risk, product development and parallel updates of relevant information and continuous documentation (15). Correct cleaning procedures for the processing plant to avoid cross-contamination are particularly critical.

Labelling

Food allergen labelling: Issues relating to the deliberate use of allergenic ingredients

Within the current EU legislation (European Directive 2007/68/EC) (16) amending Directive 2000/13/EC (17), the labelling of 13 allergenic foods (or food groups) and derived products thereof, as specified in annex IIIa of Directive 2007/68/EC, is mandatory when used as ingredients for pre-packed foods, regardless of the concentration of the potentially allergenic ingredient. The 13 allergenic foods (or food groups) include the most important foods (Table 2) that cause IgE-mediated and non-IgE-mediated allergies, coeliac disease and nonallergic food hypersensitivities. Sulphur dioxide and sulphites also listed in this Directive cause intolerances and are therefore not further discussed in this review.

Certain products derived from the foods on the list may be exempted from the labelling requirement if they can be assessed and found to be nonallergenic. For example, wheat-based glucose syrups including dextrose or maltose do not require labelling. Other exceptions are fish gelatin used as a carrier for vitamins or carotenoids, fully refined soya bean oil, and alcoholic distillates derived from nuts.

Regulation 1169/2011 (18) on the provision of food information (FIR) to consumers that will be effective from 13 December 2014 will replace the existing labelling directive, including its provisions for allergens. The FIR provides detailed information on how to present allergen information and clearly states the nature of the allergy-inducing substance or product on the respective labels and extends allergen labelling to non-pre-packed foods. A systematic re-examination and potential update of the allergen list by the EU Commission is also foreseen (18). As this EU legislation is enforced by the national legislation of its member states (18), differences across countries regarding the type of labelling are likely, and strategies to harmonize these activities are needed as examples have shown in the past. For non-pre-packed food products that lack an ingredient list, provision of allergen information is also required at the point of sale after the end of the regulatory transition period in December 2014. Also, the information on allergenic ingredients is mandatory. However, the means through which information about the presence of these allergenic compounds is to be made available to consumers has been derogated to the EU member states. Issues remain regarding the inadvertent presence of so-called 'cross-contact' allergens which are not covered by Directive 1169/2011 and may therefore result in the ongoing application and both over-use and the lack of precautionary labelling statements, such as 'may contain', or 'trace amounts of'.

Similar activities on allergen labelling legislation have been performed in other parts of the world and are summarized in Table 1. The EU list is currently the most comprehensive one and was followed by other countries such as Switzerland, Argentina and Ukraine (19). In other countries, such as the United States, Canada, Australia and New Zealand,

Table 2 Labelling of allergenic foods according to regulatory frameworks

	Wheat/ Cereals*	Eggs	Milk	Peanut	Fish	Crustaceans	Soy	Tree Nuts	Sesame	Shellfish/ Molluscs	Mustard	Celery	Lupine	Other
Codex†	X	X	X	X	X	X	X	X						
European Union‡	X	X	X	X	X	X	X	X§	X	X	X	X	X	
Australia/ New Zealand	X	X	X	X	X	X	X	X	X	X				
Canada	X	X	X	X	X	X	X	X¶	X	X	X			
China	X	X	X	X	X	X	X	X						
Hong Kong	X	X	X	X	X	X	X	X						
Japan	X**	X	X	X		X††								X‡‡
Korea	X**	X	X	X	X§§	X	X							X¶¶
Mexico	X	X	X	X	X	X	X	X						
United States	X	X	X	X	X	X	X	X						

*Cereals containing gluten.

†The following countries use CODEX regulations: Barbados, Chile, Papua New Guinea, Philippines, St. Vincent and The Grenadines.

‡Argentina, Switzerland and Ukraine use The European legislation.

§European Union listed the following tree nuts: almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, pecans, pistachio nuts and walnuts.

¶Canada listed the following tree nuts: almonds, Brazil nuts, cashews, hazelnuts, macadamia nuts, pecans, pine nuts, pistachio nuts and walnuts.

**Wheat and Buckwheat.

††Shrimp and crab listed under Crustaceans.

‡‡Foods recommended for labelling: abalone, squid, salmon roe, salmon, mackerel, chicken, beef, pork, gelatin, matsutake mushroom, walnut, orange, kiwifruit, soya bean, banana, peach, apple, kiwifruit, yam.

§§Mackerel as the only fish listed.

¶¶'Other' includes: pork, peach, tomato.

Table modified from (19). Reprinted from *Regulatory Toxicology and Pharmacology*, Vol. 63, Gendel, 'Comparison of international food allergen labeling regulations', Pages 279–285, Copyright 2012, with permission from Elsevier.

mandatory allergen labelling is required according to a reduced allergen list. In contrast, Japan only requires mandatory labelling for wheat, buckwheat, egg, milk, peanut and crustaceans. However, an additional 19 foods are listed for 'recommended labelling'.

The allergenic foods cited in almost all labelling regulations are milk, egg, gluten-containing cereals, crustaceans, peanuts and tree nuts. Others, such as mustard, celery, mollusc, lupin and buckwheat, seem to be restricted to certain geographic areas, possibly reflecting the different dietary habits and thus risk of exposure.

Precautionary labelling: impact on food avoidance strategies of consumers at risk

In cases of unintended presence of allergens, voluntary allergen labelling information is applied by the food manufacturer to inform and protect the allergic consumer and is guided by Article 36, which also provides a regulatory basis for a more consistent implementation framework. However, precautionary allergen labelling indicating the unintentional presence of allergens should only be used when there is a significant probability of allergen cross-contamination representing an unacceptable risk to the allergic consumer. Detailed guidance on quantitative risk assessment remains to be developed and needs to be underpinned by a transparent evidence base. A recent study from Crotty and Taylor (20) analysed precautionary labelling for milk in 100 food products. Forty per cent of products labelled with 'may contain milk ingredients' had detectable milk residues, with a wide range of concentrations (3.4–15000 ppm, (20)). In products with labels indicating 'shared equipment' or 'shared facility', the frequency of detected milk ingredients was lower. Finally, 40% of products listing milk as a minor ingredient did not have any detectable milk. Comparing different food matrices, dark chocolate was identified as a high-risk product for milk allergic consumers. Another study from Ford et al. (21) compared food products with precautionary labelling for three allergen sources, peanut, milk and egg. Detectable amounts of allergenic foods were identified in 5.3% of products with precautionary labels and in 1.9% of products without precautionary labelling. Therefore, the authors conclude that the avoidance of products with advisory statements should be recommended for the consumer at risk, even if the detectable amounts of culprit allergen source may be rather low (21). A recent Irish study on peanut-containing foods with advisory labels detected low levels of peanut in only two of 38 products (22). Based on their data, the authors discussed whether there is a sufficient risk warranting the use of advisory labelling. However, they also concluded that for the sake of patients with peanut allergy and their avoidance strategies, advisory nut statements should still be recommended. Recent studies have highlighted the fact that due to the excessive use of precaution-

ary labelling, the perception, opinions and behaviour of food allergic patients have changed (23–27). In general, they are rather complacent about this type of labelling (27). However, they also assume that different statements reflect different levels of risk with statements such as 'shared facility' implying a lower risk than 'may contain', for example (27).

Tools for effective allergen risk management

Allergen risk assessment is an integral part of allergen risk management and estimates the impact of a health hazard as a function of dose and exposure (Fig. 1. (14)). As a consequence, the definition of an acceptable *vs* unacceptable risk needs to be defined and agreed upon. Therefore, an effective allergen risk management strategy relies on the information of threshold levels for clinical reactivity. While threshold levels for toxic substances are generally available, threshold levels for allergens have until recently remained elusive (28). It is known that allergic individuals can respond to a very wide range of doses and generally accepted levels are not yet in place. Despite the individual differences in threshold doses, Crevel et al. have suggested to identify an 'eliciting dose' for a specified fraction of the allergic population, for instance 5 or 10% (ED05 or ED10; (11–13, 29)) as the amount of an allergen, known to produce a reaction, yet not severe, in defined proportion of the allergic population. This parameter could be used for the concept of 'protection of the vast majority' and representing the basis for food safety objectives. It also acknowledges the fact that complete protection of the allergic population and absolute safety ('zero risk') is not possible (30). While for 11 allergenic food sources convincing data on threshold levels have been generated, other allergenic food sources lack these data (see also section above; (13)). Within EuroPrevall, great efforts were undertaken to develop harmonized challenge protocols, apply standardized challenge meals to assess threshold levels for the most important food allergen sources in a multicentre study, and forthcoming results are expected to provide necessary information on threshold doses for both the food industry and regulators (31, 32). It should be recognized, however, that threshold levels are determined under optimal experimental conditions and little is known about changes in individuals' threshold due to cofactors such as comorbidity including infectious diseases, drug intake (nonsteroidal anti-inflammatory drugs (NSAIDs) are known to increase intestinal permeability, and antacids to interfere with the physiological breakdown of food proteins), other foods including alcohol, stress and exercise. Furthermore, the influence of processing on allergenicity should be assessed in clinical food challenge studies. Only limited data from such studies in humans are currently available (33).

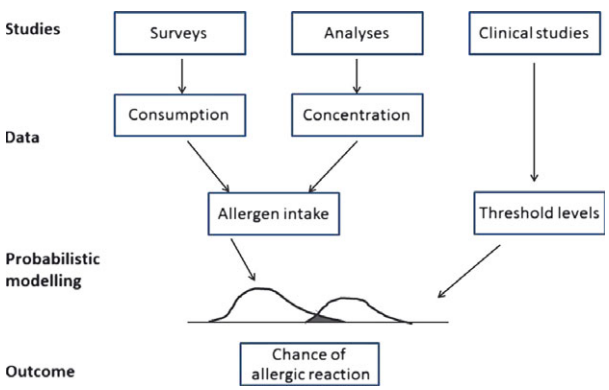

Figure 1 Food allergen risk management: a probabilistic approach according to (48). Reprinted from *Food and Chemical Toxicology*, Vol. 45, Spanjersberg et al., 'Risk assessment and food allergy: the probabilistic model applied to allergens', Copyright 2007, with permission from Elsevier.

An integral part of implementation of allergen risk management in food manufacturing and retailing is the ability to validate and then verify, for example, that cleaning practices are effective and that finished food products comply with the quality criteria laid out in allergen management plans. This applies with even more force when a claim, as in 'free-from' foods, is made. Thus, a suite of analytical methods are required that span rapid and easy-to-use qualitative and semi-quantitative methods that can be applied in a food manufacturing environment, complimented by rigorous quantitative methods. In general, it is preferable to employ analytical methods that target the hazard; hence, methods able to determine the presence of allergenic proteins *per se* should be used in preference to others. However, the majority of current methods do not target allergens but are, instead, based on the detection of indicator proteins, peptides or nucleic acids. Clearly, the detection of peptides or proteins is more closely related to the presence of allergenic proteins, although various studies have demonstrated the successful application of nucleic-acid-based methods, such as PCR (polymerase chain reaction), which correlates well with protein-based methods for certain analytical targets such as tree nuts (34). However, these methods are not suitable for foods such as milk or egg or where their ingredients are heavily processed and the content of nucleic acids is low.

The detection of specific proteins and even allergens by specific antibodies using ELISA techniques is most frequently applied (35–37). These highly sensitive methods are widely used and detect cross-contaminants in foods at or below the ppm (mg allergen per kg food) level (Table 1).

Recently, mass spectrometry (MS) approaches have been developed to detect peptide and proteins even in complex food matrices with high sensitivity (38, 39). In the case of hazelnut detection, recent work has demonstrated comparable results obtained using ELISA, PCR and MS (40). Further development of such orthogonal methodology is needed before a routine application is possible. Currently, many analytical methods do not determine absolute amounts of allergens but report the concentration of an allergenic protein or food, for example peanut, in a reference size such as a serving size, for example 50 gram, of the composed food, for example chocolate. It will be crucial that analytical methods can detect allergens quantitatively below any finally agreed reference dose and take into account the serving size.

Detection and quantification of allergens in foods should take into account the effects of food processing and the food matrix, which have unpredictable effects and make interpretation of analytical results difficult. Allergenic food proteins interact with other food components and usually undergo conformation and chemical modifications due to food processing treatments, which in turn affect their extractability and detection of allergens in foods. Data on potential changes in allergenicity are thus relevant both for refined allergen risk assessment in food production and allergen detection methodology.

These issues are further confounded by the lack of agreed reference doses for allergens in foods, making it impossible to set effective parameters for optimal analytical performance, such as limit of quantification. Furthermore, the lack of reference materials – in particular for naturally present materials – for allergen detection has meant that there is a lack of consensus regarding reporting units for allergens and also that it is not currently possible to undertake the necessary interlaboratory trials to select the best-practice methodology. The development of such reference materials will also need to ensure that the allergenic molecules are present in a relevant form. As proof of concept, a recent multilaboratory trial used a dessert matrix already validated for clinical use, which was tested as a quality control material for allergen analysis, to compare a range of commercially available immunoassays for egg and milk content (41).

Communication and training

Consumers purchase products on the basis of trust, experience and recommendation, expecting that they are for safe use, unless specific information is given on the labels (42). The food industry is increasingly recognizing its role in implementing preventive measures to protect the allergic consumer from having reactions though accidental consumption of their problem food. However, it is also evident that key knowledge and skills are essential to support them in undertaking effective food avoidance. In this context, the indiscriminate use of precautionary labelling has led to loss of confidence from the allergic consumer in this risk communication tool (10). In addition, its absence from the label does not automatically imply that the given food is safe, as precautionary allergen labelling is on voluntary basis. Therefore, appropriate communication strategies are needed (43), for example communicating that reference doses – if available – are associated with a certain risk of reaction and provide guidance according to standards. This in turn requires adequate training of the allergic patients to obtain the relevant information on the food product and from the food suppliers. Therefore, the key element is the close cooperation and effective communication between patient organizations, food industry representatives and regulators. Moreover, adequate training of individuals who have contact with customers – from helplines, to those in the retailing and catering sectors is of great importance. This also extends to those involved in caring for individuals with food allergies in the extended community including personnel in day care centres, nurseries and teachers. This is needed to increase awareness about food allergies and thus reduce the risk of accidental exposure of food allergens as well as prompt action in the event of such exposure (see also EAACI Food Allergy Guidelines (44).

Gaps in the evidence

There is an urgent need for agreement on threshold levels for individual food allergen sources based on double-blind placebo-controlled food challenge (DBPCFC) studies, as well as generation of further challenge data for allergens for which currently available data are insufficient (Box 3). In this context, the VITAL 2.0 system developed in Australia has generated much interest. For allergen detection assays, standardized and certified reference materials are still lacking. Novel analytical methods and their applicability in reliable allergen detection in various food matrices should be investigated. Novel insights into food matrices, food processing and their impact on the allergenicity of foods should also be incorporated into allergen risk management once a sound knowledge base has been developed. Although important, limited data are available on the impact of food avoidance on the quality of life and the related costs to allergic consumers (26, 42, 45).

Summary and recommendations

It is now well recognized that protecting the allergic consumer from unintended exposure to allergenic food is a shared responsibility, in which each stakeholder must play his or her part. EU Legislation on allergen labelling is in place and is implemented and enforced through the respective national laws. As a result, differences in the layout, terminology used, and practices arise. To harmonize labelling issues, industry has started efforts to disseminate best practice guidance among food producers. Labelling of nonpackaged (or indeed pre-packed) foods is not yet available in all countries, although the relevant legislation will apply in the near future. In general, precautionary labelling should be avoided whenever possible, as every additional 'may contain' warning diminishes the impact of those already used, thereby increasing unnecessary risk taking and hence exposure. As a matter of principle, it should not be applied without a thorough risk

Box 3: Gaps in the evidence

- Need for harmonization in labelling activities with regard to layout and terminology.
- Need for generally agreed reference doses for most important food allergen sources.
- Need for certified reference materials and standardized detection assays.
- Definition of acceptable risk level in food allergy.
- Best practices to train and support the food allergic consumer and to select optimal communication for both consumer at risk and third party.

management plan based on a transparent evidence base. Adequate training of the personnel working in the food manufacture, catering, nurseries and schools is critical. Lastly, access to relevant information on food allergy is an essential resource to improve the quality of life of the allergic consumer.

The food industry has started to integrate allergen management in existing food safety management procedures. However, there is an urgent need for certified reference materials. It is of concern that agreement around management threshold levels for key food allergen sources is still lacking. Implementation of such thresholds could ensure a high degree of protection while avoiding excessive food choice restriction for allergic consumers. Close cooperation is needed between regulators, food industry representatives and consumer organizations to define tolerable risk levels in food allergy.

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Conflicts of interest

Antonella Muraro has provided scientific advice for Meda. Karin Hoffmann-Sommergruber has received honoraria from Thermo Fisher and Milupa. Thomas Holzhauser had consultant arrangements with Institut für Produkt Qualität, Berlin, and scientific consultant arrangements with Monsanto Company. Lars Poulsen has provided scientific advice to Nvozymes and has received funding for research from ALK-Abelló, Anergis, Biomay, Stallergenes. Hazel Gowland is a researcher on Food Standards Agency funded projects and unpaid adviser to other FSA funded studies. Graham Roberts has provided scientific advice for Danone and ALK-Abelló; Thermo Fisher and ALK-Abelló have provided consumables for his research activities. Sabine Schnadt has support for travel to EAACI congress from Peanut Council and Novartis. Ronald van Ree has provided scientific advice for HAL Allergy, Stallergenes, BIAL, Ventria Bioscience, Pharming; he has provided contract research services to HAL Allergy, Stallergenes and Ventria Bioscience and has received consumables from Thermo Fischer. Aziz Sheikh has received funding for coordinating guidelines production and generating the systematic reviews from EAACI. He has provided scientific advice to ALK-Abelló, Meda, Lincoln Medical, Thermo Fisher, Pfizer and Stallergenes; he is on the Anaphylaxis Campaign UK's Scientific Committee, World Allergy Organization's Anaphylaxis Special Committee, UK Resuscitation Council's Anaphylaxis Committee and the BSACI's Standard of Care Committee. Cezmi A. Akdis has received research grants from Allergopharma, Stallergenes, Actellion and Novartis. Besides, Cezmi A. Akdis was President (2011–2013), Past President (2013–2015) and ExCom member in EAACI, who has received financial support from several relevant business entities. Clare Mills has received funding from the European Food Safety Authority, sits on the UK Food Standards' Agency's Advisory Committee and is a cofounder of the start-up company Reacta Biotech Ltd. Nikos Papadopoulos is currently EAACI President (2013–2015) and has provided consulting for several relevant business entities. Stefan Vieths has no conflict of interest in relation to this document.

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