Policy Brief
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Next-generation detection technologies for food safety

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Main takeaways

- Emerging food safety risks are increasing due to climate change, globalisation, and changing consumption patterns.
- Traditional targeted monitoring systems are insufficient to detect complex and emerging hazards.
- Metagenomics, AI-supported analytics, and rapid diagnostics can significantly strengthen early warning and prevention capacities.
- Regulatory and validation frameworks for innovative detection technologies remain underdeveloped at EU level.
- Better alignment between regulation, risk assessment, and scientific innovation is needed to support implementation at scale.
- Integrated and interoperable EU data infrastructures are essential for predictive and risk-based food safety systems.

Introduction

Food safety systems across the European Union are under increasing pressure due to the emergence of new microbiological and chemical hazards. Climate change, globalised food supply chains, and changing consumption patterns are contributing to a more complex and dynamic risk landscape. Traditional monitoring approaches, largely based on targeted detection of known hazards, are no longer sufficient to ensure timely identification, prevention, and mitigation of risks. The HOLiFOOD project addresses these challenges by developing innovative analytical tools that support earlier detection, prevention, and risk-informed decision-making.

In this framework, researchers have focused on next-generation detection technologies for microbiological and chemical hazards. These include metagenomics, artificial intelligence (AI)-supported chemical analysis, and rapid on-site diagnostic tools. The results demonstrate that these technologies can substantially strengthen European food safety systems. At the same time, they reveal important scientific, regulatory, and operational gaps that must be addressed before large-scale implementation can be achieved.

Issue description

EU food safety systems are facing growing pressure from emerging microbiological and chemical hazards driven by climate change,

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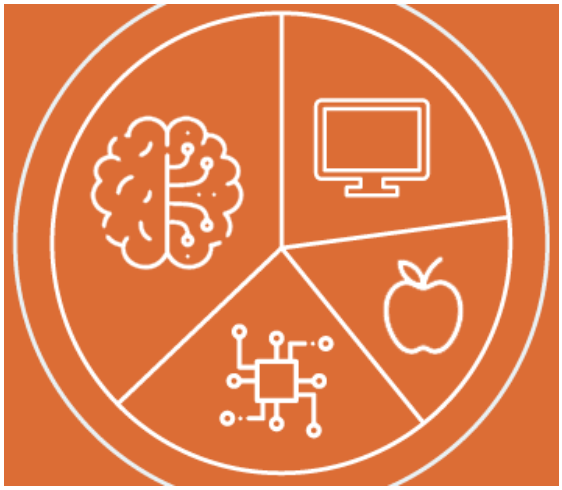
globalised supply chains, changing consumption patterns, and evolving production systems. These developments are increasing the complexity and dynamism of food safety risks across the European food chain.

Current monitoring and official control systems remain largely based on targeted detection of predefined hazards using conventional laboratory methods. While these approaches remain essential, they are less effective in identifying emerging, unexpected, or rapidly evolving risks. As a result, existing surveillance frameworks may not provide sufficient capacity for early warning, prevention, and rapid response.

For example, Listeria monocytogenes was detected in 12 of 13 sampled poultry slaughterhouses, demonstrating the persistence and widespread occurrence of important foodborne hazards within food production systems. At the same time, next-generation technologies such as metagenomics, AI-supported analytical methods, and rapid on-site diagnostics show strong potential to strengthen hazard detection and support more predictive and risk-based food safety management.

However, the deployment of these technologies remains constrained by scientific, regulatory, and operational barriers. These include limited harmonisation of validation procedures, challenges related to data interpretation and biological complexity, and the absence of clear implementation pathways within EU regulatory frameworks.



Without coordinated European action, the integration of these innovations into official food safety systems may remain fragmented, limiting the EU's capacity to respond effectively to emerging food safety threats.

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Key messages for policy makers

Recommendation #1:

Strengthen EU validation and regulatory frameworks for next-generation detection technologies

Innovative detection technologies are increasingly capable of supporting early warning, prevention, and risk-based food safety management. HOLiFOOD demonstrated that metagenomics can simultaneously detect multiple pathogens, while AI-supported high-resolution chemical screening can identify unknown contaminants and contamination patterns. Rapid diagnostic tools, including portable PCR systems, biosensors, and spectroscopy-based approaches, also demonstrated strong potential for near real-time application along food supply chains, complementing conventional laboratory-based confirmatory methods and strengthening preventive controls.

Despite these advances, current EU food safety legislation and official control systems remain strongly centred on conventional laboratory-based confirmatory methods. The absence of harmonised validation criteria and regulatory pathways for metagenomics, AI-supported analytical methods, and rapid diagnostics limit wider implementation across Member States.

EU-level action is therefore needed to:

- establish harmonised validation frameworks for innovative detection technologies;
- develop guidance for interpretation and use of AI-supported analytical tools;
- support interoperability and comparability across Member States;
- and facilitate integration of validated rapid screening tools into official controls and preventive monitoring systems

Such measures would support the transition from reactive monitoring towards more predictive and risk-based food safety systems.

Recommendation #2:

Adapt risk assessment methodologies to better account for biological complexity and uncertainty

HOLiFOOD findings demonstrate that biological complexity can significantly influence hazard detection and risk assessment outcomes. Research showed that microbial competition in complex food matrices may lead to under-detection or false negatives for certain pathogens in complex food matrices, highlighting important limitations in current monitoring approaches. In addition, substantial differences were observed between strains of the same pathogen, including highly resistant and persistent subpopulations that may not be sufficiently captured by current risk models.

The project also demonstrated that explainable AI approaches can improve transparency and trustworthiness in the use of advanced analytical tools, thereby supporting future regulatory acceptance of AI-assisted decision-support systems. Explainable AI helps clarify how models generate predictions and supports future regulatory acceptance of AI-assisted decision-support systems.

To ensure reliable and scientifically robust risk assessment, EU institutions and national authorities should:

- update risk assessment methodologies to better reflect biological variability and uncertainty;
- promote probabilistic and data-driven modelling approaches;
- strengthen guidance on the use of AI and advanced analytics in food safety;
- and support explainable and transparent AI systems to improve accountability and trust.

Closer cooperation between regulatory authorities, EFSA, JRC, scientific institutions, and national competent authorities will be essential to achieve consistent implementation.

Recommendation #3:

Support integrated European data infrastructures and coordinated surveillance systems

Next-generation food safety monitoring depends on access to integrated, interoperable, and high-quality datasets. HOLiFOOD highlights the importance of combining targeted and untargeted surveillance approaches to improve flexibility and responsiveness across different hazards and food matrices.

The project also demonstrates the value of coordinated data sharing and integrated analytical platforms for strengthening early warning capacities across the European Union. Real-time or near real-time data exchange can support earlier detection and coordinated responses and enhance preparedness for emerging food safety threats.

To strengthen EU resilience, policymakers should:

- support interoperable EU-wide data infrastructures;
- promote standardised data-sharing practices across Member States;
- support real-time or near real-time data exchange to strengthen coordinated early warning and response capacities across the EU;
- expand surveillance systems to include emerging and opportunistic hazards;
- and encourage integration of genomic, microbiological, and chemical monitoring data.

A coordinated European approach will be critical to ensuring that innovative detection technologies can effectively contribute to public health protection and food system resilience.

Conclusion

HOLiFOOD demonstrates that next-generation detection technologies can significantly strengthen the European Union's capacity to identify and respond to emerging food safety risks. Metagenomics, AI-supported analytics, and rapid diagnostic tools provide important opportunities to improve early warning, prevention, and risk-based monitoring across food supply chains. However, scientific innovation alone is insufficient. Effective implementation will require enabling regulatory frameworks, harmonised validation methodologies, updated risk assessment approaches, and interoperable European data infrastructures. European Commission services, EU agencies, and national authorities should work together to support the transition towards a more preventive, data-driven, and resilient European food safety system.

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