Food Allergen Precautionary Labelling: A Risk-Based Approach

Overview for Food Business Operators

ILSI EUROPE

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COMMISSIONNED BY ILSI EUROPE FOOD ALLERGY TASK FORCE

November 2024

This document is intended to introduce and summarise the published report: "**Practical guidance on the Application of Food Allergen Quantitative Risk Assessment within Food Operations**" by B. C. Remington, J. Baumert, W. M. Blom, L. Bucchini, N. Buck, R. Crevel, F. de Mooj, S. Flanagan, D. A. Stavropoulou, M. W. van den Dungen, M. van Ravenhorst, S. Wang and M. Walker, available at: https://ilsi.eu/publication/practical-guidance-on-the-application-of-food-allergen-quantitative-risk-assessment-qra/

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Summary

Precautionary allergen labelling (PAL), such as statements that a food 'may contain' an allergen, are used to alert consumers who are sensitive to this risk. However, currently, these statements often do not reflect the real risk that would be experienced by an allergic consumer if they ate the food in question. There are two reasons for this:

1. Precautionary allergen labelling is often used based on a theoretical assumption that an allergen that is not an intended ingredient could physically contaminate a food, rather than through proper consideration of whether (and to what extent) this can and does ever happen.
2. Even if it has been deemed that allergen contamination of a given food could occur (and PAL has consequently been applied), it may be that the concentration of the unintended allergen in that food would be so low that the amount consumed would not present an appreciable health risk to the food allergic population if they ate the food.

The process of understanding the health risk posed by unintentional allergen presence (UAP), is known as 'Quantitative Risk Assessment' (QRA). Quantitative risk assessment essentially involves comparison of the amount of UAP that a consumer may be exposed to, with a pre-established allergen Reference Dose (RfD). Allergen RfDs for major food allergens have been established by various scientific organisations and authoritative bodies. Implementation of food allergen QRA within a food business necessitates knowledge of situations that could result in UAP and quantification of the subsequent allergen exposure that may result.

Food allergen QRA is a methodology that can be used in addition to established practices as a part of decision-making on whether PAL should be applied to a finished food. When used as such, this decision-making should follow a consistent set of principles. A Food allergen QRA tools are available[1] to be used by food business operators (FBOs) on top of existing methods of allergen risk assessment, to better inform decisions about allergen management.

This short document is intended to provide an overview of food allergen QRA and how it can help decision making by FBOs, especially regarding PAL. It will also serve to raise awareness and uptake of QRA as an approach to food allergen risk assessment. Subsequent documents will provide information on how food allergen QRA can be applied effectively by FBOs located at specific points along the supply chain.

[1] For example: 'Practical Guidance on the Application of Food Allergen Quantitative Risk Assessment (QRA)', published by ILSI Europe, accessible at https://ilsi.eu/publication/practical-guidance-on-the-application-of-food-allergen-quantitative-risk-assessment-qra/

1. Introduction

It is well recognized that food allergy is a significant public health issue that can lead to severe or even fatal reactions to allergenic foods in a sensitive individual. Since the mid 1990s, when an FAO Technical Consultation identified 8 major foods or food groups as responsible for the majority of allergic reactions to food (FAO, 1995), a series of initiatives and consultations by public health and regulatory authorities has led to the introduction of legislation and guidance on food allergens in many countries, aimed primarily at food business operators (FBOs). Requirements vary by country/region but generally specify a priority list of allergenic foods that must be declared on the finished product label when used as an ingredient. The criteria for placing allergens on these lists also varies but always involves a risk assessment. This generally gives particular consideration to: the *prevalence* of allergic reactions to the allergenic food in the community; the *severity* of such reactions (i.e. the proportion of severe objective reactions), and the *potency* of the allergenic food/ingredient (i.e. the amount required to cause objective symptoms in a sensitive individual) (FAO/WHO, 2022a). At a global level, an FAO/WHO Expert Consultation recently reviewed the current Codex priority list and concluded on a list of eight priority allergenic foods or food groups (FAO/WHO, 2022a)[2], noting that several other food allergens may additionally be considered for inclusion in some individual countries.

For a recent, comprehensive, review of food allergy, see Bartha et al., 2024

Most legislative provisions do not specifically cover the issue of unintentional allergen presence (UAP) in manufactured foods or stipulate the conditions of use of precautionary allergen labelling (PAL) that is commonly used to communicate the risk of UAP to the consumer via the product label[3]. At the time of writing, this situation was beginning to change, partly as a result of the work of the Codex Alimentarius Commission, WHO and FAO, who have recently produced guidance on allergen management and the application of PAL (Codex, 2020; FAO/WHO, 2022b). Unintentional allergen presence may arise because of cross-contact between allergen-containing raw materials, foods or ingredients during production or at any point along the supply chain, starting with commingling during harvest and transport. It can also occur as a result of so-called 'incidents' such as where a

[2] Cereals containing gluten (e.g. wheat and other *Triticum* species, rye and other *Secale* species, barley and other *Hordeum* species and their hybridized strains), crustacea, eggs, fish, milk, peanuts, sesame and specific tree nuts (almond, cashew, hazelnut, pecan, pistachio and walnut).

[3] At the time of publication there were 3 exceptions to this statement: 1) the Netherlands is currently introducing legislative provisions covering UAP in pre-packaged foods; 2) In Switzerland, PAL is not permitted and any priority list allergen that could potentially be present at >1,000 mg/kg due to cross contact is required to be labelled; 3) in Japan, PAL is also not permitted, instead if cross-contamination cannot be eliminated then a specific advisory label is recommended. This list should not be taken as definitive. For current provisions applying in individual countries, FBOs are advised to contact the regulatory authority for the jurisdiction in which the food will be sold.

change in the formulation of a food or ingredient has not been matched by an appropriate change on the product label, or where the wrong ingredient or packaging has been used. Given that minimum eliciting doses of an allergen observed to provoke a food allergic reaction can span five to six orders of magnitude (FAO/WHO, 2022b), it is very important that FBOs have robust allergen management systems in place. These need to minimize the risks of UAP and set out appropriate measures to quantify and communicate those risks that cannot be adequately controlled.

Understanding and managing the risks presented by UAP in foods is not straightforward and is a major current challenge for FBOs. Guidance to support FBOs has been emerging over the last decade (for example, from FoodDrinkEurope, 2024, FoodDrinkEurope, 2023 and from ILSI Europe, 2022) and continues to be refined and further developed. Quantitative risk assessment forms a key part of the tools available to FBOs to improve their food allergen management systems, for the benefit of all stakeholders including food allergic consumers.

2. What is food allergen QRA?

The long-established approach to food allergen risk assessment is the binary (qualitative) method, whereby FBOs determine whether or not an allergen is potentially present in a food. This approach provides a simple 'yes' or 'no' answer. It can still be adequate in situations where the available evidence makes clear that there is a clear risk to the allergic consumer, or sufficient data are not available to adequately perform an exposure assessment which is a necessary part of performing QRA. However, in situations where the risk to consumers is unclear, a binary approach to allergen risk assessment may result in a high degree of in-built conservatism or equally of uncertainty. Either of these can lead to the inappropriate, or inconsistent, use of PAL. This can be confusing to consumers and has led to mistrust in food labelling. In contrast, QRA uses verifiable data to inform the four key steps of risk assessment (hazard identification, dose-response assessment, exposure assessment and risk characterization). It thus generates a more accurate, quantitative, prediction about the nature and true likelihood of UAP occurring in a given finished food in a given UAP scenario. It also provides an estimate of the likely level of consumer exposure, and an understanding of whether that exposure is above or below a pre-established limit of acceptability (RfD). Use of food allergen QRA can therefore lead to more confidence about the need for PAL and other risk management actions.

3. Motivations for applying food allergen QRA

The motivations for applying food allergen QRA are several. As already stated, implementing QRA can lead to a more accurate assessment of risk and to more evidence-based risk management decisions. Ultimately, this results in more effective and consistent use of precautionary allergen labelling (PAL) on finished foods. Implementing a QRA approach can therefore contribute directly to ensuring food safety, a bedrock requirement of food legislation worldwide. In addition, it requires the sourcing of information (including data) regarding known or potential food allergen risks across the entire supply chain, from raw materials through ingredients to finished product. Hence, it can contribute to improving supply chain management and ingredient (including carry-over[4] ingredient) traceability within the supply chain.

External motivators for implementing QRA include a growing expectation among food safety regulators for FBOs to have robust allergen management programs in place that include allergen risk assessment procedures. This is being fuelled by recent developments in national and international legislation and guidance. The major developments in this area over the last three decades are captured in Figure 1. In particular, a new Chapter (Chapter 11) has been included in the 2024 US FDA draft guidance update that recommends FBOs establish and implement a food allergen program. The program must ensure that finished food is protected from cross-contact from priority food allergens and is properly labelled with respect to the priority food allergens. How this can be achieved is also detailed (FDA, 2024). Separate to this, there is a need for harmonization across FBOs in how food allergen risk assessment is performed and used, in order to drive consistency across food products and food product labelling. Implementation of food allergen QRA can help achieve this.

[4]Allergen carry-over refers to the unintentional transfer of residues of an allergenic food or ingredient into another food or ingredient which may not be designed or labelled for that allergen, for example where common equipment is used to make two different finished foods resulting in unintentional residue of the first food within the second food.

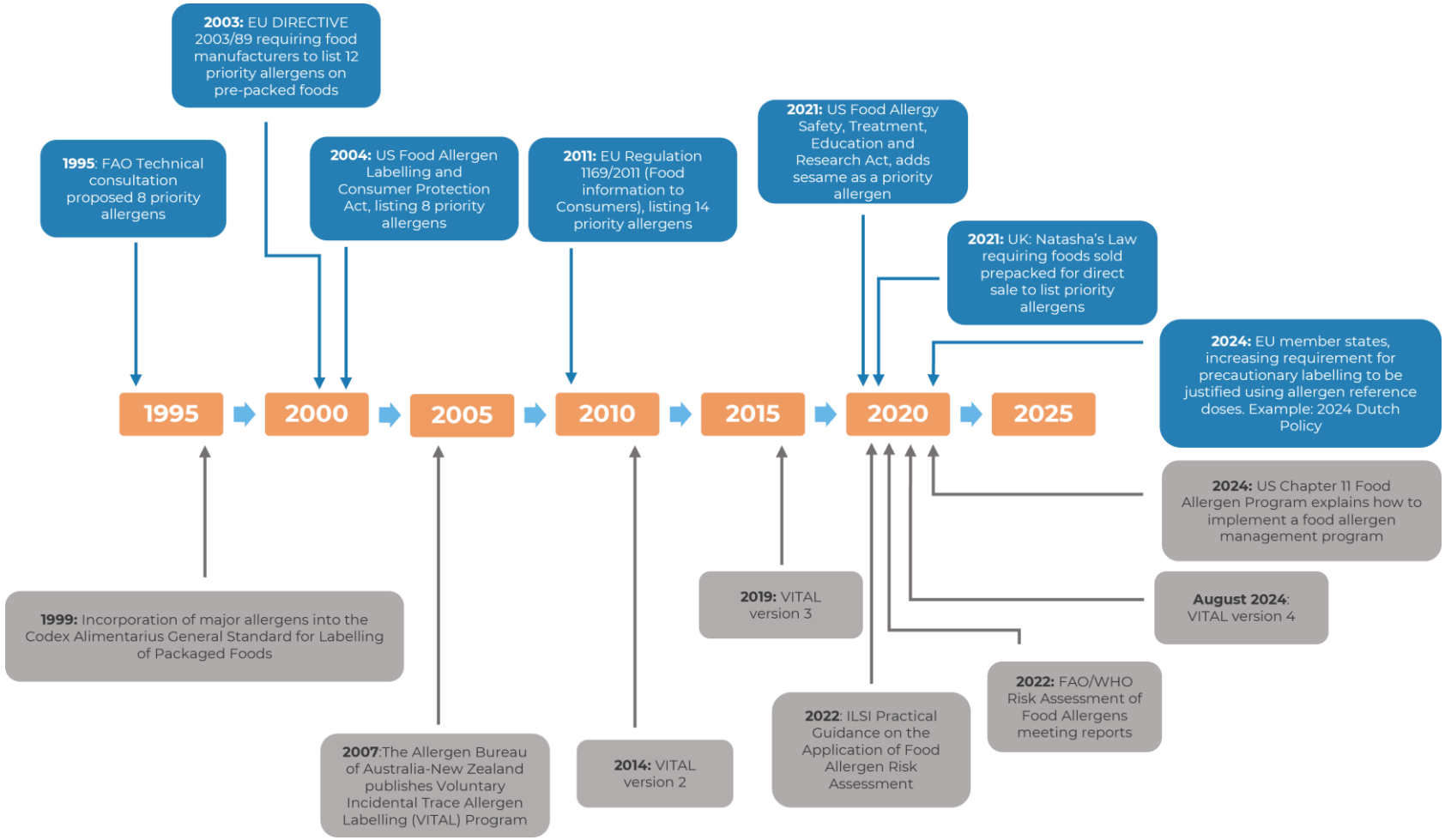

Figure 1. Timeline of major developments in global food allergen legislation (blue) and guidance (grey).

4. Where food allergen QRA sits within a food business operations

The place of food allergen QRA within the operations of a food business can be visualised as shown in Figure 2. At the heart of all regulatory controls are Good Manufacturing Practice (GMP), Hazard Analysis and Critical Control Point (HACCP), as well as the prerequisite programs (PRPs) that support these. Good manufacturing Practice describes the general methods, equipment, facilities and controls for producing processed food, while HACCP describes the specific management system through which food safety is assured via the analysis and control of biological, chemical, and physical hazards right through from raw material production through to the finished product. Food Safety Management Systems (FSMS) detail the specific controls in place to assure food safety. Food allergen management systems (including food allergen QRA) should be seen as being layered on top of these fundamental control programs and linked to them. For example, adherence to existing GMP controls is essential to effective allergen management, by having appropriate and effective measures in place to segregate ingredients and finished foods (via the appropriate use of cleaning, equipment and utensils), and by having dedicated production lines and controls on storage. Similarly, food allergens as potential sources of risk should be listed under the chemical hazards part of any HACCP plan and a separate, dedicated, allergen management plan referred to for the management of the identified hazard(s). Other, voluntary, food safety programs that may be in place such as certification against a recognized Global Food Safety Initiative (GFSI) standard, may also mandate implementation of an allergen management plan. These should sit alongside and be linked to that plan which should include details of how, whether and when to conduct a QRA. Layered upon these controls should be the measures that individual food businesses apply based on their specific operations.

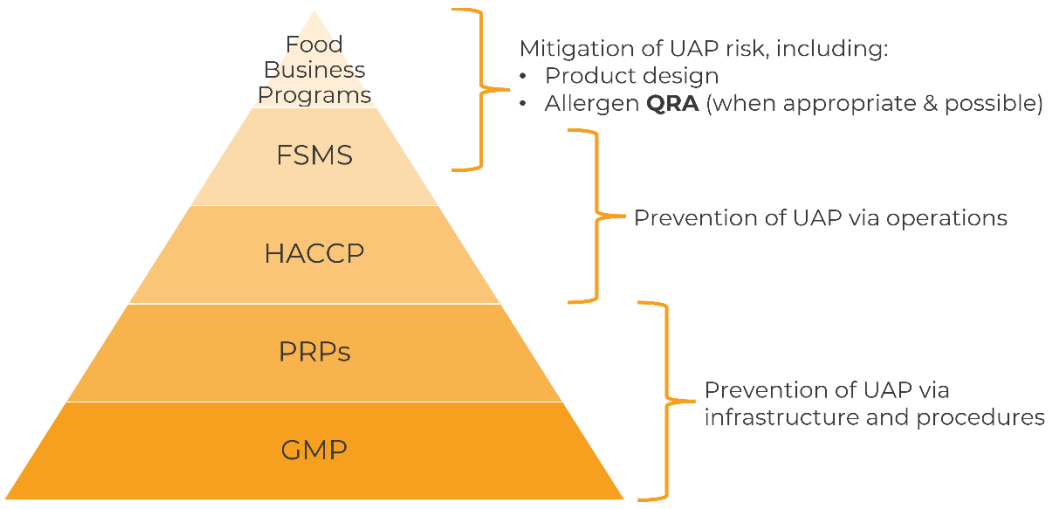

Figure 2. Visualisation of the place of allergen QRA within food business operations.

At the core of food allergen QRA is a better understanding of where in the supply chain the potential points of cross-contact are, whether these can be mitigated and, where they cannot, characterization of the UAP to understand and quantify the risk in meaningful terms. As QRA requires higher quality, more detailed, information on points of cross-contact than qualitative (binary) risk assessment, it should be seen as enabling a better understanding of potential cross-contacts that should be communicated with food as it moves along the supply chain.

5. The fundamental components of food allergen QRA and how these fit together

There are two main methodological approaches for undertaking a QRA in the context of food allergens: deterministic QRA and probabilistic QRA. A deterministic QRA involves comparing an exposure to an amount of protein from the allergenic food/ingredient with an appropriately protective (clinically predetermined) reference dose (RfD) for the allergen[5]. This comparison enables a decision about whether the calculated risk is considered to be acceptable or not (and informs risk management and communication actions). On the other hand, probabilistic QRA uses dose-distribution information (rather than a point estimate or RfD) together with probabilistic estimates of exposure (rather than a point estimate of exposure) to estimate risk. It is thus more powerful, produces more detailed information and reduces uncertainty in the QRA result, but is more computationally complex to perform and more data demanding. The decision about which methodology to use will depend on both the purpose of the QRA being undertaken (i.e. the risk assessment question being asked) and the availability of data and expertise to conduct the assessment. Deterministic QRA is the approach that is most commonly applied by FBOs.

A basic calculation for a deterministic QRA is shown via the equation below. Here, an estimate of exposure to the total protein from an allergenic source (among other sources) is compared to the pre-determined RfD for that allergen. In this comparison, if the result is less than 1 then the exposure does not exceed the Reference Dose and the risk may be considered as without appreciable health risk.

$$\frac{Exposure\ (mg\ allergenic\ source)}{Reference\ Dose\ (mg\ allergenic\ source)}$$

If, on the other hand, analytical results are available on the actual concentration of an unintended allergen that is present, these can be compared to the calculated concentration of the allergen in a food that is without appreciable health risk (the RfD)

[5] Published Reference Doses have been developed for many regulated allergens (FAO/WHO 2022b; The Allergen Bureau of Australia-New Zealand, 2024). The default approach is to apply RfDs derived by FAO/WHO 2022b. However, advice can be sought from any competent authority or a recognized food allergen expert.

taking account of the amount of food that is typically consumed in a single setting. The latter is known as the 'Action Level' for that food. The calculation for this comparison is shown via the equation below. If the result is less than 1 then the concentration of allergen within the food does not exceed the Action Level and the risk may be considered as without appreciable health risk. Allergen analytical results are invariably expressed as a concentration (mg/kg or ppm) but must be expressed as allergenic protein (e.g. peanut protein) for the calculation. If the results are expressed as the commodity (e.g. peanut) a conversion factor from mg peanut per kg food to mg peanut protein per kg food is needed. This would be obtainable from the lab that carried out the analysis.

$$\frac{Concentration\ within\ food\ of\ protein\ from\ allergen\ \left(\frac{mg}{kg}\right)}{Action\ Level\ \left(\frac{Reference\ Dose\ (mg)}{Reference\ Amount,\ the\ quantity\ of\ food\ consumed\ (kg)}\right)}$$

An overview of different types of QRA calculations that can be applied in different settings by FBOs is given in Annex 1.

5.1 The exposure assessment

In deterministic QRA to evaluate the risks from UAP, the exposure assessment uses two main types of data (variables): 1) data on the concentration of total protein from the allergenic food in the finished product that is consumed. This may be obtained either through finished product sampling and analysis or estimated from calculations of the likely amount of allergenic food in the finished product and proportion of the allergenic food which is protein, and; 2) the intake amount of the finished food product when consumed by an individual. This may be estimated from information such as package size or dietary surveys conducted in the country or region in question, and is called the 'Reference Amount'. In addition to 1) and 2), the exposure assessment should also consider the form of UAP in the finished product so that there may be an accurate estimation of the amount of allergenic protein consumed. For example, whether it is particulate such as particles of nuts or amorphous (such as a milk powder), and whether its distribution within the product is homogeneous (e.g. liquid milk or liquid egg cross-contact on a product line) or heterogeneous (e.g. sesame seeds cross-contact). Finally, the frequency of occurrence of the cross-contact (e.g. whether continuous or sporadic, predictable or unpredictable) should also be considered as part of an assessment of the likelihood of occurrence and likely frequency of occurrence. Even though data on these aspects are not included as such in the calculation part of a QRA, they provide insight into the scale of risk and likelihood of detecting an allergen upon sampling an affected product.

There are advantages and disadvantages associated with using actual (measured) data from product testing vs. using a theoretical (calculated) estimate. Estimates of carry-over

can be based on knowledge of such things as the design of the production equipment, cleaning regimes, scheduling of production runs and basic measurements of the mass of the preceding product that may reside within the equipment after a production run. Estimates may be cheaper, easier and quicker to undertake but carry a degree of uncertainty because they are not based on actual measurements in the finished product and will more likely over-than underestimate the potential for UAP. This can lead to unnecessary use of PAL. Estimates can be supplemented by using actual data based on sampling and analysis of the food, which can lead to greater accuracy in the QRA. However, the results of sampling and analysis can also carry significant uncertainty. This is especially the case if the nature of the cross-contact is intermittent and depends on whether the sampling strategy and analytical methods employed were appropriate and adequate for the food and allergen in question.

For the intake estimate part of the exposure assessment, it is conventional to use a sufficiently protective assumption (which in many cases is more than the stated portion size of the product). In some cases, for foods that are sold in bulk, a percentile of consumption from community food intake surveys[6] can serve as the Reference Amount (i.e. as the estimate of intake at a single eating occasion). This recognises that the actual amount of consumption of a given finished food by a consumer during a meal/eating occasion can vary considerably and that it cannot be assumed that the nominal portion/serving size indicated by the FBO is a realistic estimate of exposure.

5.2 The comparison to a Reference Dose

Food allergen RfDs, are amounts of total protein from an allergenic food source (e.g. amount of protein from a peanut) that reflect an exposure deemed to be without appreciable health risk. They are commonly derived from allergen dose-distribution modelling, in which oral food challenge data from (ideally) multiple clinical studies are combined to predict the cumulative proportion of the allergic population that will react at (or below) a given dose (the so called 'eliciting dose' (ED)) of allergenic protein. For example, the amount of total protein from an allergenic food source that is predicted to result in an objective reaction in no more than 5% of allergic consumers is known as the 'eliciting dose' 05 (ED05). An example of the use of data from food challenge studies to generate an ED05 for a given allergic population is shown in Figure 3.

[6] Dietary intake surveys are undertaken and published by a number of countries, although not all are designed specifically for use in allergen risk assessment. For information relevant to your region/country, FBOs are advised to contact the relevant food safety authority or a recognized allergen expert. Further information is also available in the separate ILSI Europe publication 'Practical Guidance on the Application of Food Allergen Quantitative Assessment Within Food Operations' (ILSI, 2022).

Expert review of the available data has led to the ED05 being recommended by some authorities as the basis for appropriate RfDs to use in allergen QRA (The Allergen Bureau of Australia-New Zealand, 2024; FAO/WHO, 2022c). Decisions about which specific RfDs and associated values to use in a QRA are currently for individual FBOs to decide on. However, the regulatory landscape regarding RfDs and PAL is moving forward quite quickly in some countries. Therefore, FBOs are advised to consult regulatory bodies or allied food safety authorities for up-to-date guidance on the requirements applying in a given region.

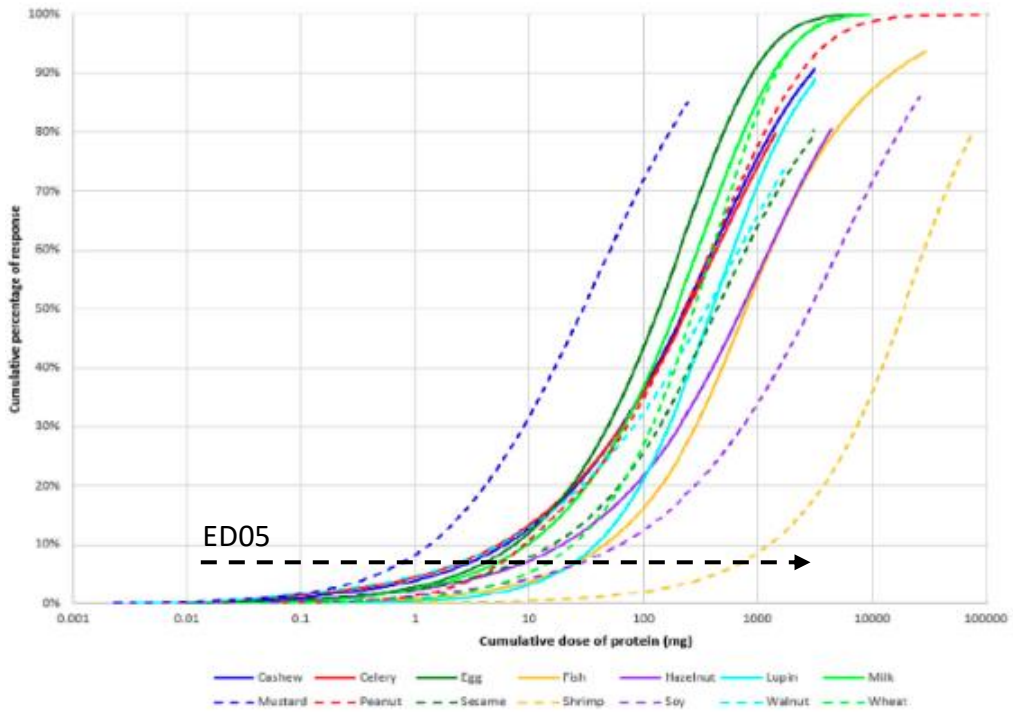

Figure 3. Eliciting dose curves from the model averaged population threshold dose distributions for 14 priority allergenic foods, based on cumulative dose datasets. Doses are expressed in mg total protein from the allergenic food. *Image copied with permission from Houben et al., 2020. Food Chem. Tox. 146:111831*

5.3 Sampling and analysis

As already explained, data on the concentration of total protein from the allergen of concern in the finished product are a key input into a QRA calculation and can be estimated or measured. Measurement requires product/ingredient sampling and analysis. Both activities require careful consideration and planning in order to generate information that is representative, accurate and useful for a QRA. In undertaking sampling and analysis, there are a number of factors FBOs will need to consider: 1) the approach to sampling that will be undertaken, including thinking about the timing and number of samples that will be taken, whether samples will be pooled or analysed separately; 2) the type of analytical test that will be used to detect and quantify the allergen in question. This will need to consider the availability of reliable tests for the allergen and the method *used* (currently

testing is mainly by Enzyme Linked Immunosorbent Assay (ELISA) although other methods are available); 3) the performance criteria of the chosen test and its ability to produce an accurate result in the specific food matrix to be tested, and; 4) the reporting units of the chosen test, recognising that different test kits may report different analytic units. What is needed for comparison to an action level (and also the RfD from which it was calculated) is mg/kg of total protein from the allergen. The importance of communicating at an early stage with the laboratory that has done (or is going to do) the analysis, or with supplier of the test kit being used, is key to addressing these factors. Further detail on sampling and analysis for input into food allergen QRA calculations is given in Section 5.2 of the ILSI Europe publication 'Practical Guidance on the Application of Food Allergen Quantitative Risk Assessment Within Food Operations' (ILSI Europe, 2022).

5.4 Applicability and feasibility of food allergen QRA

An illustration of the common steps that should form part of a decision-making process to inform whether or not to undertake a food allergen QRA in a given UAP scenario, is presented in Figure 4. As part of this, it is important to recognize that QRA is not always necessary or feasible in all scenarios. The ability to perform a QRA will depend on the nature of the food allergen risk being evaluated and the quality (and availability) of input data regarding the hazard (the allergen), and the exposure. For example, where a qualitative analysis of UAP risk indicates that there is a clear risk beyond doubt to consumers that cannot be eliminated by measures such as cleaning, product line segregation etc., then PAL may be warranted and QRA may not be necessary. An example of this scenario might be dark chocolate produced on a line that previously produced milk chocolate, wherein cleaning cannot adequately and predictably remove milk chocolate residue. Alternatively, where data are insufficient to estimate exposure with adequate certainty, QRA may not be possible. However, in situations where a cross-contact point is identified that cannot be fully mitigated, and the characteristics of cross-contact are known with a reasonable degree of certainty (form, distribution and concentration of UAP in the affected food), then QRA may be deemed possible.

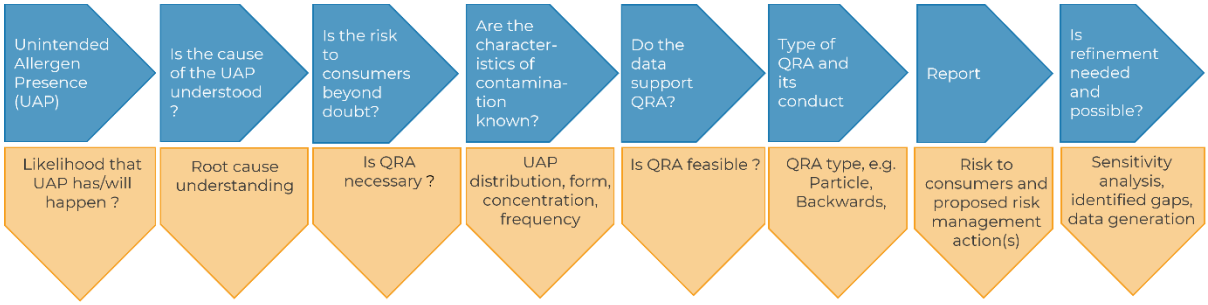

Figure 4. Common steps in the process of allergen risk assessment

5.5 Record keeping and reporting

Where a food allergen QRA is undertaken, it is important to document all stages of the process including the reasons for applying a QRA, any assumptions made regarding the characteristics of the potential UAP and of the exposure scenario, and the sources of data used (including those associated with sampling and analysis). In addition, the scale of uncertainty associated with the output of a QRA should be reported alongside the QRA result so that it may inform (and potentially qualify) subsequent risk management and communication decisions. Adequate documentation of a QRA is vital for being able to repeat a QRA to compare the outputs obtained. It is also useful for refinement of the QRA process should more detailed or more accurate information, methods and data become available in the future.

6. Risk assessment scenarios in which food allergen QRA can be applied

There are three main scenarios in which food allergen QRA can be applied by FBOs, the first two of which are proactive assessments that may be linked to decision making on the use of PAL:

1) QRA can be used for evaluating risks of UAP originating upstream of a manufacturing facility and finished product production, e.g. from allergens arising in a raw material or ingredient obtained from a third-party supplier
2) QRA can be used for evaluating allergen cross-contact risks within operations, i.e. within production processes that are under the direct control of the FBO. This includes the validation and verification of production equipment cleaning regimes
3) QRA can be used for assessing risks arising from food allergen 'incidents' that may occur when an allergen is unexpectedly found in a foodstuff that has already been produced, distributed or sold (reactive assessment)

6.1 Evaluating upstream UAP risks (from supplied ingredients) as part of a food allergen QRA

A food manufacturer's allergen management plan for production of a finished product and its associated packaging will need to consider the risks of UAP arising in all parts of the supply chain. This includes those from ingredient and raw material suppliers upstream of the production of the finished product and outside of the FBO's direct control. To achieve this, information flow is needed from farmer to commodity producer, to ingredient maker

and then to final product maker. Acquiring the necessary information and data about residual allergen risks attributable to an ingredient from upstream suppliers is complicated by the fact that modern supply chains often have multiple players that may span multiple geographical regions that may have differing legislative requirements regarding food allergens. It requires a thoughtful approach to manage each supplier situation so that there is good communication between parties, the right questions are asked at the right time and sufficient detail is recorded in the answers (and data provided) to inform the QRA. It also needs to be recognised that information requirements may be different for suppliers of complex ingredients compared with primary producers (e.g. suppliers of raw peanuts or treenuts). Communication between trading parties is facilitated by good supplier documentation, often in the form of an 'ingredient survey'. This should ideally be in a common format and used to collect information necessary for the downstream assessment of allergen cross-contact.

Other tools separate to those used to collect ingredient and residual ingredient carry-over information can also be useful in ensuring a high quality of information/data from suppliers for input into a QRA. These include: 1) Supplier training, to improve knowledge of what information needs to be communicated to the FBO, when and why, and to ensure documentation is correctly completed; 2) Supplier auditing, to check that suppliers are conforming to the FBO's requirements for allergen control and provision of information, and 3) Analytical testing, which may include testing of supplier raw materials/ingredients by the FBO or by the supplier themselves, to identify and quantify any allergens present other than those that are known ingredients. Figure 5 illustrates a risk mitigation strategy that can be used to ensure good quality data input into an allergen QRA, wherein the level of focus on the three risk mitigation areas (training, data generation and audit) depends upon knowledge of both the supplied ingredient and the specific supplier. Mapping this out enables resources and effort to be focused where they are likely to be most effective for mitigating the risks of allergen cross-contact.

Quality of knowledge about cross-contact risks in the supply chain			Required level of focus to mitigate risks from allergen cross-contact		
....about the supplied material	...about the supplier including their upstream management		Training (on the quality of supplied information)	Generation of data (e.g. testing)	Audit
high	high	→	low	low	low
high	med	→	med	low	med
high	low	→	med	med	high
med	high	→	med	med	low
med	med	→	med	med	med
med	low	→	high	med	high
low	high	→	high	med	low
low	med	→	high	high	med
low	low	→	high	high	high

Figure 5. Risk mitigation strategy illustrating where effort should be focused to gather information on cross-contact scenarios additional to that supplied via 'ingredient surveys'. This enables good quality data input into allergen QRA.

6.2 Evaluating UAP risks resulting from in-house operations

Food allergen QRA represents one of the key tools available to FBOs for allergen risk assessment and management during in-house operations. In this setting, QRA is predominantly used for assessing allergen risks arising from cross-contact but can also be useful for validating equipment cleaning regimes, or indeed for determining the appropriate cleaning regime to use (e.g. whether a 'hygiene' or 'allergen' clean is necessary).

For the determination of a UAP risk from cross-contact in-house, FBOs will commonly use a HACCP-based risk assessment approach based on a foundation of GMPs and robust PRPs to identify controls (risk management measures, that could include cleaning, production line segregation, scheduling, storage controls or other controls). These controls require subsequent validation to determine their effectiveness. The assessment of controls usually considers both qualitative and quantitative information to determine whether the controls are effective at preventing cross-contact. This needs to be undertaken by trained personnel such as members of the FBO's HACCP team. Where the chance of cross-contact cannot be eliminated by the controls, then a QRA may be undertaken to quantify the degree of risk and inform a decision on PAL. Conversely, if the controls are successful in eliminating the chance of cross-contact then QRA may not be needed and PAL is not warranted. (It is important to point out that, if a QRA is undertaken, this will also need to take into account the UAP risks upstream of production of the finished product that are described in Section 6.1.)

An illustration of the process for the management of allergen cross-contact risks within a production facility under direct control of the FBO, including the place of QRA within that process, is given in Figure 6. The process starts with the identification of potential sources and points of cross-contact. This is followed by an estimation of the likelihood of the cross-contact occurring, and the characterization of the form, frequency and concentration of cross-contact. Controls to manage the identified risks are then developed and those controls are assessed and validated. This step includes applying a QRA if the controls are not effective in eliminating the risk. Finally, risk management measures are implemented, where warranted.

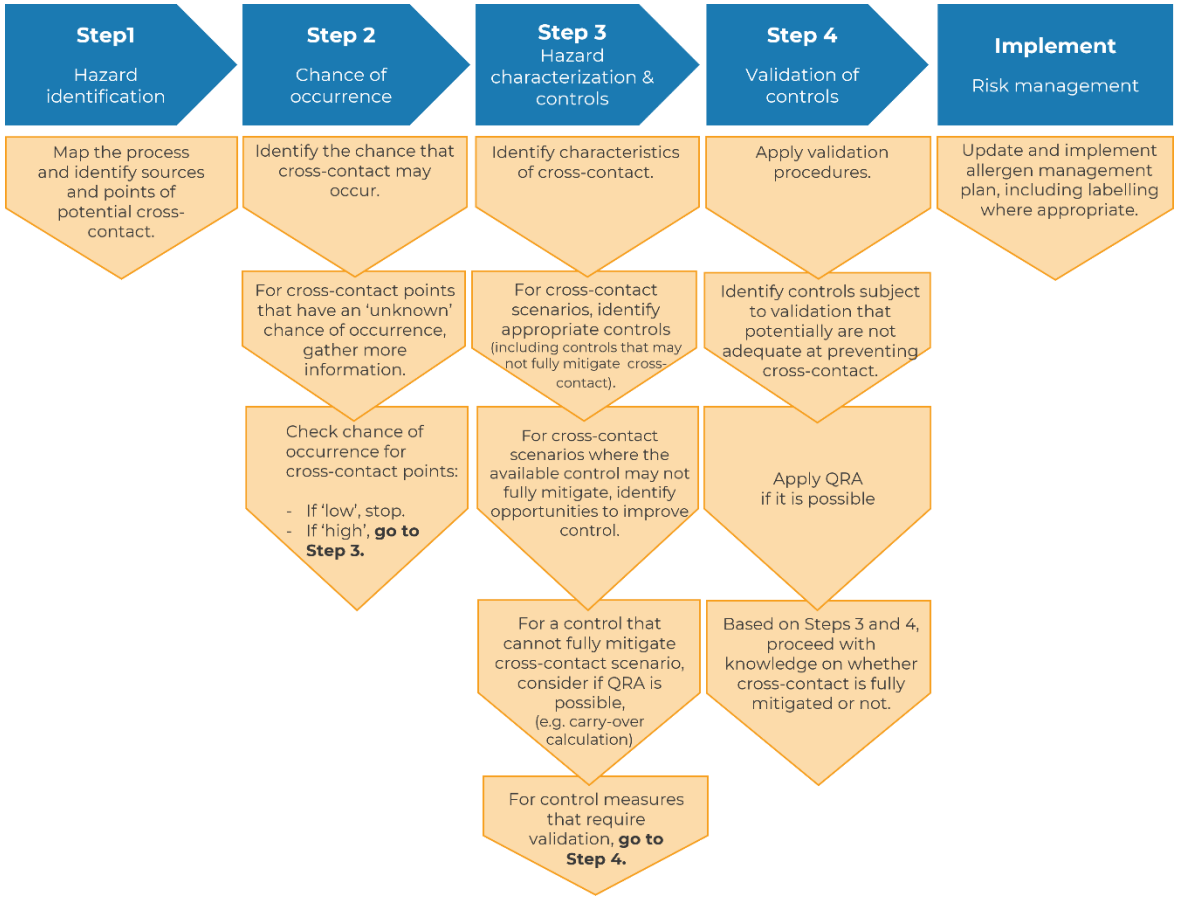

Figure 6. Process for the management of allergen cross-contact within production processes under direct control, including the role of QRA within that process.

6.3 Applying food allergen QRA to the management of 'incidents'

Quantitative risk assessment can form a key part of an assessment of the risk to food allergic consumers following the identification (or suspicion) of the presence of a food allergen in a finished product that is not adequately communicated on the label of that product (a so-called allergy 'incident'). This can arise via a number of scenarios which may occur at different points in the supply chain, as shown in Figure 7. The risk assessment to manage such incidents may be carried out either by an individual FBO to inform in-house

risk management actions or by a public health authority as part of a public health QRA to inform population level risk management actions.

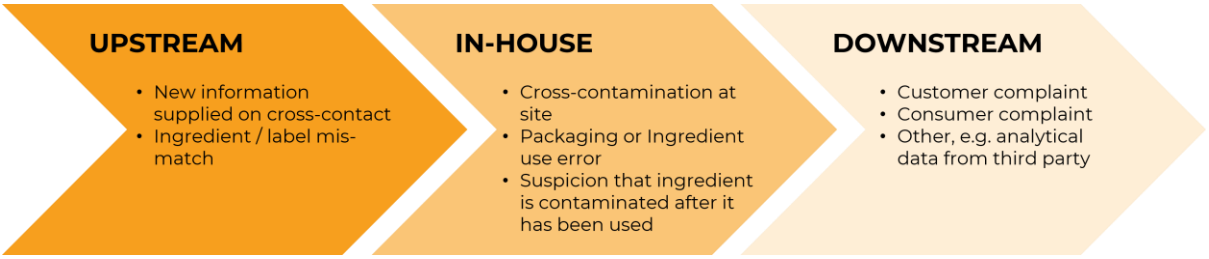

Figure 7. Types of allergy incident that can occur at different points in the supply chain.

Risk assessment for incidents management normally starts with a root cause analysis to understand the source of the UAP, the allergen(s) involved, and the type of exposure. This is followed by data gathering about the characteristics of the UAP, calculation of the likely exposure to the allergen based on a worst-case estimate of the quantity of food per consumption event, and an assessment of the general quality of available evidence. An assessment decision is then made regarding whether immediate risk management/communication measures such as product recall are needed (where an immediate risk beyond doubt to consumers has been identified) and/or whether a QRA is feasible and warranted if the risk is unclear. There are a couple of differences between incident QRA and QRA undertaken for more proactive UAP risk assessments (such as those covered in sections 6.1 and 6.2). These should be noted. First, as there may be a pressing need to understand risk, the assessment may be performed with data of higher uncertainty than would normally be the case in a QRA to support normal operations. Where this is the case, it is important to capture and communicate the degree of uncertainty together with the QRA outcome. Secondly, to fully assess the potential risk to the food allergic community it is sometimes necessary in incident QRA to compare the exposure estimate to ED values greater than the those on which RfDs are based (e.g. ED10, ED20, etc).

7. Conclusions

This overview provides an introduction and summary of the key concepts of QRA as it can be applied to food allergen management by FBOs. The reasons why FBOs should consider applying QRA to assess the risks of UAP and the benefits of doing so have been communicated. The fundamental components of a food allergen QRA and how these fit together have been described, and the considerations surrounding when QRA can be used and in what risk assessment situations it may be useful have been outlined. Figure 8. attempts to draw all of these aspects together in an illustration of the broad process that FBOs might follow for considering whether, when and where to apply food allergen QRA within their food production processes and wider supply chain. For more detailed and practical guidance on these and other aspects mentioned in this article, as well as example QRA calculations for a range of UAP scenarios and to address a range of risk assessment questions, FBOs are encouraged to refer to the separate ILSI publication 'Practical Guidance on the Application of Food Allergen Quantitative Assessment Within Food Operations' (ILSI Europe, 2022).

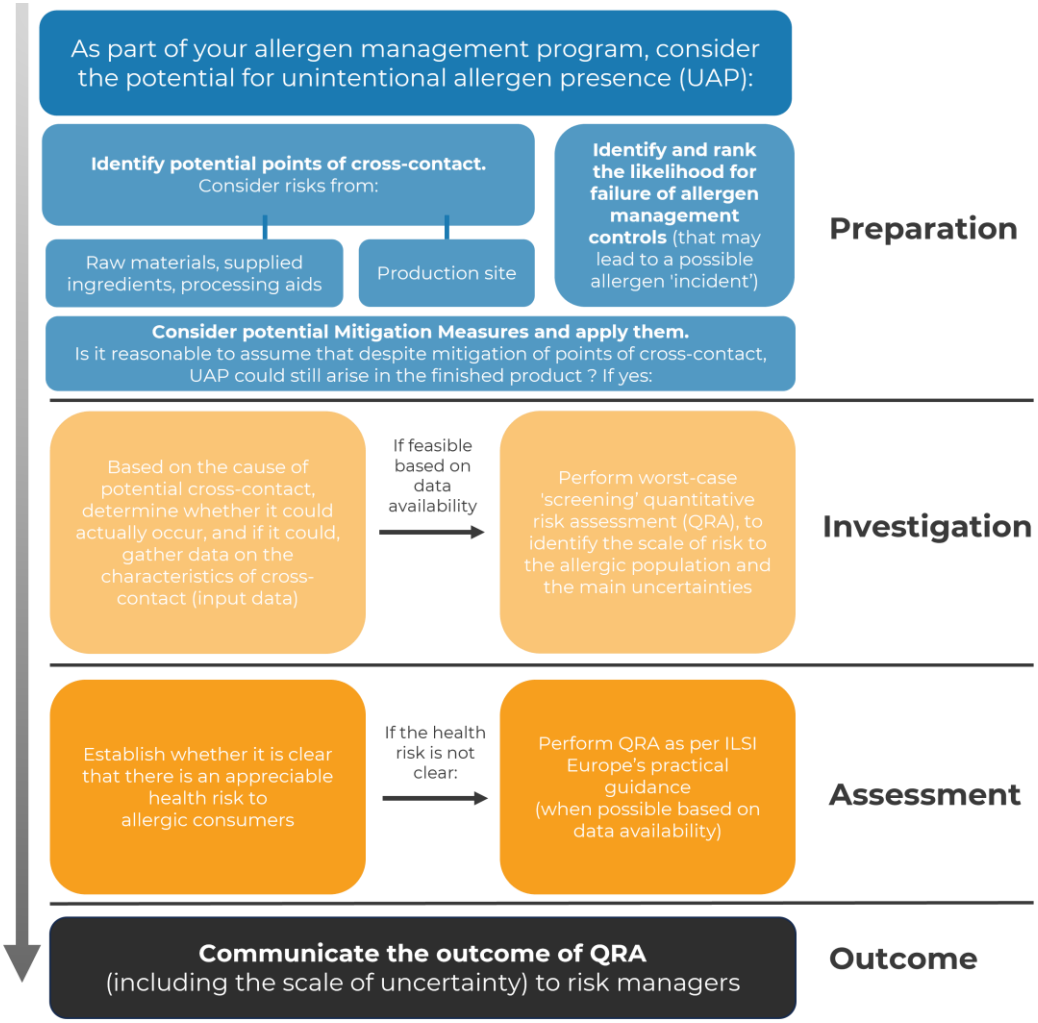

Figure 8. Visualisation of the broad process leading up to allergen QRA for FBOs.

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ANNEX 1

Overview of types of food allergen QRA calculations and their application in different FBO settings.

Type of QRA	Description of calculation to be undertaken	Uses	Characteristics
1. Standard QRA (deterministic)	Compares a point estimate of the amount of allergen consumed to the relevant RfD. (Note: If analytical data are available, and reported as a concentration, this concentration can be compared to the 'action level' for the food)	Useful during normal food business allergen management situations, such as to inform decisions on PAL.	Requires understanding of the nature of UAP in the food (including the concentration) and amount of food consumed. Calculation is simple to perform.
2. Backwards QRA (deterministic)	Given data about the amount of food consumed, and the RfD, this calculation provides the concentration of allergen in the food beyond which there may be an appreciable health risk for allergic consumers.	Can be used to provide a reality check on whether a cross-contact situation has the potential to result in a public health concern where data on UAP are not available.	As for 1.
3. Population QRA	Given data about the amount of allergen consumed, this calculation provides the fraction of the overall food allergic population that may experience a reaction.	Useful for informing incident management in situations where an allergen is unlabelled on a food already at market.	Requires a number of inputs, including the nature of UAP in the food (including the concentration), the amount of food consumed, number of products at market and prevalence of the allergy within the population.
4. Probabilistic QRA	Given the ranges of amounts of an allergen consumed by the allergic population, this calculation provides the ranges of the proportion of the allergic population that may experience a reaction.	Useful for informing incident management in situations where an allergen is unlabelled on a food already at market. Provides a more accurate estimation of risk than Population QRA.	As for 3. but requires multiple calculations which are combined into ranges (with the aid of a computer).

QRA, quantitative risk assessment; UAP, unintentional allergen presence; RfD, reference dose


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