

Developing a Food Safety Hazard Assessment Tool: Insights from Qualitative Analysis and Case Studies in Poland*

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Abstract

Food safety is a fundamental requirement of the food supply chain, and ensuring rapid and effective response to food hazards is essential for protecting public health. This study was motivated by the need to develop practical tools that can support the assessment and management of food-related risks, particularly in urgent situations requiring swift action.

Although international systems such as the Rapid Alert System for Food and Feed (RASFF) and national institutions like the Chief Sanitary Inspectorate (GIS) play a key role in monitoring and communicating food safety risks, there is a gap in the literature concerning detailed analyses of food recall practices at the national level. Moreover, existing studies rarely provide standardized methods for assessing the severity of food hazards or supporting decision-making processes during recalls.

The methodology of the study was based on a qualitative analysis of food safety systems and recall procedures operating in Poland. This included a review of institutional frameworks, selected case studies of food recalls, and the identification of key factors influencing hazard management. On this basis, the authors developed a tool for assessing food hazards, incorporating criteria such as the type of contamination, level of risk, and urgency of response.

The findings indicate that there is a need for more structured assessment approaches. The proposed tool improves consistency in hazard evaluation and has the potential to enhance the effectiveness of recall processes.

Keywords: food safety, food hazard, hazard assessment, food safety crisis management

Introduction

Safe food is the basic human right. Food safety means the state in which food does not cause harm to the consumer when prepared and consumed as intended. This definition is adopted by Food and Agriculture Organization (FAO). In 2018 FAO and WHO established the World Food Safety Day. Food safety is a shared responsibility of public authorities, producers, and consumers. Every participant in the food chain—from agricultural production to consumption—plays a vital role in ensuring that food is safe and does not pose a health risk. By celebrating World Food Safety Day, the World Health Organization is taking action to raise the profile of food safety in public debate and reduce the number of foodborne illnesses worldwide. Food Safety Day is celebrated each year on the 7th of June.¹

Food safety is its fundamental and most important characteristic. Consumers expect safe food. Given the obligation to offer safe food, this is a characteristic that consumers have the right to consider fulfilled. Given the need to consume food, the presence of hazards in it can negatively impact the health and lives of consumers. Food

¹ <https://www.who.int/campaigns/world-food-safety-day>

safety hazards result from a lack of action by, among others, standards and food sector employees. Mandatory and optional food safety systems and standards are primarily preventative in nature, meaning they are intended to prevent hazards from occurring in food (Niewczas-Dobrowolska, 2020).

Safe food is food free from hazards. A hazard means "a biological, chemical, or physical agent in food or feed, or a condition of food or feed, that may cause an adverse health effect." Regulation 2017/625 provides a broader definition of a hazard – a hazard means "an agent or condition that may have an undesirable effect on human, animal, or plant health, animal welfare, or the environment." Food safety – "all the conditions that must be met, relating in particular to: the additives and flavorings used, the levels of contaminants, pesticide residues, the conditions for food irradiation, organoleptic characteristics, and the measures that must be taken at all stages of food production or marketing to ensure human health and life." Changes in organoleptic (sensory) characteristics, e.g., a change in color, may indicate that a given food is unsuitable for consumption. Foodstuff harmful to human health or life – a foodstuff whose consumption under normal conditions and as intended may cause negative consequences for human health or life.

Lack of food safety and recalls

Food safety also has economic and social dimensions (Liao et al., 2020). Lack of safety can lead to: illnesses and poisonings, product recalls, financial losses for businesses, decreased consumer confidence, social panic following information about contamination.

The Chief Sanitary Inspectorate in Poland is responsible for overseeing food safety and can order the withdrawal of a product from the market when there is a risk to consumer health. A recall most often occurs after the detection of: bacteria, e.g., listeriosis or salmonellosis, exceeding pesticide standards, the presence of foreign bodies, mislabeling of allergens, contamination with chemical substances. The procedure is usually as follows: the hazard is detected by the manufacturer, laboratory, sanitary inspection, or the Rapid Alert System for Food and Feed, the manufacturer notifies the Chief Sanitary Inspectorate (GIS) and initiates the recall of the product batch, GIS issues a public warning with the product name, batch number, and the recommendation "do not consume", storekeepers remove the product from sale, and consumers can return it. According to the law, the GIS can issue an administrative decision ordering the seizure or withdrawal of food from the market if it finds non-compliance or exceeding permissible standards.

The sooner consumers are notified of a food hazard, the fewer people will be exposed to the hazard's effects (Carlson and Peake, 2012). However, as Food and Drug Administration says that recall alerts are often delayed. Each food operator should be prepared for the food recalls through elaboration and implementation of the dedicated food recall procedures, documents and crisis scenarios. Food traceability is considered essential for successful product recalls. It allows for the rapid identification of the source of contamination, identification of product batches, and identification of the recipients of the affected food. This allows the company to limit the scope of the recall to only the affected batches. Traceability plays a role in three stages of food recall management: before the crisis, it allows for the development of a rapid batch identification system, during the crisis, it enables the rapid recall of products and the determination of the cause of contamination, after the crisis, it supports the rebuilding of trust and the analysis of errors in the supply chain (Pulita et al., 2022). According to Aung and Chang (2014), traceability minimizes the spread of dangerous products, limits economic losses, and reduces the risk of damage to a company's reputation. The authors emphasize that the lack of an effective traceability system results in the need to recall many more products than are actually at risk.

The aim of this paper is to elaborate the assessment of the food hazards with the matrix that can be use to assess the hazard in food in the future.

Research and Methods

The research process was divided into stages. First, public warnings issued by the Chief Sanitary Inspectorate (GIS) in Poland 2025 were reviewed. During the review, attention was paid to the following information: type of hazard (chemical, physical, biological, information), product, recommendation for consumer conduct. Eighty notifications were published, and those not related to food and those that were duplicates were rejected. Finally, 50 notifications concerning food safety hazards were analyzed. The main groups of food hazard were identified as well as actions taken by food institutions and producers. Then the assessment of the harmfulness of hazards in food was elaborated.

Research Results

Figure 1 presents the number of food recalls in 2025 by the type of food hazard. Among chemical food hazards there were mainly pesticides residues. Among physical hazards parts of metal or glass in food products. As far as

biological food hazards are considered the main groups were the pathogenic bacteria such as Salmonella or E.coli. The fourth type of food hazard was lack of information about the allergen in food. Food allergen information on food product is obligatory under the Regulation 1169.

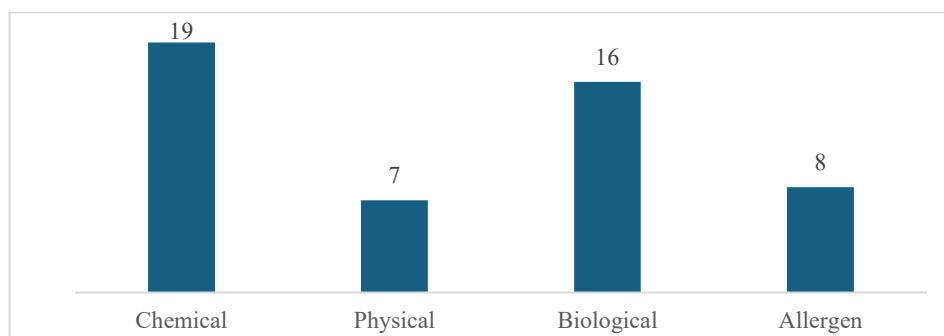


Fig. 1. Food recalls in 2025 by the type of food hazard. Source: own elaboration.

The products that have been withdrawn from the market are products that are consumed by most consumers, e.g. meat, tea or eggs. Each food recall information provided details about the product, its batch number and recommendations for consumers.

The following method assesses the risk level of a food hazard (e.g., unlabeled allergen, foreign body, microbiological contamination, labeling error). The assessment is based on three criteria: severity of health effects, likelihood of occurrence, possibility of detection before consumption (the extended version also takes into account the exposure factor). The final result allows us to determine whether: monitoring, process correction, product recall, immediate recall is necessary. The severity score is shown in Tabel 1, the likelihood score is shown in Table 2, and the possibility of detection is shown in Table 3.

Table 1. Severity score of the food hazard (S)

Points	Description of the effect	Example
1	No health impact or only a quality defect	Incorrect product color
2	Mild, transient symptoms	Slight stomach discomfort
3	Moderate symptoms requiring medical consultation	Diarrhea, rash
4	Serious health impact	Hospitalization, severe allergic reaction, poisoning
5	Life-threatening or possible death	Anaphylaxis, toxin, glass in the product

Source: own elaboration

Table 2. Likelihood score of the food hazard (L)

Points	Interpretation
1	Very unlikely single incident, no previous cases
2	Unlikely sporadic event
3	Possible may occur several times a year
4	Likely regularly occurring variations
5	Very likely problem occurs frequently or constantly

Source: own elaboration

Table 3. Possibility of detection of the food hazard (D)

Points	Detectability	Example
1	Very easy to detect	Visible packaging damage
2	Easy to detect during inspection	Labeling error detected by the operator
3	Moderately difficult	Requires additional inspection
4	Difficult to detect	Allergen or bacteria invisible without testing
5	Practically undetectable before consumption	No allergen label, toxin

Source: own elaboration

The fourth characteristics can be added to shown the exposure factor so the size of the sale. The bigger it is, the more consumers can be potentially exposure (Table 4).

Table 4. Exposure factor (E)

Points	Distribution scale
1	Product held at the plant
2	Limited number of recipients (locally)
3	Regional sales
4	Domestic sales
5	International sales

The formula then becomes: $Risk = S \times L \times D \times E$

S- severity

L - likelihood

D – detectability

E – exposure

This allows us to distinguish a local incident from a market-wide threat.

After adding the exposure factor (E), the maximum score is 625 points.

Taking into consideration the minimum and maximum value of S, L, D and E the risk matrix score was elaborated (Table 5).

R	Level of risk	Recommended actions
1-39	Low	Monitor and document the incident
40-99	Moderate	Corrective action, increased monitoring
100-199	High batch lockout	Analysis of the need for a recall
200-349	Very high	Product recall
350-625	Critical	Immediate recall and notification of authorities

Source: own elaboration

Explanation:

The ranges are not random – the risk score is the product of several ratings, so the distribution of points is not linear. For the formula: $R = S \times L \times D$ - most typical risks fall in the middle range of 20–60 points. Scores above 75 only appear when at least two factors are rated very high (4–5), indicating a real health risk.

Therefore, the following thresholds were adopted: 1–19: scores with at most one factor rated medium or high; 20–39: typical deviations requiring correction, but usually not recalled; 40–74: situations in which at least one parameter is high and there is a real threat; 75–125: a combination of very severe consequences and high probability or no detection.

Similarly, for the formula with E: $R = S \times L \times D \times E$

the maximum score increases to 625, so the limits have been scaled approximately 5-fold. Additionally, high scores are achieved only by those cases that are simultaneously: health-threatening, difficult to detect, widely distributed in the market. Comparison example: the same labeling error in a single local batch can have a score of approximately 100–150. The same error in a product sold nationwide or internationally can reach 300–500 points.

This approach is consistent with the practice used in HACCP and FMEA risk analysis, where thresholds are set so that the highest actions are triggered only for combinations of several serious factors. The ranges are set so that a single high parameter doesn't immediately trigger a recall decision. Although the impact may be very severe, the threat is unlikely and easy to detect, so monitoring is sufficient. Severe impacts are combined with high probability and practically impossible to detect. Therefore, the result falls into the critical zone.

Example 1- no allergen label:

S = 5

L = 4

D = 5

E = 4 (domestic sales)

Result: $5 \times 4 \times 5 \times 4 = 400$

Interpretation: 400 points = critical risk → immediate product recall and notification of the relevant authorities.

Example 2 - A laboratory test revealed that the permitted pesticide residue level was exceeded in a batch of frozen strawberries sold nationwide.

Score:

S = 4, Exceedance may cause serious health effects upon consumption, especially in children.

L = 3, One batch is contaminated, but the product has already been released for sale.

D = 4, Consumers are unable to detect the hazard themselves; laboratory testing is required.

E = 4, National distribution.

Calculation: $R = 4 \times 3 \times 4 \times 4 = 192$

Interpretation: 192 points = high risk. This means: immediate blocking and recall of the indicated batch, assessing whether other batches may also be contaminated, informing customers and distributors, deciding whether a full recall is necessary.

Conclusions

The presented example of pesticide contamination demonstrates that extending the classic $S \times L \times D$ model with an exposure factor (E) significantly impacts the final risk classification. In the analyzed case, the risk value increased from 48 points to 192 points for domestic distribution and to 240 points for international distribution. This represents a four- to five-fold increase in the assessment without changing the nature of the hazard itself. This phenomenon has significant practical implications because classic risk assessment models often focus solely on hazard properties, such as toxicity or probability of occurrence. As a result, two incidents with identical contamination levels can receive the same score, even though the number of potentially exposed consumers is completely different. For example, a batch of 500 packages detained at a facility, a batch of 50,000 packages sold nationwide.

In a model without the E factor, both cases could receive a score of 48 points. However, this result does not reflect the actual risk to public health. Including the exposure parameter causes the first case to remain in the moderate or high zone, while the second case moves into the zone requiring a product recall. This is particularly important in relation to pesticide contamination because: the hazard is usually invisible to the consumer, detection requires specialized laboratory analyses, the product may be consumed by a large number of people before the problem becomes apparent, health effects may be delayed and difficult to link to a specific batch of product. When pesticide residue levels are exceeded, clinical effects are not always immediate. Unlike an allergen or foreign body, which can lead to a rapid reaction, pesticide exposure is more often associated with subclinical risks, including: gastrointestinal disturbances, neurological symptoms, hepatotoxic effects, increased risk of long-term health effects with regular consumption (EFSA, 2023). For this reason, the S parameter for pesticides is typically set to 3–4, not 5. However, a relatively high E value can shift the final result into the critical zone. This demonstrates that for chronic hazards, the scale of distribution is often more important than the maximum severity of a single event.

Food safety management literature emphasizes that product recall decisions should consider both the severity of the hazard and the number of people potentially exposed. This approach aligns with the HACCP (Hazard Analysis and Critical Control Point) principles (Wallace et al., 2014; Codex Alimentarius, 2022), which prioritize hazards with the greatest impact on the consumer, and with the FMEA (Failure Mode and Effects Analysis) methodology, where risk assessment is based on a combination of severity, frequency, and detectability (Mc Dermott et al., 2020; Stamatis, 2019; Arvanitoyannis and Varzakas, 2009).

The classic FMEA method uses the RPN (Risk Priority Number) parameter, which is the product of several factors. In the proposed model, the E factor serves as an additional RPN modifier. This solution can be considered particularly useful for the food industry, as it allows for better differentiation between: internal incidents and market incidents, errors limited to a single production shift and systemic errors, local threats and threats affecting the entire country or export.

Based on the obtained results, the following practical interpretation can be proposed: Score Range Practical Significance - Below 100: Limited risk; batch lockdown and corrective actions are usually sufficient, 100–199: Significant health risk; batch recall and extended analysis required, 200–349: Large-scale risk; recall and customer notification required, above 350: Crisis of public health significance.

In the analyzed example, a score of 192 suggests that the contamination of a single batch sold nationwide is on the border between a batch recall and a full recall. The final decision should depend on additional data, such as: the level of exceedance of the maximum permissible limit, the type of pesticide used, the number of packages already sold, the possibility of identifying recipients, the consumer group to whom the product was intended. If the product was intended for children, pregnant women, or particularly sensitive individuals, parameter S should be increased by one level. For example, an increase from $S = 4$ to $S = 5$ results in a change of the result: $5 \times 3 \times 4 \times 4 = 240$, which automatically moves the event to the very high risk category.

However, the model also has limitations. The adopted ranges are based on expert judgment and do not result directly from applicable regulations. In practice, individual companies may use different decision thresholds, depending on the type of product, scale of operations, and customer requirements. Furthermore, the model does not take into account: measurement uncertainty of laboratory tests, the time from production to threat detection, full batch traceability, media influence and company reputation, and the simultaneous occurrence of multiple threats. Therefore, the proposed scoring system should be considered a tool supporting the decision-making process, not its sole basis. The model achieves its greatest value when used in conjunction with laboratory analysis, a batch traceability system, and the company's product recall procedure.

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