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Food Safety Regulatory Research Needs 2030

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The European Food Safety Authority (EFSA) regularly collects recommendations from members of the Scientific Committee and Scientific Panels on EFSA's research needs and priorities (EFSA, 2017). At the end of the 2015–2018 Scientific Panels mandate, we collected views of outgoing Panel members on what food safety research areas should be prioritised for the coming 5–10 years. The objective was, not only to capitalise on experience gained during the Panel mandate, but also to inform research agendas, such as the upcoming Horizon Europe – Research Programme. The identification of risk assessment research priorities and the communication of such priorities to the relevant actors is an important aspect of the 'EFSA Strategy 2020: Trusted science for safe food'.¹ In addition to the Panel members, EFSA staff and other EFSA partner organisations and stakeholders were consulted, including the following:

- By July 2018, 43 research needs were received from Scientific Committee/Scientific Panel members, as well as from EFSA's own scientific staff, describing briefly the scope and desired impact of the research.
- These research needs were collated and shared with EFSA's Advisory Forum for comments by September 2018.
- During EFSA's Scientific Conference (18–21 September 2018),² EFSA consulted the wider scientific community participating in the conference and received 30 additional contributions.
- The various inputs were grouped into themes, and then tabled for consultation with EFSA's stakeholders at the Stakeholder Forum meeting (20 November 2018).³
- These consultations formed the basis for EFSA to formulate its regulatory research priorities under three research streams (Safe Food Systems, Innovation in Risk Assessment, and Holistic Risk Assessment).
- These research streams and priorities were tabled at the workshop: 'Food Safety Systems for the Future' on 17 January 2019 that was convened by Directorate General Research &



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¹ http://www.efsa.europa.eu/sites/default/files/corporate_publications/files/strategy2020.pdf

² <http://www.efsa.europa.eu/en/events/event/180918>

³ <http://www.efsa.europa.eu/en/events/event/181120>

Innovation, where the chair of EFSA's Scientific Committee introduced the first break-out session to define the main challenges and opportunities for food safety.

- In February 2019, the Scientific Committee discussed and endorsed the research needs.

In formulating the research needs, attention was paid to relate to the current debate and reflections in preparation towards Horizon Europe. In particular, the Food2030⁴ debates are relevant for food safety, where Research & Innovation will need to support a systems change, in ways to deliver enough safe food to feed a growing world population. Considering the UN Sustainable Development Goals and citizens' requests for sustainable and safe food, regulatory science will need to support sustainable food systems by assessing the safety and efficacy of innovation in the food chain. The 7th Environment Action Programme (EAP)⁵ formulated an inspiring forward-looking vision: 'In 2050, we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. ...'. Furthermore, research needs identified in the 'JRC report on delivering on EU food safety and nutrition in 2050' (Mylona et al., 2016) have informed this paper.

Recent discussions and statements, including the 'Lamy Report'⁶ and the Tallinn Call for Action,⁷ call for better alignment with EU/national R&I investments and facilitate collaborative approaches. The interim evaluation of the H2020 research programme found that more attention needs to be given to make sure research delivers impact. Therefore, our research priorities do not stop strictly at the borders of risk assessment but consider the full risk analysis framework to ensure that research and innovation indeed can deliver the desired innovation and impact on science and society.

Innovation is important to EFSA's work, for example, when performing safety assessments of regulated products in food, feed and the environment, to be able to assess novel products in a pre-market phase (e.g. synthetic biology, nanotechnology). Therefore, we choose to formulate broad research streams, showing the interconnectivity and impact on science and society, under which we brought together the more specific research themes and topics from the consultations. The ten research themes and underlying topics from the consultations are listed in Annex A.

Other important developments that influenced the formulation of these research needs include the cooperation with other EU Agencies and the Risk Assessment Research Assembly (RARA).⁸ In February 2018, EFSA convened policymakers and the wider scientific community (200 participants from 39 countries) to discuss research priorities and ideas (EFSA, 2018). On this occasion, EFSA's Advisory Forum highlighted the mutual benefits of increased interaction between funders, EU agencies and national partners on food safety research,⁹ to enable:

- access to expert networks in Member States (MS), pre-accession and neighbourhood countries
- avoid duplication/redundancy in research efforts
- strengthen the science/policy interface and help research to deliver impact
- exploit outcomes of research projects and provide sustainable follow-up
- disseminate research results: engage regulators, public bodies, civil society.

EFSA performs regulatory science, assessing the latest science to inform policy decisions, and operates a large network in and beyond Europe. EFSA actively works with many partners to exchange data, information, expertise and staff, through our Advisory Forum and 375 competent organisations, including public authorities, universities and research organisations. EFSA coordinates 16 scientific networks with representatives from all MS and is active in several international networks and liaison groups, such as the Global Coalition for Regulatory Science Research.¹⁰

In response to the call for coordination in the area of food safety research at the RARA event, where participants called on EFSA to be a knowledge-broker between scientists and policy makers, EFSA established a Research Platform (<http://www.efsa.europa.eu/en/engage/research-platform>) on its website that is home for the wider food safety research community, aiming to support project ideas, promote consortia formation, and help scientists find opportunities for food safety research funding.

⁴ <http://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=food2030>

⁵ <http://ec.europa.eu/environment/action-programme/>

⁶ http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/hlg_2017_report.pdf

⁷ https://www.hm.ee/sites/default/files/tallinn_call_for_action_2017.pdf

⁸ <http://www.efsa.europa.eu/en/events/event/180207>

⁹ <http://www.efsa.europa.eu/en/press/news/180206>

¹⁰ <https://www.fda.gov/about-fda/science-research-nctr/global-summit-regulatory-science>

EFSA works closely together with the EU Agencies Network for Scientific Advice (EU-ANSA)¹¹ that provide scientific advice to EU policymakers. This network recently published a reflection paper (EU-ANSA, 2018) that proposes actions to enhance the added value of EU agencies to EU research actors and policymakers in the EU institutions, by engaging more actively in the research knowledge cycle. One such action for EU Agencies is to be more actively involved in shaping and informing research agendas.

In order to inform research agendas, this paper presents, in the following tables, three research streams bringing together the main research needs and priorities in support of food safety risk assessment in the coming years. These Food Safety Regulatory Research Needs for 2030 should be useful when developing Safe Food Systems of the future as well as EFSA's Strategy for 2027.

1. SAFE FOOD SYSTEMS

Improve food safety while moving towards alternative and sustainable production systems

This research stream shall consider impacts on food safety of innovation in food production and food systems. Risk assessment operates at the science-policy interface, informing decision- and policy-making and food safety is integral part of food and nutrition security. For food systems to be safe, it does not suffice to assess risks, but also benefits, impacts and alternatives need to be assessed and put into the equation. This should be done at processing level as well as primary production level, hence animal and plant health issues need to be considered. Dietary prevention strategies focusing on energy or single nutrients have generally failed and should be broadened.

Themes	Impact
Food Risk Analysis Capacity	<ul style="list-style-type: none"> • Widening the EU food risk analysis capacity to incorporate risk-benefits in the socio-economic analysis of alternative and sustainable production systems • Increased EU capacity for Agri-Food Technology impact assessment to anticipate impacts of food safety interventions
Reduce, Replace, Re-organise across the food chain	<ul style="list-style-type: none"> • Primarily aimed at reducing the impacts of pesticide use on human health and the environment by alternative approaches • Stimulate innovation by developing and introducing non-chemical alternatives such as microorganisms used as Plant Protection Products (PPP) • Understand the influence of soil and ecosystems for alternative and sustainable production systems
Ensure food, feed, nutrition security	<ul style="list-style-type: none"> • Consider the continuum of food safety & food and nutrition security • Support food sustainability through safe agricultural and aquaculture practices • Quicker detection of food fraud through improved surveillance • Smarter methods to responsibly deal with food, including reduction of waste • Anticipate the impact of socio-demographic and consumer trends on food availability, product reformulation and dietary patterns • Establish the public health impact of food fortification • Ensuring nutritional health through understanding and acceptance of science-based dietary guidelines • Shift attention towards overall dietary patterns and role of specific foods on disease prevention
Impact of new technologies on food production and circular economy	<ul style="list-style-type: none"> • Ability to assess impact of new technologies on food production (e.g. emissions) and circular economy (e.g. reintroduction of food waste) • Deliver tools to identify vulnerable systems for food production, susceptible to (multiple) pest and pathogens • Development of novel foods and feeds and ensuring their safety, including the development of safe GMO-based plant and animal products • Deliver methods for assessing the environmental impact of new technologies. • Better preparedness through transdisciplinary analysis of threats to food safety, for migrant and indigenous populations
Impact of social changes	<ul style="list-style-type: none"> • Anticipate how social changes (e.g. climate change, consumer choices, migration, personalised nutrition) drive changes in exposure patterns, and choices in diets that may constitute new hazards • Support personalised nutrition, while providing an assessment of nutrient intake and nutritional status across different populations, including migrants

¹¹ <https://fra.europa.eu/en/cooperation/eu-partners/eu-agencies/eu-ansa>

2. INNOVATION IN RISK ASSESSMENT

Anticipating impact of innovations and new technologies on integrated risk assessment

This research stream shall consider what impact new knowledge and tools may bring to risk assessment of food safety, so to be prepared for the future. The current risk assessment paradigm is challenged by recent scientific and technical advances, and public demands. The current approach is considered too resource-intensive, is mostly animal-based and can raise issues in terms of reproducibility and ethics. A paradigm shift is required to deliver testing strategies that enable reliable, animal-free hazard and risk assessments, which are based on a mechanistic understanding of chemical toxicity. Increasingly, we see that different compartments are interlinked, and understand the importance of a OneHealth approach.

Themes	Impact
Integrated approaches for chemical and microbiological hazards and antimicrobial resistance	<ul style="list-style-type: none"> • Apply an integrated risk assessment approach on chemical and biological hazards including social and environmental factors based on a 'One Health' approach • Have means to identify emerging chemical and biological risks at global level and propose prevention strategies • Identify potential hazards associated with antibiotic resistant species present in food of non-animal origin and the environment • Using standardised and validated analytical and sequencing methodologies and tailored tools to use Whole Genome Sequencing (WGS) analysis for risk assessment purposes • Integration of molecular data (genomics, transcriptomics, proteomics and metabolomics) in microbiological risk assessment
Integrating new technologies in risk and safety assessment	<ul style="list-style-type: none"> • New methodologies: integrated non-animal testing, integrated exposure assessment, new approach methodologies based on <i>in silico</i> and <i>in vitro</i> approaches, mechanistic information (e.g. Adverse Outcome Pathway, impact of regulated products) • Facilitate the paradigm shift in terms of gathering/accessing new data and re-engineering/making better use of available ones • Develop approaches to assess the health relevance of changes in the microbiome • Incorporate knowledge from interindividual variabilities in metabolism and susceptibility in population-based assessment
Integrating new knowledge in risk and safety assessment	<ul style="list-style-type: none"> • To have measures from biomonitoring, microbiome and exposome analysis that reflects consumer 'real life' exposure • To develop methodologies for the safety assessment of the combined exposure and effect of multiple chemicals in food • To integrate knowledge generated by the new technologies into risk assessment and regulatory processes
Integrated approaches to pests and diseases in plants and animal production	<ul style="list-style-type: none"> • Have a holistic approach on assessing the environmental impact of farming practices, crop threats (e.g. plant pests and diseases, climate change effects as droughts, floods etc.) and threat mitigation measures (e.g. PPP, resistant plant varieties, fertilisers, irrigation, etc.) to biodiversity and ecosystem services
Integrating outcomes of human and environmental risk assessment	<ul style="list-style-type: none"> • Have indicators for 'chemical, microbial and overall safety' of food products, and for sustainability of 'safe food production' • Have a systems approach to environmental risk assessment • Understand the dynamics of micro-/nano-plastics in food chain and impacts on health • Develop landscape-based environmental scenarios for non-target organisms and the impact of regulated stressors • Ability to assess safety and human and environmental impact of technologies such as nanomaterials and synthetic biology • Develop tools to consider protein toxicity and allergenicity

3. HOLISTIC RISK ASSESSMENT

Understanding the context and delivering and communicating impactful science

Holistic risk assessment uses insights from society, explores the use of latest technologies and relies on outstanding scientific expertise. Coupled with evidence-based risk communication, these elements allow delivery of impactful scientific advice meeting expectations of citizens. This research stream will focus on understanding the societal context in which science is delivered, as well as how that science can be strengthened - through the use of big data and innovative tools in the risk assessment process and by building a generation of experts who are able to use evidence from different disciplines. To understand the context, research will focus on understanding citizens' awareness, perceptions and behaviour, integrate risks and benefits, while at the same time promoting education and mobility of experts to acquire transdisciplinary expertise.

Themes	Impact
Social research to understand citizens' awareness, perceptions and behaviour in the area of food safety	<ul style="list-style-type: none"> • Insights from social research will help identify right timing and adequate methods of engaging with society during the risk assessment process • Understanding citizen's perceptions will inform risk communication which, on evidence-base, will employ a tailored approach to meet the information needs of target audiences • Improvements to the way science is communicated will contribute to accountability and trustworthiness of regulatory bodies • Traditional quantitative and qualitative methods will be complemented with tools such as social media analysis, or community-based monitoring
Integrated risk-benefit assessment	<ul style="list-style-type: none"> • To develop and apply methodologies for the combined effects of risks and benefits into one overall assessment, using the same denominator (e.g. Disability Adjusted Life Years, cost-of-illness) • To develop and apply cost-benefit assessment methodologies to assess costs associated with preventing risks and/or establishing benefits • To develop and apply methodologies for risk-risk comparisons and risk-ranking • To develop and apply methodologies for communicating on and informing risk-managers on risk-benefit assessments, cost-benefit assessments, risk-risk comparisons and risk ranking endeavours
Tools for data-driven food systems	<ul style="list-style-type: none"> • Ability to use crowdsourcing, operate real-time monitoring and signal alerts with help of appropriate big data analytical platforms to assess effectiveness of interventions • Improving tools and approaches in exposure assessment • Open and interoperable data from various domains to support risk assessment • Benefits of using blockchain technology along the food chain, including for supply chain monitoring and potential prevention of food fraud
Artificial Intelligence and machine learning	<ul style="list-style-type: none"> • Intensified cooperation with wider society and value provided by society for risk assessment through the use of Artificial Intelligence (primarily focused on machine learning) by real time analysis of big data (incl. Internet of Things) • Increased efficiency (in terms of time and human resources) in the data-to-evidence process (search, appraise, integrate)
Building capacity for future transdisciplinary expertise	<ul style="list-style-type: none"> • Training programmes will widen scientist's knowledge and provide hands-on experience in risk assessment and communication • The mobility nature of the programme will ensure familiarity with different disciplines, for experts to acquire transdisciplinary expertise • Educate next generation experts for risk assessment and food safety

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Abbreviations

EAP	Environment Action Programme
EU-ANSA	EU Agencies Network for Scientific Advice
FCM	food contact material
GMO	genetically modified organism
MS	Member State
PPP	Plant Protection Products
RARA	Risk Assessment Research Assembly
WGS	Whole Genome Sequencing

Annex A – Consolidated Research Themes and Topics suggested in consultations

1) **THEME: Integrated approaches for microbiological hazards**

- Use of meta-genomics and meta-transcriptomics in food safety;
- Development of biomonitoring for cross domain monitoring and exposure assessments;
- Investigating the role of food-borne infections in mental health;
- Use of social science and economic analysis to incentivise food safety initiatives;
- Safety of microorganisms used in the food and feed chain;
- Gain monitoring microbiological data from the private food sector;
- Testing novel prebiotic drugs based on nanoparticles (inorganic).

2) **THEME: Tackling antimicrobial resistance**

- Use of bacterial isolates from EU surveillance for molecular epidemiology studies;
- Epidemiology of antimicrobial resistance in animal primary production environment;
- Biosecurity in livestock production to reduce disease introduction and antimicrobial resistance;
- Role of the environment and food of non-animal origin (including probiotics) in the transmission of antimicrobial resistance;
- Bacteriophages.

3) **THEME: Dealing with new opportunities from the human microbiome**

- Microbiome as a protection goal: how can a healthy microbiome be defined and preserved?
- Approaches to evaluating and interpreting effects on the microbiome;
- Food additive effects on microbioma at different ages;
- Probiotics and activity on Microbiome;
- Personalised use of probiotics and prebiotics for treatment of metabolic syndrome;
- Early life exposure;
- Gut-brain axis: healthy food → positive cognitive effects.

4) **THEME: Migration and food safety**

- Human migration – unusual pathogens, new food habits, and food safety;
- Assessment of nutrient intake and nutritional status of immigrant populations in the EU;
- Promote the EU high safety standards beyond the EU and create possibilities for exchange and learning.

5) **THEME: Integrated approaches to pests and diseases in plants and animal production**

- Wild-life surveillance to reduce introduction of transboundary diseases in livestock;
- Plant health crisis preparedness: breeding plant resistance to invasive alien pests and pathogens;
- Plant health crisis preparedness: improving agro-ecosystems resilience to invasive alien pests and pathogens, also in context of climate change;
- Multiple pest risk assessment: develop methods to identify vulnerable systems, susceptible to (multiple) pest and pathogens.

6) **THEME: Tools for data-driven food systems**

- Improving tools and approaches in exposure assessment in risk analysis;
- Databases representing today's reality in Europe across populations and sub-populations, using established and new statistical, sampling and refinement methods;
- Performing representative biomonitoring studies for different exposure scenarios;
- Developing PBPK models and methods to convert external into internal exposure;
- Non-dietary cumulative exposure and risk assessment;
- Integrate involvement with wider society and Artificial Intelligence;
- Use of computational science in risk assessment;
- Open (interoperable) data from various domains to support risk assessment.

7) **THEME: Food safety – systems approaches to human risk assessment**

- Methods for evaluation of nanoparticles in food;
- Integration of big molecular datasets in risk assessment of GMO products;

- Identification of Adverse Outcome Pathways, including integration of large molecular datasets;
- Integrated risk-benefit assessment of food safety and nutrition;
- Protein toxicity and allergenicity;
- New challenges: risk assessment of RNAi-derived applications;
- Analytical tools to improve the risk assessment of food contact materials (FCMs);
- New tools for assessing genotoxicity potential, of chemical substances, with an emphasis on mixtures;
- Developmental Neurotoxicity Testing Strategy;
- Risk assessment for microorganisms used as plant protection products;
- Tools for evidence synthesis and integration;
- Special climates – accessibility to healthy food/Awareness of food choices;
- Probiotics and personalised foods for Sport and Pain Medicine;
- Food-borne viruses (e.g. Hepatitis E), viraemia, diagnostics/infectivity assay, WGS.

8) THEME: Food safety – systems approaches to environmental risk assessment

- Understanding the functioning of ecosystems and their contribution to ecosystem services – impact of regulated stressors on ecosystem services;
- Methodologies for assessing environmental impact of diets in Nutrition;
- Landscape based environmental scenarios for all non-target organisms;
- Environmental Fate and Behaviour of plant protection products (e.g. spray drift);
- Risk assessment for microorganisms used as plant protection products;
- Developing new methodologies for agriculture without PPPs → sustainable food production;
- Soil at the root of food production;
- Creating new environment-friendly materials.

9) THEME: Ensure food, feed, nutrition security

- Food sustainability through better agricultural practices and sustainable diets;
- Methods for assessing environmental impact of diets in nutrition;
- Development of novel food and feed and their safety;
- Development of GMO organisms (plants or animals) and safety;
- Parameters of efficient production of edible protein of animal origin;
- Advanced glycation end products and ageing-related diseases;
- Probiotics and personalised nutrition choices;
- Food Fraud and Blockchain;
- Aquaponics in agriculture as sustainable solution;
- Increased food production from aquaculture to be assessed for residues and contaminants, as well as assessment of production processes.

10) THEME: Holistic risk assessment

- Food safety risk communication. Public perception of food safety. Behaviour change.
- Consumer education on food hygiene at domestic level
- Whole food system wide risk assessment = holistic risk assessment
- Risk-benefit: negative effects of risk mitigation efforts on food safety and sustainability → integrated approach.
- Integrated risk assessment not only of food components but also other consumer products.
- Tools to integrate assessment from multiple sources and multiple routes.