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REVIEW ARTICLE

Risk Assessment and Food Safety within the One Health Framework

Joanna Bucka-Kolendo

Prof. Waclaw Dąbrowski Institute of Agricultural and Food Biotechnology, State Research Institute, Department of Microbiology
36 Rakowiecka Str.,
02-532 Warsaw, Poland

Correspondence

joanna.bucka@ibprs.pl@ibprs.pl

Prof. Wacław Dąbrowski Institute of Agricultural and Food Biotechnology, State Research Institute, Department of Microbiology
36 Rakowiecka Str.,
02-532 Warsaw, Poland

Abstract

Food safety risk assessment is increasingly considered within the One Health framework, which recognises the interdependence of human, animal and environmental health in the emergence and transmission of food-chain hazards. In the European Union, risk analysis is based on Codex Alimentarius principles and the functional separation of risk assessment, risk management and risk communication. This narrative review examines how a One Health perspective affects the four established stages of food safety risk assessment and how they are implemented within the European institutional system, particularly through the European Food Safety Authority (EFSA). The reviewed evidence indicates that One Health does not replace the classical risk-assessment paradigm. Instead, it broadens the range of relevant exposure pathways and the institutional interfaces considered during hazard identification, hazard characterisation, exposure assessment and risk characterisation. The clearest operational examples concern zoonotic diseases and antimicrobial resistance, where data from human health, animals, food, feed and the environment must be interpreted together. EFSA and partner agencies have developed joint surveillance reports, scientific networks, emerging-risk procedures and cross-agency cooperation mechanisms, however, limitations remain. The European Food Risk Assessment Fellowship Programme (EUFORA) is considered as a capacity-building instrument of the One Health framework. Future progress will depend on interoperable data systems, transparent uncertainty analysis, stronger environmental surveillance, sustained inter-agency governance and the careful evaluation of new genomic and metagenomic tools. This review presents One Health-based food risk assessment as an extension of established scientific methods whose full implementation requires organisational as well as methodological change.

KEYWORDS

One Health; food safety; risk assessment; EFSA; emerging risks

Introduction

Ensuring food safety is a fundamental component of public health protection and a key objective of regulatory systems worldwide. However, the increasing complexity of modern food systems - driven by globalisation, agricultural intensification, climate change and evolving consumer choices - has amplified the range and interconnections among biological, chemical and environmental hazards affecting the food chain. As a result, conventional sector-specific approaches may be insufficient when risks emerge at the interface of human, animal and environmental health (Destoumieux-Garzón et al. 2018; Bronzwaer et al. 2021). The One Health framework has emerged as a scientifically and politically endorsed response to these interdependencies (Figure 1). It promotes collaboration across human health, animal health and environmental disciplines, and has progressively expanded

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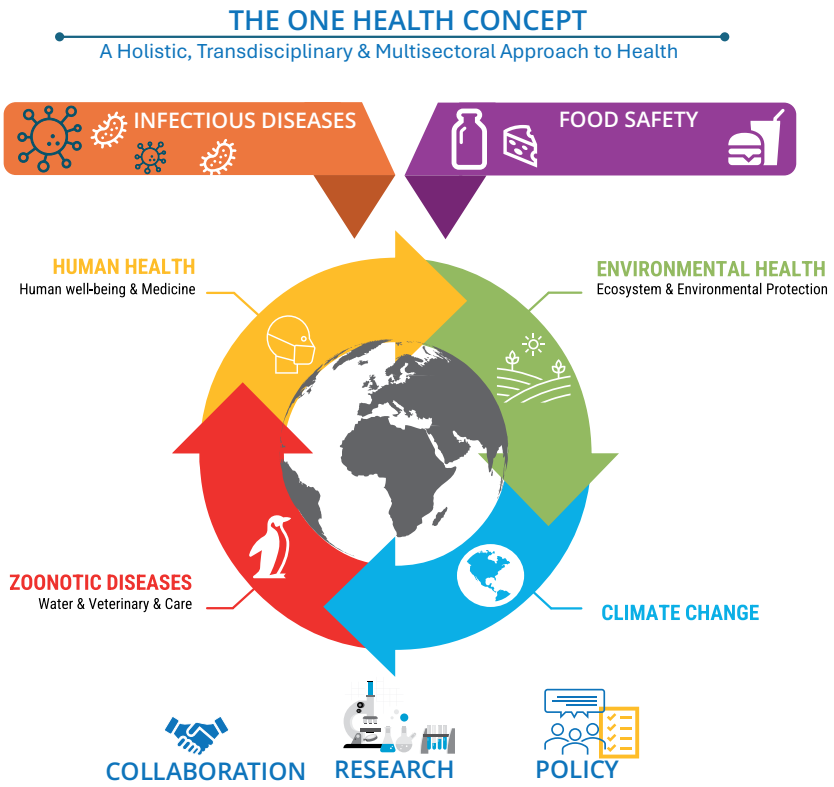


Figure 1. The One Health concept.

beyond its earlier focus on zoonotic disease to include antimicrobial resistance (AMR), chemical contamination, ecosystem health and wider food-system challenges (Destoumieux-Garzón et al. 2018; Bronzwaer et al. 2021). At the same time, the literature warns that the environmental component is frequently acknowledged more readily than it is incorporated into operational research and assessment (Destoumieux-Garzón et al. 2018).

Risk assessment remains the scientific component of food safety governance and evidence-based decision-making. According to Codex Alimentarius principles and Regulation (EC) No 178/2002, risk assessment comprises hazard identification, hazard characterisation, exposure assessment and risk characterisation (FAO and WHO 2019; Regulation (EC) No 178/2002). The same legal and methodological framework distinguishes risk assessment from risk management and risk communication, while recognising that the three components remain closely connected.

Within the EU, the EFSA provides independent scientific advice and risk assessments across the food and feed chain. Its founding regulation requires food law to be based on risk analysis and requires risk assessment to be independent, objective and transparent. The regulation also establishes procedures for the systematic identification of emerging risks, and requires EFSA to consider, where appropriate, animal health and welfare, plant health and the environment (Regulation (EC) No 178/2002). National competent bodies and other EU agencies retain important assessment, surveillance and regulatory functions, so EFSA should be understood as the central EU-level scientific body rather than the sole European risk assessor.

The original four-step paradigm remains applicable, but the One Health perspective changes the breadth of evidence and the relationships that must be considered within it. Human surveillance, veterinary monitoring, food and feed control, environmental observations, genomic data and information on production and consumption may need to be interpreted together. This creates opportunities for more complete assessments, but it also introduces problems of comparability, interoperability, governance and uncertainty (Bronzwaer et al. 2021; Donohoe et al. 2018; Fernandes 2026).

This review therefore moves beyond a sequential description of One Health, EFSA and the four stages of risk assessment. Its objective is to analyse: (i) how the One Health perspective modifies the evidence used at each stage of food safety risk assessment; (ii) how EFSA and cooperating EU bodies have operationalised these principles; and (iii) which methodological, institutional and normative limitations continue to restrict implementation. EUFORA is discussed separately as an instrument for capacity building and methodological harmonisation, rather than as a central pillar of One Health risk assessment (Alonso Andicoberry et al. 2022).

Review methodology

This article was prepared as a targeted narrative review. The source set comprised legal and methodological documents, EFSA and ECDC (European Centre for Disease Prevention and Control) scientific opinions and surveillance reports, and peer-reviewed reviews or perspectives addressing One Health implementation, microbiological and chemical risk assessment, AMR, genomics and metagenomics, emerging risks, inter-agency cooperation and ethical challenges. Foundational older sources were retained when they remained methodologically relevant, and the final source set covered publications issued between 2002 and July 2026.

Full texts were assessed for relevance to one or more predefined themes: the conceptual foundations of One Health and risk analysis; the four stages of risk assessment; EFSA's institutional role; EUFORA; and current challenges and future directions. When successive editions of recurring institutional reports served the same purpose, the most recent edition was used to describe the current situation, while older documents were retained when they provided a historical or methodological context. The material was then organised thematically and critically compared across scientific, legal and institutional source types.

The review was not designed as a systematic review or meta-analysis. No formal risk-of-bias scoring was applied because the source set included heterogeneous materials, such as legislation, guidance documents, scientific opinions, annual monitoring reports, narrative reviews and viewpoint articles. Institutional publications were used to document legal mandates, procedures and declared strategic objectives, but were not treated as independent evidence that those objectives had been fully achieved. Targeted literature searches were conducted in Web of Science, Scopus, and PubMed, complemented by institutional sources including the EFSA Journal, EFSA Scientific Opinions, ECDC surveillance reports, EUR-Lex (EU legislation and guidance documents),



Figure 2. Components of risk analysis.

and FAO/WHO Codex Alimentarius publications. Searches were performed iteratively between 2002 and July 2026. The main groups of search terms reflected the thematic scope of the review and included combinations of keywords such as "One Health", "food safety", "risk assessment", "risk analysis", "hazard identification", "hazard characterisation", "exposure assessment", "risk characterisation", "EFSA", "ECDC", "emerging risks", "AMR", "genomics", "metagenomics", "microbiological risk assessment", "chemical contaminants". Retrieved publications were screened for relevance to predefined thematic domains and organised through structured thematic coding. Institutional reports were included to document legal mandates, procedures and declared strategic objectives, but were not treated as independent evidence of implementation.

Conceptual basis: One Health and food safety risk analysis

Risk analysis in the European food safety system

Risk analysis consists of three distinct but closely linked components: risk assessment, risk management and risk communication (FAO and WHO 2019; Regulation (EC) No 178/2002) (Figure 2). Risk assessment is the scientifically based process used to estimate the nature and magnitude of a food-related risk. Risk management involves weighing policy alternatives, considering the scientific assessment and other legitimate factors, and selecting prevention or control measures where required. Risk communication is the interactive exchange of information and opinions concerning hazards, risks, risk perceptions, assessment findings and the basis of management decisions (FAO and WHO 2019).

The functional separation of risk assessment and risk management is intended to protect the scientific integrity and independence of the assessment. It does not imply institutional isolation. Codex Alimentarius explicitly describes risk analysis as iterative and states that interaction between risk assessors and risk managers is necessary for a practical application. It also requires the scope and purpose of an assessment to be stated clearly, relevant uncertainties and assumptions to be documented, and the final output to be presented in a form that is useful to risk managers (FAO and WHO 2019).

In the EU, this division is reflected in Regulation (EC) No 178/2002. EFSA provides scientific opinions and technical support at the EU level, whereas risk-management decisions are taken by the European Commission, Member States and other competent authorities within their legal mandates. The regulation also recognises that management decisions may consider legitimate factors in addition to the scientific assessment and may apply provisional measures when harmful effects are possible, but scientific uncertainty persists (Regulation (EC) No 178/2002).

This distinction is especially important in a One Health context. Scientific assessment can compare evidence concerning human illness, animal reservoirs, food contamination and environmental pathways. Decisions about acceptable risk, allocation of resources, animal culling, production restrictions or economic consequences belong primarily to risk management. A review of One Health-based zoonotic disease control shows that these decisions may involve conflicts between human health, animal health and animal welfare rather than automatic benefits for all sectors (van Herten et al. 2019). One Health therefore expands the range of evidence and values that may become relevant, but it does not remove the need to distinguish scientific assessment from policy choice.

One Health as an extension of the four-step framework

The four steps of risk assessment remain hazard identification, hazard characterisation, exposure assessment and risk characterisation (FAO and WHO 2019; Regulation (EC) No 178/2002). The One Health approach is not a replacement for this structure. In this review, it is treated as an extension of the evidence base and analytical boundaries within which the four steps are carried out (Figure 3).

For a conventional food assessment, the principal endpoint is usually an adverse effect in consumers following exposure through food. A One Health perspective requires additional attention to the systems that generate or modify that exposure. These may include animal infection and treatment, feed contamination, environmental reservoirs, wastewater, agricultural practices, food-processing environments, human behaviour and cross-border surveillance. The relevance of each domain depends on the hazard. Zoonotic pathogens and AMR require particularly broad integration (Al-Khalaifah et al. 2025). Chemical assessments may connect environmental contamination, feed, animal and dietary exposure, but they continue to rely on substance-specific toxicological methods (Alexander et al. 2012). Physical hazards are retained in the general framework but are not developed further because the reviewed sources did not provide a comparable One Health evidence base for this category.

The practical consequence is not that every assessment must include every One Health domain. Rather, the scope should be defined according to plausible causal pathways and the decision problem. Codex Alimentarius requires risk assessments to consider production, storage and handling throughout the food

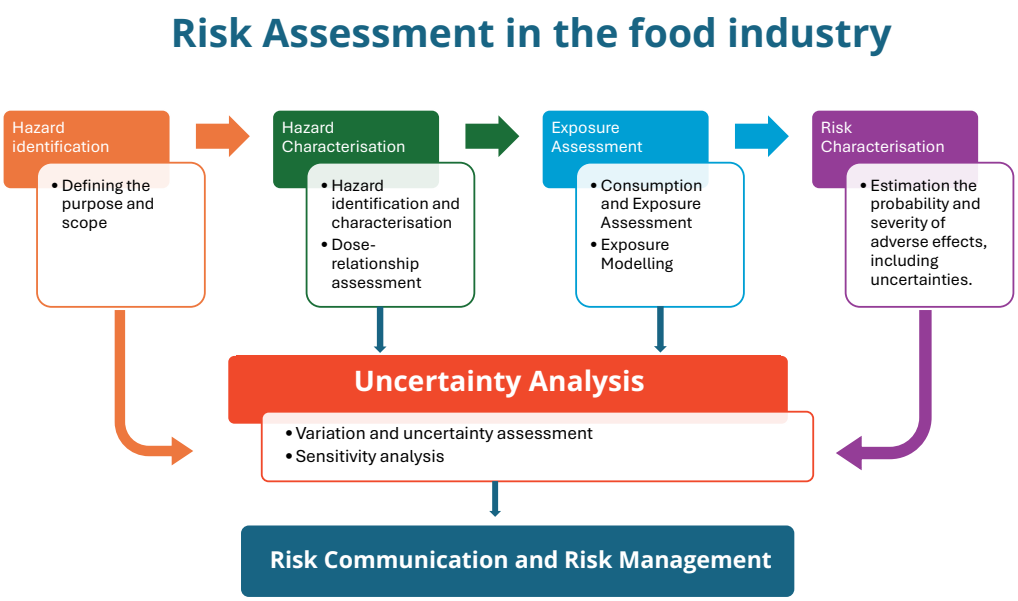


Figure 3. Risk assessment in the food industry.

chain, realistic exposure scenarios, susceptible populations and, where relevant, cumulative or combined effects (FAO and WHO 2019). One Health adds a structured reason to ask whether evidence from animal, environmental or other institutional systems would materially alter hazard identification, exposure estimation or interpretation of risk.

One Health across the four stages of risk assessment

Hazard identification

Hazard identification is the identification of biological, chemical or physical agents capable of causing adverse health effects and which are potentially present in a particular food or group of foods (FAO and WHO 2019). In practice, it draws on peer-reviewed literature, outbreak investigations, epidemiological evidence, laboratory findings, monitoring programmes and expert judgement. The original distinction among biological, chemical, physical and emerging hazards remains useful, but the One Health perspective is most consequential where the origin or transmission of a hazard crosses sectoral boundaries.

Biological hazards include bacteria, viruses, parasites and other agents associated with food-borne disease. The current EU One Health zoonoses reporting system illustrates integrated hazard identification by combining and historically interpreting information on humans, food, animals and feed. The 2024 report covers major agents including Campylobacter, Salmonella, Shiga toxin-producing Escherichia coli and Listeria monocytogenes, as well as food-borne outbreaks and additional zoonoses (EFSA and ECDC 2025). This does not mean that the underlying surveillance systems are methodologically identical. It does, however, show how signals from separate sectors can be brought into a shared assessment context.

Within EFSA, the BIOHAZ Panel has historically used qualitative assessments, quantitative models, structured risk ranking and rapid evidence synthesis according to the question, available data, resources and timeframe (Nørrung et al. 2012). The Scientific Network on Microbiological Risk Assessment adds a cooperation mechanism through which national organisations exchange information, expertise and examples of ongoing microbiological assessments (EFSA 2023a). These structures support broader evidence collection, although a network report documents cooperation and topics discussed rather than demonstrating that all national data are harmonised.

New sequencing approaches can extend hazard identification beyond culture and single-isolate analysis. Metabarcoding, shotgun metagenomics and long-read metagenomics can profile microbial communities directly in food, ingredient or environmental samples, potentially detecting organisms that are difficult to culture and allowing multiple hazards to be investigated in the same sample (Billington et al. 2022). Real-time genomic analysis, particularly portable nanopore sequencing, can shorten the interval between sampling and genomic interpretation and has been applied to zoonotic disease, emerging pathogens, AMR and environmental monitoring (Urban et al. 2023).

These technologies also create new interpretive limitations. Metagenomic results depend on sampling, extraction, library preparation, sequencing and bioinformatic pipelines. Standardisation remains incomplete, low-abundance organisms may be difficult to detect, reference databases influence classification, and DNA detection does not by itself establish viability or infectivity (Billington et al. 2022). Real-time genomics also requires infrastructure, data processing, training and access to appropriate databases, while raising practical, legal and ethical questions concerning data generation and sharing (Urban et al. 2023). Consequently, new molecular methods can expand the range of detectable signals, but they do not eliminate the need for validation, epidemiological interpretation or conventional microbiology.

Chemical hazard identification covers contaminants and undesirable substances in food and feed, including natural toxicants, mycotoxins, environmental contaminants and unauthorised residues. The CONTAM Panel's (Panel on Contaminants in the Food Chain) work illustrates the connection between food and feed: an assessment may concern adverse effects in humans, farm animals, fish or pets, or the possibility that contaminated feed creates a risk for consumers of animal-derived food (Alexander et al. 2012). This is compatible with a One Health perspective because environmental occurrence, feed exposure, animal health and human dietary exposure may form a connected pathway. Nevertheless, the scientific methods used to identify and characterise chemical hazards remain substance-specific and should not be replaced by a general One Health label.

Emerging hazards require a different type of identification because evidence is often incomplete and the relevant concern may initially appear as a weak signal rather than a characterised risk. Article 34 of Regulation (EC) No 178/2002 requires EFSA to

establish monitoring procedures for systematically searching, collecting, collating and analysing information to identify emerging risks (Regulation (EC) No 178/2002) EFSA's 2018 review of this procedure identified strengths in expert networks but also weaknesses in data collection and integration, consistent prioritisation, governance of follow-up actions and communication under uncertainty (Donohoe et al. 2018).

The 2025 annual report documents a broader system combining emerging-risk identification with horizon scanning, collaborative networks, structured characterisation and multi-agency activities. It reports that 55 topics were considered, 43 underwent in-depth analysis, 25 were characterised and four were identified as emerging risks. It also records the establishment of an EU early-warning system for emerging chemical risks (EFSA et al. 2026). These outputs indicate procedural development since the 2018 critique, but they do not by themselves demonstrate the predictive accuracy or public-health impact of the system. Emerging-risk identification remains constrained by early-signal uncertainty and by the need for continued monitoring and research (EFSA et al. 2026).

Taken together, the reviewed literature shows that One Health most clearly changes hazard identification by widening the search space and connecting signals across human, animal, food and environmental systems. Its added value depends on whether these signals are comparable, validated and relevant to the assessment question. More data sources do not automatically produce a more reliable assessment (Billington et al. 2022; Donohoe et al. 2018).

Hazard characterisation

Hazard characterisation is the qualitative or quantitative evaluation of the nature of adverse health effects associated with an identified hazard. Where the data permit, it includes assessment of the relationship between the magnitude of exposure and the frequency or severity of the response (FAO and WHO 2019). The methods differ substantially between chemical and microbiological hazards.

For chemical hazards, EFSA may establish health-based guidance values such as an acceptable daily intake (ADI), tolerable daily intake (TDI), or acute reference dose (ARD). For genotoxic carcinogens, or where the evidence is insufficient to derive a health-based guidance value, approaches such as the Margin of Exposure (MoE) may be used. The CONTAM Panel also considers uncertainties in hazard characterisation and exposure (Alexander et al. 2012). These methods are established components of chemical risk assessment; their relevance to One Health arises when toxic effects, occurrence and transfer must be considered across environmental, feed, animal and human compartments.

Probabilistic guidance for pesticide exposure illustrates the importance of explicitly separating variability from uncertainty. EFSA's guidance addresses acute and chronic exposure, multiple substances, residues below reporting limits, alternative assumptions and cumulative assessment. It recommends outputs that characterise the upper tail of exposure distributions and allow the reliability of estimates to be examined (EFSA PPR Panel 2012). Although this guidance is focused on dietary pesticide exposure rather than One Health as such, it provides the methods needed when an integrated assessment introduces heterogeneous sources of variation and incomplete evidence.

For microbiological hazards, characterisation often combines information on pathogenicity, virulence, susceptible populations, severity and dose-response. EFSA's assessment of L. monocytogenes in ready-to-eat foods provides a useful example. The assessment used a conceptual model that considered factors related to the host, the food, national surveillance systems and the bacterium. It integrated contamination and consumption data, host susceptibility, storage after retail, virulence information, quantitative modelling and whole-genome sequencing (EFSA BIOHAZ Panel et al. 2018).

The Listeria example shows why hazard characterisation cannot always be reduced to a single average pathogen effect. Differences in host susceptibility and strain characteristics can materially influence risk, while uncertainty remains because isolate collections, dose-response data and surveillance systems are incomplete or non-representative. The assessment also found that whole-genome sequencing could strengthen links among human cases and food isolates, but source attribution remained limited by the representativeness of isolates and by contamination occurring during processing (EFSA BIOHAZ Panel et al. 2018). Thus, integrating more biological detail improves resolution only when the supporting data are sufficiently representative.

From a One Health perspective, hazard characterisation is strengthened when evidence from clinical cases, food isolates, animal reservoirs or environmental persistence explains the differences in disease potential. However, the reviewed sources do not support treating every hazard-characterisation exercise as inherently One Health-based. The key question is whether cross-sector evidence changes the estimated nature or severity of the adverse effect. Where it does not, adding sectors may increase complexity without improving the scientific conclusion (EFSA BIOHAZ Panel et al. 2018; Alexander et al. 2012).

Exposure assessment

Exposure assessment is the qualitative or quantitative evaluation of the likely intake of a hazard through food and, where relevant, from other sources (FAO and WHO 2019). In EFSA practice, dietary exposure assessment relies on food-consumption information, occurrence data and factors related to processing, preparation and storage (EFSA 2011; EFSA PPR Panel 2012).

The EFSA Comprehensive European Food Consumption Database was developed from individual-level national dietary surveys and includes several age classes. The guidance accompanying the database also identifies methodological differences among national surveys, including differences in food description, classification and survey design (EFSA 2011). These differences are important because a shared database does not remove heterogeneity from its component data. Harmonisation improves comparability, but uncertainty associated with national methods and population coverage must remain visible.

Exposure may be estimated through deterministic or probabilistic approaches. Deterministic estimates are useful for screening or conservative scenarios. Probabilistic methods describe distributions of consumption and occurrence and can distinguish variability among individuals or samples from uncertainty caused by incomplete knowledge. EFSA's pesticide guidance provides

a structured approach to modelling acute and chronic dietary exposure, cumulative exposure and the effects of uncertain assumptions (EFSA PPR Panel 2012).

Quantitative microbiological risk assessment extends exposure assessment across the successive stages of a food chain. A review of dairy-product QMRA describes models in which contamination can change through growth, inactivation, redistribution, partitioning, processing and cross-contamination. It also emphasises that consumption patterns, transport, retail conditions, storage and raw-material hygiene can substantially affect the final risk estimate (Ramos et al. 2021). This farm-to-fork structure is closely aligned with One Health when animal production, environmental inputs or human practices influence contamination before consumption.

The One Health contribution is especially clear for AMR. Resistant bacteria, resistance genes and antimicrobial residues may move among healthcare, livestock, crops, wastewater, soil, water and food. A lifecycle perspective also draws attention to antimicrobial production, use and disposal as points at which selection or environmental release can occur (Al-Khalaifah et al. 2025; Altevogt et al. 2025). For food safety risk assessment, however, the relevant task is not merely to list all possible reservoirs. Exposure pathways must be linked to defined endpoints and supported by evidence on movement, persistence and contact with the assessed population.

This distinction prevents One Health exposure assessment from becoming unlimited in scope. Environmental or occupational routes should be included when they materially contribute to the food-related risk question or when the assessment explicitly covers broader health outcomes. Otherwise, the model may become too complex to parameterise or interpret. The reviewed literature repeatedly identifies the limited integration of environmental data, inconsistent monitoring and difficulty attributing the relative contribution of different sectors to AMR transmission (Al-Khalaifah et al. 2025; Destoumieux-Garzón et al. 2018).

Exposure assessment therefore represents both a major opportunity and a major constraint for One Health. It is the stage at which cross-sector connections must be converted into measurable pathways. Without harmonised occurrence, consumption, environmental and behavioural data, conceptual interdependence cannot be translated into quantitative estimates (EFSA 2011; Ramos et al. 2021; Donohoe et al. 2018).

Risk characterisation and prioritisation

Risk characterisation integrates hazard identification, hazard characterisation and exposure assessment to estimate the probability and severity of adverse effects in a defined population, including attendant uncertainties (FAO and WHO 2019). Depending on the purpose and the evidence available, the result may be qualitative, semi-quantitative or quantitative. In microbiological assessment, QMRA can provide numerical estimates of contamination or illness and can identify the model parameters that have the greatest influence on the result (Ramos et al. 2021).

A One Health risk characterisation may need to integrate evidence generated under different sampling frames, units, time periods and institutional purposes. The final estimate should not conceal these incompatibilities. Codex Alimentarius requires constraints, assumptions, uncertainty and variability to be documented at each stage and communicated in a form that is useful to risk managers (FAO and WHO 2019). This requirement becomes more important as the number of data domains increases. Risk ranking and prioritisation are related but distinct applications. The EFSA's prioritisation of zoonotic diseases for coordinated One Health surveillance combined multi-criteria decision analysis with a Delphi process. The method included defining pathogen- and surveillance-related criteria, weighting them, scoring diseases through Member State input, and discussing the resulting priorities in a workshop [EFSA et al., 2023b]. This provides a concrete example of One Health operationalisation because it converts heterogeneous criteria and stakeholder expertise into a transparent priority-setting process.

Such methods do not produce a conventional probability-of-illness estimate. They support decisions about where surveillance resources or methodological development should be directed. The distinction should remain explicit: risk characterisation estimates the risk under a defined assessment, whereas prioritisation compares problems using selected criteria and value judgements. The weighting of criteria belongs at the boundary between assessment and management and should therefore be documented transparently (EFSA et al. 2023b; FAO and WHO 2019).

Risk-assessment outputs also connect to food-industry controls. In QMRA, concepts such as an appropriate level of protection, food safety objective, performance objective and performance criteria can connect public-health goals to required changes in hazard frequency or concentration along the production chain (Ramos et al., 2021). EFSA scientific opinions may support regulatory limits, microbiological criteria or other management measures, while food business operators use those requirements within preventive systems such as HACCP. The scientific assessment informs these measures but does not replace the operator's process-specific hazard analysis or the risk manager's legal decision.

EFSA's institutional role in operationalising One Health

Legal mandate and scientific assessment

Regulation (EC) No 178/2002 established EFSA to provide scientific advice and scientific and technical support for EU legislation and policy in fields affecting food and feed safety. It requires scientific opinions to be independent, objective and transparent and gives EFSA functions related to data collection, scientific cooperation, communication and emerging-risk identification (Regulation (EC) No 178/2002). The regulation also situates food law across the stages of food and feed production, processing and distribution and allows the consideration of animal health and welfare, plant health and the environment where appropriate.

EFSA's scientific panels and working groups apply methods suited to different categories of hazard. The BIOHAZ Panel addresses food-borne zoonoses, food microbiology, hygiene, AMR and transmissible spongiform encephalopathies, using qualitative and quantitative approaches according to the terms of reference and evidence available (Nørrung et al. 2012). The CONTAM Panel assesses contaminants and undesirable substances in food and

feed and may evaluate effects in humans and animals or risks transferred from feed to foods of animal origin (Alexander et al. 2012). These examples demonstrate that EFSA's remit already crosses parts of the human-animal-food interface, although the degree of environmental integration varies among assessments.

EFSA's own strategic and editorial publications explicitly position One Health as relevant to future risk-assessment needs. They identify data access, harmonised terminology, environmental inclusion, partnerships and transdisciplinary expertise as continuing requirements (Bronzwaer et al. 2021; EFSA 2025). These documents are important evidence of institutional direction, but they are not the independent evaluations of implementation outcomes.

Integrated surveillance and cooperation among EU agencies

The annual EU One Health Zoonoses Report is the clearest recurring example of operational cooperation between EFSA and ECDC. The 2024 report integrates monitoring and surveillance information on humans, food, animals and feed from EU Member States and additional reporting countries (EFSA and ECDC 2025). Its value lies in presenting sector-specific data within a common epidemiological narrative. At the same time, the report itself shows that sampling responsibilities and results may differ among competent authorities and food business operators, illustrating why data provenance and surveillance design must remain visible.

Cooperation extends beyond EFSA and ECDC. A 2025 analysis describes scientific cooperation among EFSA, ECDC, the European Medicines Agency, the European Chemicals Agency and the European Environment Agency. The mechanisms include memoranda of understanding, working arrangements, coordination structures, data exchange, joint working groups, shared publications, horizon-scanning activities and capacity building (Tampach et al. 2025). The agencies' joint framework for action identifies strategic coordination, research coordination, capacity building, stakeholder engagement, and joint activities and partnerships as common objectives.

This cooperation has produced tangible outputs, particularly for zoonoses, food-borne outbreaks, AMR and chemical safety. However, the same analysis notes that relatively few joint publications involved more than two agencies and that its bibliographic review did not capture all forms of cooperation (Tampach et al. 2025). Formal agreements and joint outputs therefore demonstrate institutional activity, but they should not be equated automatically with the full integration of mandates, data systems or decision processes.

The Scientific Network on Microbiological Risk Assessment provides a second layer of cooperation by connecting EFSA with national organisations. Its annual report documents exchange on current microbiological assessments and scientific methods among participating countries (EFSA 2023a). This is relevant to harmonisation and shared capacity, although meeting participation and exchange of practice are intermediate outputs rather than direct measures of improved assessment quality.

Emerging risks and horizon scanning

Emerging-risk identification is one of the areas in which EFSA's legal mandate and One Health ambitions intersect most directly. Emerging issues may arise from biological hazards, chemical contaminants, technological change, environmental drivers, trade, food fraud or changing consumption habits. Because the initial evidence is incomplete, the task differs from a full risk assessment: it involves detecting and characterising signals, deciding whether additional data are needed, and determining whether an issue warrants monitoring or assessment (Donohoe et al. 2018; EFSA et al. 2026).

EFSA's 2018 evaluation found that expert networks were a major strength of the procedure, but it also identified a short- to medium-term focus on individual issues, inconsistent weighting and ranking, weaknesses in data integration, unclear follow-up governance and a need for better communication of uncertainty (Donohoe et al. 2018). These limitations are analytically important because they show that identifying more signals is not sufficient. A functioning system also needs transparent prioritisation, ownership of follow-up action and a way to evaluate whether the process improves preparedness.

The 2025 annual report describes the integration of emerging-risk identification and horizon scanning, broader use of collaborative networks, multi-agency foresight and a structured analysis of drivers, trends and weak signals (EFSA et al. 2026). The parallel multi-agency foresight report proposes moving from episodic exercises toward an institutionalised, modular capability with shared horizon scanning. Its central finding is that the principal bottlenecks are institutional rather than methodological: fragmented data governance, misaligned mandates and planning cycles, uneven capacity, and problems of trust and legitimacy (Könnölä et al. 2026).

Together, these documents suggest that EFSA's anticipatory activities have expanded since 2018, but they also confirm that technical methods cannot resolve governance problems on their own. Horizon scanning can identify possible future pressures; it cannot ensure that agencies share data, agree on priorities or have authority and resources to act on (EFSA et al. 2026; Könnölä et al. 2026).

EUFORA as a capacity-building instrument

The European Food Risk Assessment Fellowship Programme was established to expand the pool of food-safety risk-assessment experts, increase the involvement of Member States and contribute to a shared European risk-assessment culture. Its principal focus is chemical and microbiological risk assessment. The programme combines a 12-month learning-by-doing placement in a competent organisation with dedicated training (Alonso Andicoberry et al. 2022).

EUFORA's stated objectives are to attract and develop risk assessors, strengthen exchange between national bodies and EFSA, and contribute to harmonising risk-assessment practices and methods. Training covers the EU food-safety system, basic scientific and statistical concepts, chemical and microbiological risk assessment, emerging topics, risk communication, crisis response, and data collection and reporting. The programme also includes the publication of fellowship outputs and an alumni network (Alonso Andicoberry et al. 2022).

These characteristics make EUFORA relevant to One Health implementation because sustained cooperation requires professionals who can understand different evidence types and institutional contexts. The programme may support a common methodological language and create cross-border professional networks. Nevertheless, its role should not be overstated. The available programme description documents objectives, structure, evaluation processes and intended benefits; it does not establish that EUFORA alone produces harmonised One Health assessments or resolves structural barriers among sectors. It is therefore best presented as a one capacity-building mechanism within a wider institutional system (Alonso Andicoberry et al. 2022; Fernandes 2026).

Challenges, limitations and future directions

Data integration and the environmental component

The strongest recurring limitation in the reviewed literature is the gap between acknowledging interdependence and integrating usable evidence. One Health publications frequently include the environment conceptually, but comparatively few studies examine ecosystem processes, define shared indicators of ecosystem health or integrate environmental evidence at appropriate spatial and temporal scales (Destoumieux-Garzón et al. 2018). EFSA has similarly identified data access, harmonised terminology and environmental inclusion as challenges for transdisciplinary work (Bronzwaer et al. 2021).

Data integration is not simply a matter of combining databases. Human surveillance, veterinary monitoring, food-control sampling, environmental measurements and research studies may use different case definitions, sampling frames, analytical methods, metadata and reporting cycles. These differences limit comparability and complicate joint interpretation. The 2018 emerging-risk review consequently recommended improved data-processing pipelines, validation, FAIR data principles and data-sharing agreements (Donohoe et al. 2018).

Consistent with Codex Alimentarius requirements for clearly stated scope and transparent assumptions, integrated assessments should define the purpose of cross-sector data use before additional information is incorporated. They should specify which One Health domains are relevant to the assessment question, what each dataset represents, whether measurements are comparable and how missing or non-representative data affect the conclusion (FAO and WHO 2019; Donohoe et al. 2018). Environmental surveillance should be strengthened where it provides information that cannot be inferred from food, animal or human data, particularly for AMR reservoirs, wastewater pathways and persistent contaminants (Al-Khalaifah et al. 2025; Destoumieux-Garzón et al. 2018).

Institutional and governance barriers

Recent critical literature argues that the main difficulties of One Health implementation are structural. Human health, veterinary services and environmental management retain separate mandates, budgets, professional jurisdictions and accountability systems. Cross-sector collaboration may therefore be added to existing institutions without changing the incentives or authority that maintain sectoral work (Fernandes 2026).

The multi-agency foresight report reaches a compatible conclusion from a different source base. It identifies fragmented data governance, misaligned mandates and planning cycles, uneven organisational capacity, trust and legitimacy as central bottlenecks (Könnölä et al. 2026). These findings qualify optimistic descriptions of collaboration. Memoranda, networks and joint reports are necessary infrastructure, but long-term implementation also requires stable responsibilities, resources, shared standards and mechanisms for resolving disagreement.

The existence of participating sectors, memoranda or joint activities should therefore not be treated as sufficient evidence of effective integration. The reviewed institutional sources document cooperation mechanisms and outputs more extensively than their downstream effects on assessment quality or public-health outcomes (Tampach et al. 2025; Könnölä et al. 2026).

Methodological complexity, uncertainty and new technologies

Integrated assessments may be more comprehensive, but they can also accumulate uncertainty. Adding datasets with different biases and scales can create a more complicated model without improving validity. Codex requires uncertainty and variability to be explicitly considered, and EFSA guidance provides methods for probabilistic modelling and alternative assumptions (FAO and WHO 2019; EFSA PPR Panel 2012). In One Health assessments, the documented uncertainties should also include the validity of assumed cross-sector links, the comparability of surveillance systems and the representativeness of the included data domains (FAO and WHO 2019; Donohoe et al. 2018).

Genomics, metagenomics, automated data analysis and real-time surveillance are repeatedly proposed as future tools. Their strongest contribution is likely to be faster and higher-resolution detection, comparison of isolates and the investigation of complex microbial communities (Billington et al. 2022; Urban et al. 2023). Their limitations include incomplete standardisation, uncertain viability interpretation, sequencing and database errors, uneven infrastructure, bioinformatic requirements, data ownership and unequal access. They should therefore be incorporated as validated components of an assessment rather than presented as automatic solutions to fragmented evidence.

EFSA's Strategy 2027 and recent emerging-risk reports identify new data services, foresight, integrated early-warning systems, surveillance methods and One Health-oriented risk-assessment capabilities as priorities (EFSA 2025; EFSA et al. 2026). These priorities are consistent with the scientific literature, but implementation should be evaluated through transparent performance criteria rather than through the adoption of technology alone.

Ethical and normative tensions

One Health is often described as producing simultaneous benefits for humans, animals and the environment. In practice, interests may be in conflict. Zoonotic-disease control may involve culling healthy animals to protect public health, and antimicrobial restrictions may create tensions among disease treatment, animal welfare, production and long-term population benefit. Van Herten et al. argue that the conceptual flexibility of One Health facilitates cooperation but can conceal underlying normative differences when sectors do not benefit equally (van Herten et al. 2019).

These questions mainly concern risk management rather than the calculation of risk itself, but they affect problem formulation and communication. Assessments should state clearly whose health outcome is being estimated, which effects are outside the scope and where management choices require ethical or socioeconomic judgement. A broader evidence base should make trade-offs more visible, and not disguise them as purely technical decisions (van Herten et al. 2019; FAO and WHO 2019).

Priorities for further development

The reviewed evidence supports five practical priorities. First, assessment questions should define in advance which human, animal, food and environmental pathways are relevant, avoiding both sectoral omission and unnecessary expansion (FAO and WHO 2019). Second, shared metadata, validated analytical methods and interoperable reporting structures are needed before datasets can be combined reliably (Donohoe et al. 2018; Billington et al. 2022). Third, environmental surveillance should be developed where it materially informs source attribution, exposure or persistence (Destoumieux-Garzón et al. 2018; Al-Khalaifah et al. 2025). Fourth, cross-agency cooperation should move from episodic or time-limited activities toward stable governance and shared responsibilities (Fernandes 2026; Könnölä et al. 2026). Fifth, genomic, metagenomic and foresight tools should be implemented with standards for validation, transparency, data governance and equitable access (Billington et al. 2022; Urban et al. 2023; Könnölä et al. 2026).

Capacity building remains necessary across all five priorities. EUFORA, EFSA scientific networks and cross-agency training can support shared terminology and methodological competence, but professional education must also address the different assumptions, evidence hierarchies and responsibilities of public health, veterinary, food and environmental disciplines (Alonso Andicoberry et al. 2022; Fernandes 2026).

Conclusions

The integration of One Health into food safety risk assessment is best understood as an extension of the established Codex framework rather than a separate method. Hazard identification can draw on broader surveillance and molecular signals; hazard characterisation can combine information on pathogens, hosts and food matrices; exposure assessment can trace pathways across production, environment and consumption; and risk characterisation can integrate heterogeneous evidence while explicitly reporting uncertainty.

Within the reviewed material, zoonotic surveillance and AMR provide the clearest operational examples. EFSA and its partner agencies have created joint reports, scientific networks, cooperation agreements, emerging-risk procedures and foresight activities that support cross-sector work. These are substantive developments, but the evidence does not justify presenting One Health integration as complete. Environmental information remains inconsistently incorporated, data systems are heterogeneous, and cooperation continues to be constrained by mandates, resources, planning cycles and institutional accountability. EFSA's contribution is therefore significant but should be described precisely. It provides EU-level scientific assessment, coordinates networks, collects and analyses data, and cooperates with national and European bodies. It does not replace national institutions or risk managers, and its strategic publications should not be treated as independent proof of impact. EUFORA complements this system by developing expertise and professional networks, but it is a capacity-building instrument rather than the central mechanism of One Health implementation.

A stronger One Health approach to food safety will depend less on adding the label to existing assessments and more on demonstrating how cross-sector evidence changes the assessment question, the estimated exposure, the interpretation of uncertainty or the resulting priorities. Methodological innovation is necessary, but sustained governance, transparent data practices and the explicit treatment of trade-offs are equally important.

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