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Addressing the need for safe, nutritious and sustainable food: Outcomes of the "ONE – Health, Environment & Society – Conference 2022″

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ABSTRACT

Background: On 21–24 June 2022, the European Food Safety Authority, together with the European Centre for Disease Prevention and Control, the European Chemicals Agency, the European Environment Agency, the European Medicines Agency, and the Joint Research Centre of the European Commission, held the "ONE – Health, Environment & Society – Conference 2022".

Scope and approach: The conference brought together experts and stakeholders to reflect on how scientific advice related to food safety and nutrition will need to develop to respond to a fast-changing world. The event also explored how institutions that provide such advice should best prepare for the challenges ahead, and how they can contribute to policy targets and societal demands for safe, nutritious and sustainable food.

Key findings and conclusions: Overall, participants concluded that food safety assessments must be further advanced to remain fit for purpose and increase their relevance to society. To address the growing complexity in science and society, new ways of working that connect and integrate knowledge, data and expertise across a wide range of disciplines, sectors and actors must be embraced. One Health provides a valuable conceptual framework for advancing food safety assessments by ensuring the delivery of more integrated, cross-sectoral and collaborative health assessments. These assessments may help to better inform policies that support the transition towards a sustainable food system. As such, One Health could serve as a steppingstone to sustainable food. Urgent action is now required to define how the One Health principles can be implemented in food safety and nutrition.

1. Introduction

The European Food Safety Authority (EFSA) is the agency of the European Union (EU), set up in 2002, that contributes to the safety of the European food and feed chain by: providing independent scientific advice to risk managers (such as the European Commission (EC), the European Parliament and EU Member States) on a wide range of food-related issues; and communicating on existing and emerging risks in the food chain. EFSA's scientific advice helps to protect consumers, animals, plants and the environment from food-related risks, from farm to fork (EFSA, 2021). To deliver the highest societal value in response to its mandates, EFSA keeps up with the latest developments in science and technology, capitalises on new data and works with experts, including national risk assessment organisations, across the EU (Url, 2022). EFSA also teams up with other EU Agencies, international organisations and risk assessors in non-EU countries to increase food safety impact and outreach. Recent amendments to the EU Food Law (EU, 2002) introduced by the Transparency Regulation (EU, 2019), which came into effect in 2021, have further prompted EFSA to integrate societal expectations towards more transparency and openness in its risk assessment processes (Url, 2022).

Every three to four years, EFSA organises an international scientific conference where it gathers around one thousand participants on site and many more online. The first conference "Challenging Boundaries in Risk Assessment" was held in 2012 in Parma to mark EFSA's 10th anniversary; the second one "Shaping the Future of Food Safety, Together" at the World Expo in Milan in 2015; and the third one "Science, Food & Society" in 2018 in Parma. The last edition of the conference "ONE – Health, Environment & Society – Conference 2022" took place on 21–24 June 2022 in Brussels.

The 2022 edition of the conference was special for two specific reasons. First, it marked EFSA's 20th anniversary. Second, for the first time, the conference was organised by EFSA, together with its partner agencies (the so-called "EU ENVI Agencies" that provide scientific advice on environmental, public health and food safety issues) the European Centre for Disease Prevention and Control (ECDC), the European Chemicals Agency (ECHA), the European Environment Agency (EEA), the European Medicines Agency (EMA), as well as the EC's Joint Research Centre (JRC), with the ambition of embracing a One Health approach for more integrated, cross-sectoral and collaborative health assessments.

The objective of the conference was to reflect on how scientific advice on food safety and nutrition will need to develop to respond to a fast-changing world. The conference was also intended to explore how institutions that provide such advice should best prepare for the challenges ahead, and how they can contribute to current and new policy targets and societal demands for safe, nutritious and sustainable food. A particular emphasis was placed on exploring whether the One Health conceptual framework could serve as a bridge between food safety, nutrition and sustainability. One Health stands for an integrative and systemic approach to health, grounded on the understanding that human health is closely linked to the health of animals, plants and the

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environment. It aims at balancing and optimising the health of humans, animals, plants and their shared environment at the local, national, regional and global levels. While there is no universally accepted or commonly applied definition, existing definitions share the principles of transdisciplinary cooperation across different sectors and actors (Bronzwaer et al., 2021). One Health is a well-established and globally applied concept. For example, the United Nations Food and Agriculture Organization (FAO), the World Organisation for Animal Health (OIE), the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) established the One Health High-Level Expert Panel. At the EU level, the EC as well as the French Presidency of the European Council have made One Health central to their health policy initiatives.

An important goal of the conference was to zoom in on the main principles of the One Health conceptual framework, consisting of: an integrative and systemic approach; transdisciplinary exchanges; and collaboration with co-creation. Applying these principles to food safety and nutrition would allow the increasing complexity and urgency of health and food safety challenges to be addressed by ensuring the delivery of more integrated, cross-sectoral and collaborative health assessments. The delivery of these health assessments may be seen as a way to better inform policies that support the transition towards a sustainable and resilient food system that puts the health of people, animals, plants and their shared environment at its core. As such, One Health could be a steppingstone to sustainable food, connecting food safety to food system sustainability (see Fig. 1). The conference also offered an opportunity to share knowledge and expertise, and address key topics on the European political agenda.

2. Conference at a glance

The conference consisted of a four-day event that took place in Brussels and online. An opening plenary session (including an opening ceremony) kicked off the event, followed by a series of thematic (breakout) sessions (#17) organised around four thematic tracks (One Life, One Planet, One Society and Many Ways) (see Fig. 2), across three interconnected tiers (food safety, One Health and food system sustainability).

The plenary and thematic sessions were complemented by side events, a poster exhibition gallery and networking opportunities for both in-person and online participants. Some side events, in the form of workshops, took place before the formal start of the event. A closing plenary session wrapped up the event giving strategic direction on how to further advance food safety in light of the One Health principles. The final scientific program of the conference is available in the supplementary electronic material of this Conference Report article.

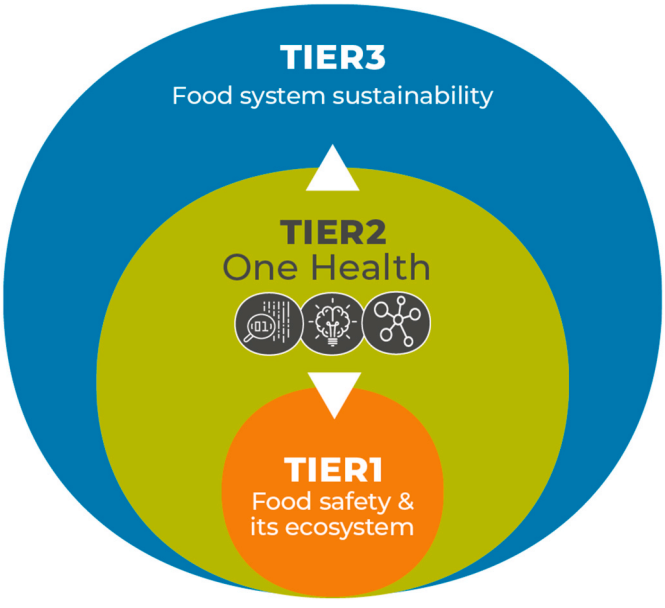

Fig. 1. Narrative of the event, with the One Health conceptual framework serving as a steppingstone to sustainable food, connecting food safety to food system sustainability.

Over 2,700 participants, of which nearly 260 program affiliates (i.e. chairpersons, speakers, moderators, panellists, rapporteurs) from academia, public institutions, the private sector and non-governmental organisations, mostly from the EU, attended and contributed to the conference, either in-person or remotely. The conference included more than 120 talks and over 250 digital posters. Speaker/poster abstracts, slides, video recordings of the conference and interviews with some leading experts are publicly available at the conference website (https://www.one2022.eu/) and EFSA's YouTube channel (https://www.youtube.com/c/EFSAchannel/videos).

3. Session outcomes

The main outcomes of each session are presented below. Thematic sessions are presented per track.

3.1. *Opening plenary session "What's next for food safety assessments?" (session coordinator: Yann Devos)*

Food safety assessments play a crucial role in ensuring that food (including feed and derived products) stays safe. Operating at the interface between science, society and policy, food safety assessments have been impacted by many changes across different fields, such as innovation in science and technology, globalisation, climate change, societal expectations and new policy targets. Besides creating opportunities, such changes also pose critical challenges for food safety science.

To ensure that food safety assessments remain fit for purpose in light of a fast-moving world, and continue to protect human, animal, plant and environmental health, they will need further advancement at different levels (Devos et al., 2019; EFSA, 2021; Garcia-Vello et al., 2022). The opening plenary session entitled "What's next for food safety assessment" addressed how food safety science will need to develop to ensure preparedness for the challenges ahead. Future scenarios for food systems, food safety, engagement and communication were explored. In addition, specific emphasis was placed on One Health in an effort to develop more integrated, cross-sectoral and collaborative health assessments. The session was designed to set the scene for in-depth discussions that continued in the thematic sessions of the conference.

Jessica Fanzo (Johns Hopkins University) explained that with climate change, conflict and the Covid-19 pandemic – the "three Cs"– food systems are more vulnerable than ever. Currently, the "three Cs" cause food shocks, which threaten food security and health. For example, the shift towards sub-optimal dietary patterns increases the risk of chronic diseases, with significant health, economic and societal costs. To ensure that people can access safe and healthy diets, Jessica Fanzo suggested to take food system actions at the local, regional, national, and global levels through One Health. Besides embracing a One Health approach to food systems, she encouraged: the adoption of a "business unusual" approach to achieve climate change and sustainability targets; harnessing the political momentum to ensure that global events where the transformation of food systems is discussed are impactful; providing evidence to help policymakers make informed decisions; and the diversification of staple foods (Fanzo, 2021).

Speaking on behalf of young people, Glyndis Virginia Luciano (Young Professionals for Agriculture Development), gave the youth's perspective on the changing interplay between food safety, nutrition and food sustainability. Glyndis Virginia Luciano challenged the audience by asking whether "our" food can be safe, nutritious and sustainable, while emphasising that young people live under the shadow of a 1.5° increase

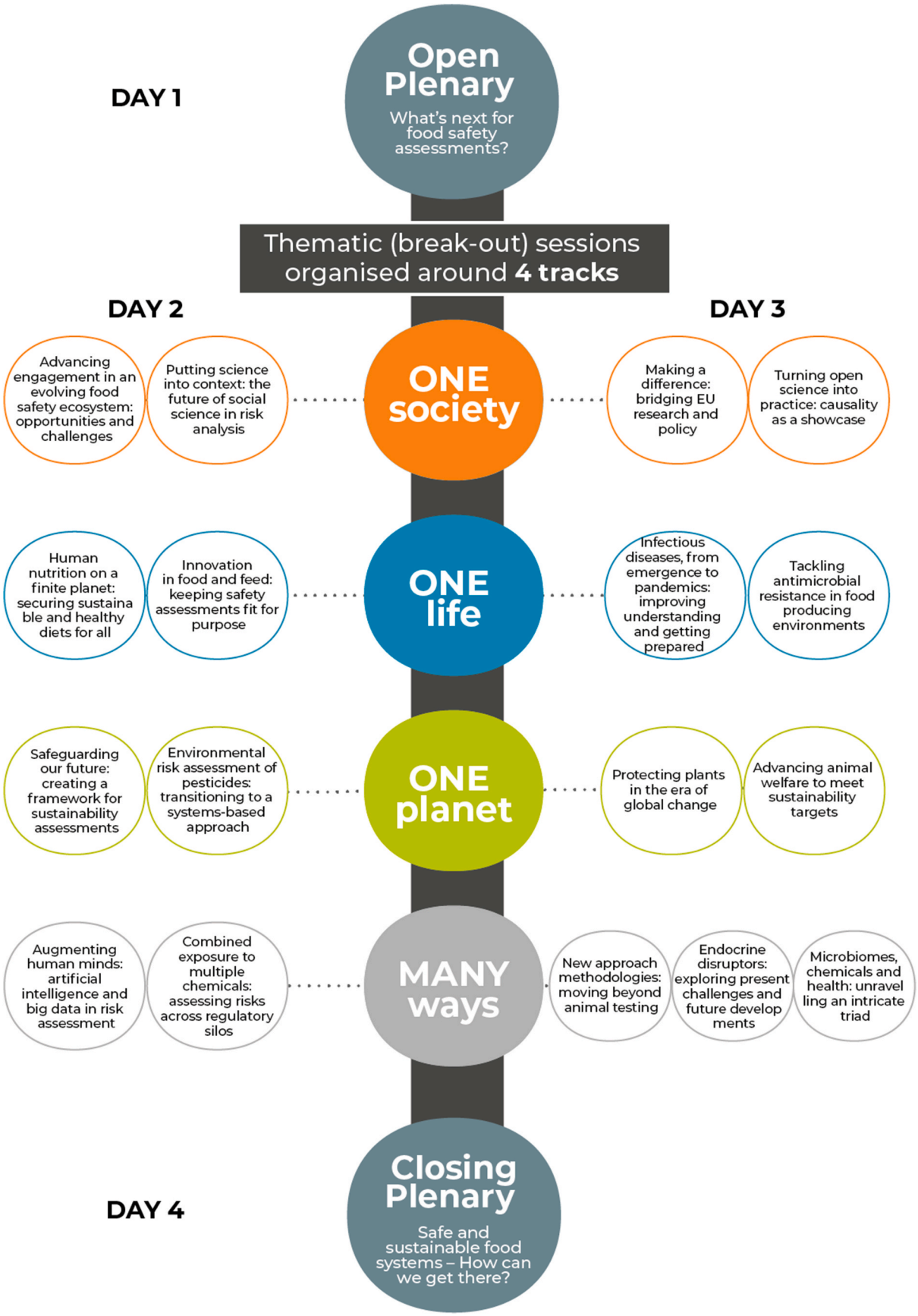

Fig. 2. Schematic overview of the scientific program, with the various topics addressed organised around four thematic tracks (One Society, One Life, One Planet and Many Ways).

in global temperature. She explained that the scope of food safety has evolved over time in line with innovation in science and technology, new policy targets and societal demands. What was recognised as safe yesterday may not necessarily be considered safe today or tomorrow. Food is now expected to meet the highest standards of nutrition and sustainability, in addition to being safe, accessible and affordable for all. Therefore, Glyndis Virginia Luciano concluded that the consideration of nutritional and sustainability outcomes must be embedded in food safety assessments to be able to respond to current global challenges.

Frank Yiannas (United States Food and Drug Administration (US FDA)) asked why food, which used to unite people, is increasingly dividing people, and why (regulatory) science contribute to this divide. When it comes to public trust, he highlighted that "our" actions speak the loudest. In this respect, Frank Yiannas presented several actions taken by the US FDA to move towards a more digital, traceable and safer food system, with the aim to instil public trust. Specific emphasis was put on the FDA's New Era of Smarter Food Safety blueprint, released in July 2020 (US FDA, 2020).

Jacqueline EW Broerse (Vrije Universiteit Amsterdam) addressed how the science communication landscape has evolved. She highlighted that the relationship between science and society has become increasingly complex due to more diverse interactions and channels for knowledge exchange. This higher diversity is extending the range of scientific and non-scientific actors to engage with, and the issues and concerns that must be addressed. Moreover, digitalisation has fundamentally changed how scientists and the public interact and communicate. In this digital communication era, she highlighted that it has become relatively easy to disregard scientific evidence as "just another opinion", as facts to support virtually every statement can be found, hence reducing the credibility of scientific facts.

Since putting more effort into educating the public has not been an effective strategy for building public trust, Jacqueline EW Broerse called for a rethink of science communication. In her view, the answer does not lie in better one-way communication, but in better listening, and more inclusive and meaningful collaboration. Therefore, engagement must be an integral part of the food safety assessment process, and go beyond single engagement events that have little impact.

Sarah A Hartley (University of Exeter) talked about epistemic engagement in risk assessment. She explained that there is a general and growing agreement in society that inclusivity and diversity are important. Such ambitions will require opening up food safety assessments to new actors and connections, which may be a challenge. However, knowledge gained from engaging with new actors can make food safety assessments more robust. Yet, this change will require engagement to reflect diversity within and amongst disciplines and actors.

Patrick Wall (University College Dublin) reiterated the need to embrace One Health as an integrative approach and as a way forward to work better together. He stressed that One Health has truly come of age, as human health can no longer be looked at in insolation from animal, plant and environmental health. The European Green Deal flags many areas that will require an interinstitutional and interdisciplinary way of working if its ambitions are to be realised.

3.2. Thematic (break-out) sessions

The thematic sessions, which were embedded between the opening and closing plenary sessions, were organised around four thematic tracks: One Society, One Life, One Planet and Many Ways.

3.2.1. One Society

How do regulators, risk assessors, stakeholders and the public interact in the risk analysis process? How can organisations find new ways to work better together? This was the focus of the One Society track.

3.2.1.1. Advancing engagement in an evolving food safety ecosystem: opportunities and challenges (session coordinator: Max Blanck). In this session, the centrality of cooperation and partnerships in tackling current and future food safety challenges was explored, and their role in ensuring that trustworthy scientific advice can be provided for society. To set the scene, the session looked at what lessons can be learned from biological forest ecosystems, how large multilateral partnership initiatives can thrive and how networks such as the EU Bee Partnership (Simón Delso et al., 2021) can help to address complexity.

New ways (including channels) of engagement are needed to connect and integrate knowledge, data and expertise, as no single organisation or actor can face the growing complexity in science and society alone. Therefore, more holistic thinking is required, and the EU's collaborative ecosystem of food safety actors must be further developed (Url, 2022). Session participants acknowledged that cooperation must become a strategic objective in itself, and be incentivised and rewarded. While collaboration and partnership as such are not novel concepts, materialising a more holistic ecosystem approach requires institutionalised buy-in from all actors. It is therefore key to foster a culture in which cooperation is perceived as desirable and needed, instead of an additional burden.

Several challenges may prevent actors within the EU food safety ecosystem from operating in a more collaborative manner. These include: diverging or competing interests; differences in values or opinions; lack of trust, time, resources and incentives to engage with other individuals and organisations; and the willingness to accept that nobody can succeed alone. Despite these challenges, it is crucial to continue the dialogue needed to realise an ecosystem approach.

Cooperation among actors can be fostered by: acknowledging differences between actors; a willingness to compromise; the ability to share knowledge despite divergences (e.g. in values or goals); bringing relevant actors into the dialogue as early as possible, and coming to the table without prejudice; making collaboration easy; and by creating win-win situations for all actors. In addition, policymakers should create the conditions necessary for realising a collaborative ecosystem in which all its actors can thrive.

Overall, session participants considered that concrete steps must be taken now to move cooperation forward, without delay, as there is no alternative. During the session, EFSA committed to play its part in developing and implementing the ecosystem approach in risk assessment in close collaboration with those actors who have already indicated their interest in being part of it.

3.2.1.2. Putting science into context: the future of social science in risk analysis (session coordinator: Domagoj Vrbos). A question that has been debated extensively in the regulatory arena over the past decade is how social sciences and humanities can be used to integrate societal aspects into risk analysis. Science and policy are indeed witnessing a paradigm shift, marked by the inclusion of societal contributions into policymaking and the growing importance of coordinated risk communication. Therefore, in this session, specific emphasis was put on how citizen participation and insights can support food safety and One Health policies, as well as risk communication in the digital age.

Session participants concurred that democratising science and having a globally agreed framework for Open Science can make scientific outputs, including food safety assessments, more accessible, transparent, collaborative and inclusive. The global recommendation on Open Science bythe United Nations Educational, Scientific and Cultural Organization (UNESCO United Nations Educational, Scientific and Cultural Organization, 2021), presented during the session, stresses the need for understanding citizens, engaging them in research, and implementing tools such as citizen science.

In terms of better understanding citizens, session participants supported the integration of social sciences and humanities into the One Health conceptual framework. Reference was made to research on

Covid-19 to illustrate how behaviours, their drivers and social and cultural contexts were considered for the development and implementation of strategies in response to the pandemic, and the optimisation of risk communication activities (ECDC, 2021). Such research must be institutionalised, and behavioural insights further considered in the design of any future public health interventions.

Digital tools are helping to understand and involve people at a scale and pace which was previously impossible. For example, social media listening allows to observe what people are talking about online, ethnographic studies via apps allow in-depth and inductive research, while rapid poll platforms can generate insights in a matter of days. Since risk is dynamic over time, digital tools help in the selection of the most relevant topics and identifying the most suitable channels for informing different audiences.

When it comes to engagement, participatory formats in policy-making allow: the early involvement of citizens by de-framing issues to allow them to be seen from different perspectives; equality in discussions at their early stages of development; and the facilitation of a common understanding. Citizen science projects are another important ingredient for solving complex problems – if risk assessors and risk managers do not reach out to citizen scientists, they risk missing out on an opportunity to make the evidence base more robust.

The overarching five rules for evidence communication suggested by Blastland et al. (2020) will be key to guide future communication about food safety. However, these are to be complemented with the use of aesthetics and differing visual language; leveraging on the potential of new technologies. Translating evidence into clear content, in a pragmatic manner, and delivering it through the right channels to the relevant audiences, is a key part of providing society with science-based solutions to complex problems.

3.2.1.3. Making a difference: bridging EU research and policy (session coordinator: Stef Bronzwaer). To foster the transition towards a more sustainable future, substantial resources will be dedicated to research and innovation (R&I) in the coming decade. This session explored the benefits of involving the EU's ENVI Agencies (ECDC, ECHA, EEA, EFSA and EMA), individually and collectively, to shape the EU research agenda, using antimicrobial resistance (AMR) as a real-life case study.

Serving as knowledge centres that bring together the necessary know-how to inform policies, the EU's ENVI Agencies can make a difference in diverse ways, and help to: foster research in support of regulatory science and policy; bring added value to the EU Member States and citizens; maximise the use of results of R&I projects; and avoid duplication of activities among research projects. However, ENVI Agencies could be more impactful by working even closer together to deliver integrated solutions needed for the society and environment. Therefore, at the conference, ENVI Agencies committed to take joint leadership in moving One Health forward, and allocate resources to the establishment of a cross-agency One Health task force to determine what is needed to deliver transdisciplinary and cross-sectoral scientific advice.

3.2.1.4. Turning open science into practice: causality as a showcase (session coordinator: Laura Martino). Open Science is a high priority of EU policy, as there is a pressing need to effectively disseminate and share science outcomes to tackle some of the big challenges facing humanity and the planet. Building upon and reusing open scientific knowledge can expedite these global efforts (EU Council, 2022). It may accelerate innovation in science and technology, and increase societal trust due to wider public scrutiny. However, to achieve such ambitious goals, new ways of working are required. Therefore, this session addressed some of the benefits and challenges associated with the adoption of Open Science approaches in the context of regulatory science. The example used focused on causality, i.e. the relationship between a cause (i.e. exposure to a substance/micro-organism/food ingredient) and an effect (i.e. an adverse/beneficial health outcome).

Session participants indicated that the FAIR – Findable, Accessible, Interoperable and Re-useable – guiding principles for scientific data management and stewardship (Wilkinson et al., 2016) and open data sharing should become the default approach in food safety assessments. At the same time, the EU's ENVI Agencies should strive to comply with the six core principles characterising Open Science: open data, open source, open methodology, open peer review, open access, and open educational resources.

Opening up science in a regulatory context will: make data available to all more quickly; enable reproducibility of scientific outcomes, including food safety assessments; increase the uptake, use and quality of scientific knowledge; promote and support research collaboration and co-creation; and foster innovation, including public participation in the scientific process via the crowdsourcing of data, methods, computational capacity and scientific knowledge (e.g. Dendler and Böl, 2020). The adoption of more participatory approaches offers new opportunities to regulatory science institutions, such as the EU's ENVI Agencies. It will help to extend the pool of data, expertise and knowledge from which to draw, thus accelerating the preparedness to address complex questions (Vohland et al., 2021). Open Science can also promote diversity, justice, and sustainability through increased levels of inclusion and access, equitable distribution of opportunities, and the dissemination of knowledge.

Challenges for Open Science addressed during the session include: the trade-off between scientific rigour and openness, while maintaining the credibility of science; perception issues such as the fear that open data can be misused or misinterpreted, thus harming scientists' reputation; concerns over quality, because a critical mass of open data is not always available to enable validation; and insufficient level of competence and awareness that hampers optimal production and use of open data, and compliance with Open Science practices.

3.2.1.5. Conclusions and recommendations. The thematic sessions within the One Society track highlighted that, within the context of a "transdisciplinary" food system, no single actor can master the level of complexity in science and society alone. To connect and integrate the knowledge, data and expertise across sectors and disciplines, new methods (including channels for knowledge exchange) for engagement, cooperation and collaboration are needed. Therefore, EFSA, together with other food safety actors, is moving forward with the development and implementation of the EU's collaborative ecosystem of food safety actors. Moreover, the EU's ENVI Agencies committed to establish a cross-agency One Health task force to improve institutional cooperation. To deliver impactful and pragmatic policy solutions, there is also a need to better account for behaviours, their drivers and social and cultural contexts, and engage citizens in data collection and policy development. The potential of Open Science must be harnessed to meet societal needs and accelerate progress in regulatory science. The cultural change towards openness and sharing is to be embedded in daily risk assessment practices. And, given that science will not deliver impacts until the results and what these mean for food safety and One Health are communicated, an audience-first approach must be applied throughout risk analysis to remain relevant in a digital age.

Further details about the main outcomes of the One Society track are summarised in Table 1.

3.2.2. One Life

Dietary choices are important not only for human health, but also for fighting diseases and AMR, and protecting the environment. How are these aspects connected and how can they be considered together? This was the focus of the One Life track.

3.2.2.1. Human nutrition on a finite planet: securing sustainable and healthy diets for all (session coordinator: Silvia Valtueña Martinez). As

Table 1
Summary of the main outcomes of the One Society track.

Sessions	Main outcomes
Advancing engagement in an evolving food safety ecosystem: opportunities and challenges	• Realise the EU's collaborative food safety knowledge ecosystem, as no single actor can master the level of complexity alone • Create policy and governance conditions (e.g. incentives) for a collaborative ecosystem to make collaboration the default way of working for all actors • Make collaboration tangible and measurable
Putting science into context: the future of social science in risk analysis	• Consistently apply an "audience-first" approach, and use participatory formats from science to policymaking • Make interventions impactful by accounting for behaviours, their drivers and social and cultural contexts, and engaging citizens • Explore digital audience research methods and citizen science to solve complex questions
Making a difference: bridging EU research and policy	• Dedicate resources to build bridges with research projects • Involve the EU's ENVI Agencies in research programming discussions with the European Parliament and European Council • Adopt a One Health approach across science, regulatory science and among regulators • Demonstrate leadership by the EU's ENVI Agencies (ECDC, ECHA, EEA, EFSA and EMA) to move One Health forward • Resource a cross-agency One Health task force to advance transdisciplinary research and cross-sectoral scientific advice
Turning open science into practice: causality as a showcase	• Harness Open Science's potential to meet societal needs and shape the future • Make Open Science a reality and "default" principle • Foster the transparency, reproducibility and scrutiny of research; and in turn enhance its quality • Raise awareness about the legal and ethical dimensions of Open Science (e.g. those pertaining to confidentiality and intellectual property to ensure that data are "as open as possible, and as closed as needed") • Develop Open science and open data literacy and skills, and promote Open Science education

part of the European Green Deal, the EC has put forward its Farm to Fork Strategy for a fair, healthy and environmentally friendly EU food system. It aims to facilitate the shift to healthier and more sustainable diets that respect planetary boundaries. This transition is essential to deliver societal co-benefits (e.g. less diet-related diseases, climate mitigation, land and biodiversity conservation). Therefore, at the fore of this session was the fundamental question of how to ensure diets become healthier and more sustainable.

Session participants concurred that the transition to healthier and more sustainable diets requires significant changes to: food systems and policies; food-based dietary guidelines; and food consumption patterns.

– *Food systems and policies*: Current food systems are at a pivotal turning point. They are increasingly challenged by a fast-growing world population, rising hunger and malnutrition, a rapidly changing climate, unprecedented biodiversity loss, and significant social inequities (Rockström et al., 2020). At the same time, there is accelerating momentum in efforts to reorient food systems so that they better integrate human and planetary health, economic viability and social welfare. Food policies are central to accelerate and incentivize the necessary food system transformation, and foster changes in food choices and consumption patterns. Such transformations will inevitably necessitate the involvement of all actors at all levels of the food chain (Fanzo, 2021);
– *Food-based dietary guidelines*: Current dietary guidelines worldwide are incompatible with the United Nations Sustainable Development Goals (SDGs) that target the reduction of noncommunicable diseases and aim to achieve healthy diets within planetary boundaries. It is therefore important that such guidelines are revised in relation to the amount and frequency of consumption of different food groups. For example, switching from animal-based foods to plant-based diets could improve both human and planetary health. Clearer dietary guidelines on whole grains, nuts and legumes, and on limiting red and processed meat, will provide most of the additional health benefits, whereas limiting the consumption of beef and dairy has the greatest potential for ensuring environmental sustainability (Springmann et al., 2020; Willett et al., 2019);
– *Food consumption patterns*: The Farm to Fork Strategy recognises that most of the current eating patterns in the EU are unsustainable. Hence, various levers can be applied to change such patterns, including legislation (e.g. bans, taxes, subsidies/incentives, food labelling, plant-based defaults for hospitals, schools and public canteens), nudges (e.g. food placement in supermarkets), and reducing conflicts between credence characteristics of food (e.g. healthiness, sustainability) and other motives driving food choices (e.g. price, taste) (De Bauw et al., 2021; Reisch, 2021).

3.2.2.2. Innovation in food and feed: keeping safety assessments fit for purpose (session coordinator: Antonio Fernandez Dumont). The global demand for food and feed will continue to grow as a result of population growth. To meet the food and feed demands of an increasing global population without further depleting natural resources, alternative food and feed sources are being investigated and receiving rising attention worldwide (e.g. FAO, 2022; Frezal et al., 2022; Ververis et al., 2020). Innovation in science and technology is expected to deliver new generation foods and feeds. While such future foods and feeds may be more nutritious and sustainable than some of the traditional ones, they may pose challenges for the safety assessment, potentially requiring novel or revised risk assessment approaches.

Several examples of new foods and feeds were on the menu of this session, highlighting the wide variety of food and feed sources and products. They covered: plant-based protein alternatives; animal-based protein alternatives (e.g. edible insects); marine-based food alternatives (e.g. jellyfish, seaweed); cell-based food products (e.g. cultured meat, seafood, which are animal meat products manufactured through the cultivation of animal cells *in vitro*); and products obtained through synthetic biology or new processing technologies. These examples helped to explore in which areas existing approaches for food safety assessments remain comprehensive and adequate for new foods and feeds, or require complementary or alternative approaches (see **Table 2** for the main safety assessment considerations given).

Session participants concluded that some safety assessment aspects may need revision on a case-by-case basis to keep pace with innovation in science and technology, while other aspects are comprehensive and adequate for new foods and feeds. They also indicated that such deliberations would benefit from added consultation and engagement actions to achieve sufficient transparency and societal acceptance.

3.2.2.3. Infectious diseases, from emergence to pandemics: improving understanding and getting prepared (session coordinator: Alessandro Broglia). Globalisation, climate change, deforestation and wildlife

Table 2
Summary of the main considerations on the safety assessment of new food and feed sources and products.

New food and feed sources and products	Main safety assessment considerations
Plant-based protein alternatives	More efficient means to extract proteins from raw plant materials are under development (Lie-Piang et al., 2021). By processing less, the functional properties/quality of ingredients are maintained better (e.g. retention of fibre, micronutrients and natural microstructure). However, the lower degree of processing also implies that the microbiological quality might be compromised and that more residues and antinutritional factors may remain in foods, requiring further consideration in food safety assessments.
Animal-based protein alternatives (e.g. edible insects)	Insects are complex organisms, which makes characterising the composition of insect-derived food products a challenge. Understanding their microbiology is paramount, considering that the entire insect is consumed. Critically, many food allergies are linked to proteins, so an assessment is required on whether the consumption of insects or other alternative proteins could trigger allergic reactions. In the case of insects, these can be caused by an individual's sensitivity to insect proteins, cross-reactivity with other allergens or residual allergens from insect feed (e.g. gluten).
Marine-based food alternatives	Marine-based food alternatives are new raw materials with a great potential for use in food and feed. The identification of more sustainable processes for the extraction of relevant compounds, such as carbohydrates and proteins, was an important element highlighted. Potential food safety aspects associated with such raw materials should also be considered carefully (e.g. heavy metals, allergens).
Cell-based food products	The outcomes of a series of collaborative workshops on the safety of cultured meat and seafood organised by New Harvest and Vireo Advisors in 2020 were reported (Ong et al., 2021). During these workshops input was gathered from industry representatives, researchers, regulators, and food safety experts. Chemical and biological hazards that could potentially affect the safety of cultured meat and seafood were explored for each step of the manufacturing process. It was concluded that many of the hazards that could be introduced or produced during manufacturing (such as adventitious agents, novel expression products, inputs such as cell culture media, antibiotics, scaffolds, cryoprotectants and other substances) are not novel. Consequently, currently applied safety assessment approaches remain applicable. However, further research on the safety of the inputs and associated residues, potential for contamination, and development of standardised safety assessment approaches (particularly animal-free methods) was recommended.
Products obtained through synthetic biology	Recent scientific developments in molecular and synthetic biology enable the (targeted) engineering of new generation genetically modified (GM) plants and derived food and feed products, and widen the spectrum of plant species and traits that can be genetically modified (Roell and Zurbriggen, 2020). This additional diversity may – in some cases – pose challenges for the safety assessment. Consequently, specific aspects of the risk assessment of some new generation GM plants and derived food and feed products may require adjustment on a case-by-case basis, compared with contemporary GM plants and derived foods and feeds. However, there are also instances where the risk assessment can be simplified, as some regulatory data requirements do not apply due to the precision and specificity of genetic modification techniques used to obtain a new generation GM plant and derived food and feed products, and the nature of traits conferred to it (e.g. Devos et al., 2022).

trafficking have substantially increased the risk of infectious disease emergence globally over the last decade (e.g. Carlson et al., 2022). Such diseases (e.g. avian influenza, African swine fever, Covid-19) may affect human, animal and environmental health and food systems in multiple ways. This session explored how to better predict, track and prevent disease outbreaks.

Session participants supported the need to implement more effective risk governance that includes technical components for preparation, prevention, detection (including monitoring/surveillance), response and recovery. These goals may be achieved by taking a global One Health approach. Since public health issues are closely interconnected to environmental issues, it was suggested to embed One Health in the European Green Deal, and make it operational at all levels, so that context-specific actions can be taken. This will require the development of One Health literacy and skills, the promotion of One Health education to emphasise collective goals above individual/national ones, and the sharing of data across all actors at the local, regional, national and global levels.

To reduce the risk of future zoonotic spillovers, session participants agreed that the diversity of interfaces between wildlife, domestic animals and humans must be better accounted for, while pathogen monitoring/surveillance should be expanded. This may enable an earlier detection and better control of outbreaks, and provide a better understanding of the conditions that cause them. Session participants also recommended further investment in vaccine development for humans and animals, and a transition to more sustainable and resilient food systems to reduce infectious diseases in humans and animals, and improve animal welfare and human livelihoods.

3.2.2.4. Tackling antimicrobial resistance in food producing environments (session coordinator: Beatriz Guerra). Antimicrobial resistance (AMR) is a silently evolving pandemic that threatens the health of humans, animals, plants and the environment. It represents a major public health concern worldwide. Several of the most critical antimicrobial resistant bacteria (ARB) causing infections with severe public health consequences, and/or antimicrobial resistance genes (ARGs) conferring resistance to critically important antimicrobials (WHO, 2019) also occur in food-producing environments. Surprisingly, it is only in the last years that more focus has been put on the role of natural and food-producing environments in the emergence, selection, dissemination and ultimately transmission of AMR. In light of the EC's AMR action plans and the scientific opinion of EFSA's BIOHAZ Panel (2021), the role played by the environment in the emergence and spread of AMR through the food chain was further explored in this session.

For plant-based food, fertilisers of faecal origin, irrigation and surface water are major environmental sources and transmission routes of ARBs and ARGs. For terrestrial animals, limited evidence points to feed and, to a lesser extent, humans as important sources/transmission routes. For aquaculture, water is the main transmission route. However, overall, understanding of ARB/ARG sources, transmission routes and diversity must be improved, while new strategies are needed to assess the overall quality of wastewater intended for reuse (EFSA BIOHAZ Panel, 2021).

Session participants concluded that a One Health approach is needed to tackle AMR issues in a more integrated, cross-sectoral and collaborative manner. This will help to design integrated AMR mitigation strategies that: remain in tune with current and future policy targets (e.

g. within the European Green Deal) for food-producing environments, food systems and climate mitigation; reduce the use of antimicrobials by applying better hygiene, correct use and biosecurity practices in all sectors; replace antimicrobials with alternatives; rethink food systems and transition to more sustainable farming systems; validate the efficacy of AMR mitigation measures; and invest in future preparedness (such as the development and implementation of harmonised and strengthened environmental monitoring/surveillance for the early detection of emerging AMR issues). Prioritising AMR mitigation actions can be hindered by a lack of understanding of the contribution of individual factors, so the cross-sectoral components and drivers of AMR must be understood better to improve the capacity to tackle AMR.

3.2.2.5. Conclusions and recommendations. The thematic sessions within the One Life track explored the complex relationships between human and planetary health through the lens of diets, new food and feed sources, infectious diseases, and AMR. Since the health of humans and the planet are inextricably interlinked, more integrated, cross-sectoral and collaborative approaches are needed to take such complex relationships fully into account. Public policies nudging food demand and public investments, such as agricultural subsidies, need to be aligned to pursue health objectives. Implementing targets for food safety, One Health and sustainability at multiple levels will be crucial to ensure safe and nutritious food for all, without putting further undue pressure on the environment. It is therefore recommended to embed One Health in multiple sectoral policies, and make it operational to maintain human, animal and planetary health.

Further details about the main outcomes of the One Life track are summarised in Table 3.

3.2.3. One Planet

One Planet means to live within the planet's natural limits. To do this, substantial efforts are needed to meet sustainability targets and protect the environment. How this can be achieved was the focus of the One Planet track.

3.2.3.1. Safeguarding our future: creating a framework for sustainability assessments (session coordinator: Angelo Maggiore). Food systems need urgent and significant transformation if they are to meet sustainability targets. With the Farm to Fork Strategy, which is at the core of the European Green Deal, there is accelerating momentum in efforts to make the EU food system more sustainable and resilient. Moreover, the EC intends to adopt a legislative framework for sustainable food systems by the end of 2023. It will address the sustainability of both products and processes (e.g. circularity, reduction of food loss and waste, promotion of more nutritious and sustainable diets). Owing to its nature, the legislative framework would need to be converted into more concrete parameters, including quantitative and qualitative criteria to define and measure sustainability, and monitor outcomes and progress over time. This session therefore explored possible scientific building blocks for such a legislative framework (Bock et al., 2022), how it can be co-designed, and the difficulties involved.

Session participants considered that a framework for assessing and monitoring the sustainability of food systems can draw on existing approaches, while adapting them as needed. Existing approaches have been implemented for many years, and are built on a strong evidence basis. However, since assessing and monitoring the sustainability of food systems is complicated, there is no simple, "one size fits all" solution. Instead, depending on the context, the integration of many different approaches is advocated. Approaches considered in this session focused on: life cycle thinking and assessment (e.g. Sala et al., 2020); the safe and sustainable by design concept (e.g. EEA, 2021a); the SMART-farm tool (e.g. Curran et al., 2020), which builds on the FAO's guidelines for sustainability assessment of food and agriculture systems (SAFA) designed to harmonise sustainability assessments of agricultural and food systems; multi-scale integrated analysis of societal and ecosystem metabolism (e.g. Cadillo-Benalcazar et al., 2020); and scenario analysis.

Table 3
Summary of the main outcomes of the One Life track.

Sessions	Main outcomes
Human nutrition on a finite planet: securing sustainable and healthy diets for all	• Reorient food systems so that they are socially just and deliver food for all within planetary boundaries. • Redefine food-based dietary guidelines, and largely rely on plant-based diets to improve both human and planetary health. • Incentivize healthy and sustainable diets through demand side measures, nudges, economic incentives and food labelling.
Innovation in food and feed: keeping safety assessments fit for purpose	• Foster innovation in science and technology to produce new generation foods and feeds that are safe, healthier and more sustainable. • Review safety assessment approaches for new food and feed sources to assess in which areas existing approaches for risk assessment remain comprehensive and adequate, or require complementary or alternative approaches.
Infectious diseases, from emergence to pandemics: improving understanding and getting prepared	• Take a One Health approach to better predict, track and prevent future pandemics accounting for climate change. • Build One Health literacy and skills, and promote One Health education • Promote data sharing across all actors at all levels. • Invest in vaccine technology for humans and animals.
Tackling antimicrobial resistance (AMR) in food producing environments	• Further improve the understanding and assessment of the AMR burden linked to food-producing environments, especially in light of climate change and the transformation of food systems. • Follow a One Health approach to tackle AMR issues in a more integrated, cross-sectoral and collaborative manner. • Reduce the use of antimicrobials, replace them with alternatives, and rethink food systems to tackle AMR. • Invest in future preparedness (e.g. through monitoring/surveillance for the early detection of emerging AMR issues).

Session participants highlighted that a sustainability framework needs to be comprehensive, embrace complexity (in terms of multidimensionality, multisectoral knowledge, transdisciplinarity, scalability, multiple spatial and temporal scales, occurrence of wicked problems), disclose uncertainty, and build in sufficient flexibility to remain applicable and adaptive to changing conditions in space and time. The latter would necessitate the implementation of a more dynamic, iterative interplay between prospective and retrospective sustainability assessments. Quantitative models, multicriteria assessment tools and uncertainty analyses can help to frame prospective sustainability assessments. However, they may need to be complemented by monitoring/surveillance to account for the high diversity of receiving environments and the unpredictable nature of their evolution.

3.2.3.2. Environmental risk assessment of pesticides: transitioning to a systems-based approach (session coordinator: Yann Devos). This session focused on how to advance the environmental risk assessment (ERA) of pesticides to better protect biodiversity and ecosystems. The need for a paradigm shift was explored, and how to enable it.

The use of regulated products such as pesticides is subject to

prospective ERA and regulatory approval in most jurisdictions worldwide. Such regulatory ERAs are typically performed on a single active substance and use basis. While substantial progress has been made in assessing direct effects of single active substances and uses on single groups of non-target organisms, session participants acknowledged that such assessments require further development to: integrate the latest scientific knowledge; align with new policy targets such as the European Green Deal and associated strategies, and societal demands; and deliver more fit for purpose scientific advice to decision makers both at the European and national levels. This call for action is consistent with current scientific knowledge (e.g. Topping et al., 2020), and EFSA's 2027 strategic goal to develop and implement systems-based approaches for the ERA of regulated products falling within its remit, including pesticides and other chemicals (EFSA, 2021; EFSA, 2022a).

Transitioning to a systems-based approach would enable ERAs to be delivered in a way that is more integrated, realistic and context-dependent (Sousa et al., 2022). Such ERAs would capture the overall impact resulting from exposure to pesticides under various representative environmental scenarios within the EU. It would also better address the fact that non-target organisms are present in diverse EU agricultural landscapes where they can be exposed to multiple pesticides at the same time, and that pesticide impacts depend on the environmental context (i.e. landscape structure, available food resources, farm management practices, climatic conditions).

While session participants recognised the need to develop and implement a more integrated ERA approach, the vision for future ERA is mostly conceptual at present, and was interpreted differently among session participants. A common definition of a systems-based approach for ERA has not yet been formally endorsed. Therefore, more dialogue between all relevant actors would help to fine-tune the vision for future ERA, and reach common definitions and goals for a system-based approach (Sousa et al., 2022).

Once defined, implementing the vision for future ERA may be challenging, necessitating appropriate governance and policies (Sousa et al., 2022). Session participants noted that the significant amount of data gathered so far from ERAs (e.g. higher tier field studies) and in environmental monitoring studies is currently not fully exploited in the assessment of pesticides or available for their assessment. Yet, such data could contribute to a more integrated ERA in the future, enabling the transition by linking prospective and retrospective risk assessments. In addition, the understanding of ecological processes and the technological capacities to simulate such processes (e.g. through modelling) have advanced substantially. Therefore, session participants felt that the use of available data, knowledge and new technologies could be optimised, enabling the implementation of a system-based ERA. It was also noted that numerous regulatory frameworks and strategies (such as the Water Framework Directive or the Regulation on the Sustainable Use of pesticides) address the same environment without much alignment. However, greater alignment between these regulatory frameworks and strategies would offer possibilities to reduce or compensate adverse effects of pesticide use.

Since the current EU regulatory framework for pesticides can accommodate a systems-based approach, session participants concluded that small and incremental steps to revise the current system can already be taken now, without delay.

3.2.3.3. Protecting plants in the era of global change (session coordinator: Ciro Gardi). Biological invasions of plant pests represent serious economic, environmental and social threats to natural and managed environments, agricultural and forestry production, and biodiversity in the EU territory and beyond. Such threats are exacerbated by globalisation, international trade and climate change. As a consequence, the number of invasive alien species, including plant pests, arriving in new regions is increasing globally, and there is no sign of slowing (Pyšek et al., 2020). How to manage such threats is vital in ensuring that sustainability targets are met for plant and environmental health. Therefore, they were explored further in this session.

Session participants considered that effective plant health management requires more integrated, cross-sectoral and collaborative approaches that prevent the entry, establishment and spread of pests, and mitigate impacts of pest outbreaks (Essl et al., 2020). In terms of prevention, there has been increasing focus on horizon scanning and commodity risk assessment to predict which plant pests pose an imminent emerging threat. Horizon scanning underpins the prioritisation of plant pests for risk assessment (in which the pest's identity, biology, distribution, regulatory status, host range, and its ability to enter, establish and spread in the EU are considered), as well as the process for considering whether plant pests are included on the EU's overall list of quarantine pests of concern.

Early insights to prevent new plant pest invasions can also draw on identifying entry points, ranking and prioritising possible outbreak hotspots in combination with the characterisation of the pest climatic niche. This type of information can then be used to define priority areas for surveillance. Plant pest survey cards, survey guidelines and statistical tools help to design and plan plant pest surveys and harmonise surveillance methods. It was also shown how remote sensors could help to better understand forest health (Forzieri et al., 2021) and monitor the spread of agricultural pests.

Invasive plant pests can have multiple impacts on plant, animal, human and environmental health. Moreover, plant pests know no borders. Therefore, cross-sectoral and transboundary communication and data sharing, along with globally coordinated surveillance, are critical to effective action. Measures put in place to mitigate impacts of plant pest outbreaks should be effective, safe, affordable, accessible and scalable. Expanding the toolbox to combat plant pests was advocated by session participants. Session participants also acknowledged the need to build phytosanitary capacity, develop plant health literacy and skills, and promote plant health education. Following a people-centred approach is crucial to tackle plant health.

3.2.3.4. Advancing animal welfare to meet sustainability targets (session coordinator: Sean Ashe). There are growing societal demands for animal production systems to be more sustainable, safeguarding both the environment and welfare of animals. However, it is not yet known how to deliver sustainable food animal production systems, and how to measure progress towards this goal and what compromises might have to be made along the way. Therefore, this session explored how animal-sourced food can be produced in a way that ensures higher animal welfare, protects the environment, and is economically viable.

Session participants considered that animal welfare is a public good in itself, and a sustainability issue, with both intrinsic value (benefit to the animal itself) and instrumental value (benefits of better animal welfare for citizens). Although animals are hardly mentioned in the United Nations sustainability development goals, there are many co-benefits as a result of improving animal welfare and achieving such goals (Buller et al., 2018). For example, moving to high welfare, health-oriented livestock production systems (grass-based, regenerative farming, silvo-pastoral, etc.) would lead to reduced antibiotic use, reduced AMR, a lower risk of zoonoses and pandemics, and the production of food of a higher nutritional quality. In addition, animal production can play a key role in circular food production systems and efficiently contribute to food security. Circular food systems comprising animal holdings with high welfare standards and a low environmental impact have been shown to be economically viable in pilot studies, but policies are needed to support the implementation and deployment of such solutions at a larger scale. It is therefore crucial to integrate animal welfare in sustainability definitions, frameworks, goals and assessments to support policymaking. In particular, such strategies should actively acknowledge and value societal concerns and incorporate societal demands. However, there seems to be a lack of a connection made between

animal welfare and achieving sustainability targets. The use of multi-criteria decision tools could be deployed to consider animal welfare and environmental aspects to identify areas where synergies and trade-offs occur.

Holistically sustainable animal farming systems are underdeveloped, but innovation in science and technology is ready to play a role to support the transition to such systems. Innovation in science and technology, such as precision livestock farming, should be put at the service of sustainable development, and be made available to relevant actors (e.g. farmers, certification bodies, regulators). Helping consumers make informed choices is also key to empower them to play their role in the sustainability transition.

3.2.3.5. Conclusions and recommendations. The thematic sessions within the One Planet track highlighted that the environment, plant health and animal welfare are closely interlinked and integral part of food safety, One Health and sustainability. To take these issues and their interlinkages fully into account, food safety assessments must consider environmental and plant health and the welfare of animals in a more integrated, cross-sectoral and collaborative manner, which is consistent with the One Health goals.

Further details about the main outcomes of the One Planet track are summarised in Table 4.

Table 4
Summary of the main outcomes of the One Planet track.

Sessions	Main outcomes
Safeguarding our future: creating a framework for sustainability assessments	• Ensure that a framework for assessing and monitoring the sustainability of food systems: is comprehensive; embraces complexity; discloses uncertainty; and builds in sufficient flexibility to remain applicable and adaptive to changing conditions in space and time. • Integrate a suite of existing tools and approaches, and adapt them as needed. • Engage relevant actors for co-designing such a framework. • Drive a cultural shift in behaviour and mindset from all actors involved.
Environmental risk assessment (ERA) of pesticides: transitioning to a systems-based approach	• Develop and implement systems-based approaches to deliver ERAs that are more integrated, realistic and context-dependent. • Fine-tune the vision of systems-based ERA through increased and strengthened dialogue between relevant actors. • Optimise use of available data, knowledge and new technologies to enable the transition. • Account for synergies between different relevant regulatory frameworks and strategies. • Build on the current regulatory framework by already taking small and incremental steps for revision.
Protecting plants in the era of global change	• Consider biological invasions and their impact in a broader context of globalisation, international trade and climate change. • Ensure better preparedness (through horizon scans and hot spot identification) and surveillance. • Expand the toolbox to combat pests further. • Build phytosanitary capacity, develop plant health literacy and skills, and promote plant health education. • Follow a people-centred approach to tackle plant health.
Advancing animal welfare to meet sustainability targets	• Consider animal welfare a public good in itself, as well as a sustainability issue. • Apply One Health as a leading principle in the review of the EU's animal welfare legislation to maximise systemic co-benefits. • Link animal welfare improvement to antimicrobial resistance risk mitigation. • Support the development and implementation of sustainable animal farming systems through innovation in science and technology. • Empower consumers to play their part in the sustainability transition.

3.2.4. Many Ways

Risk assessors must keep pace with the latest advancements in science and technology to ensure food safety assessments remain fit for purpose. New assessment methodologies and how they can be implemented were addressed in the Many Ways track.

3.2.4.1. Augmenting human minds: artificial intelligence and Big Data in risk assessment (session coordinator: Angelo Cafaro). Risk assessment has reached the limits of its ability to be executed in a timely manner: recruiting relevant experts is increasingly demanding, while their physical capacity to identify, search, read, appraise and integrate the exponentially growing amount of data in a structured way is stretched to a breaking point. The use of Big Data, automation and the application of artificial intelligence (AI) hold great promise to play a more prominent role in future food safety assessments (EFSA, 2022b; PwC EU Services & Intellera Consulting, 2022). Session participants concurred that automation and AI help to: speed up risk assessments; improve the quality of risk assessments (e.g. limit human error); enable the discovery of new patterns in the data landscape that are undetectable by humans; and keep pace with the exponential growth of evidence (van den Bulk et al., 2022).

However, building trustworthy AI systems to support future risk assessments will bring challenges (such as robustness, generalisation, explainability, transparency, reproducibility, fairness, privacy preservation, alignment with human values, and accountability). Therefore, further work is needed to improve their validity and build trust in AI. Robust testing – from data collection to deployment in production – will help to improve the validity of AI systems adopted in food safety assessments, while enhanced AI literacy in educational programs will help society to understand and build trust in such systems.

It was also noted that AI systems should be sustainable as they require a proper information technology infrastructure, expertise and availability of data. To this end, low and middle-income countries, which may have no access to the necessary resources, should not be left behind in the adoption of AI technology.

3.2.4.2. Combined exposure to multiple chemicals: assessing risks across regulatory silos (session coordinator: Bruno Dujardin). The Chemicals Strategy for Sustainability, which is part of the European Green Deal, aims to eliminate pollution and achieve a healthy and toxic-free environment. This includes risks arising from simultaneous exposure to multiple chemicals (also referred to as unintentional mixtures), including those in food and feed. This session explored how approaches can be developed and implemented to assess combined exposure of humans to multiple chemicals, and how regulatory silos can be broken down to advance current methodologies.

While the need to better account for the combined exposure to multiple chemicals in the risk assessment of chemicals is recognised both at the scientific and policy levels, regulatory implementation of such assessments raise challenges (EFSA, 2022c,d). Available methodologies mainly focus on the assessment of predefined groups of chemicals (e.g. dioxins), or assessments within specific regulatory areas (e.g. pesticides). Yet, they often do not cover mixtures of chemicals across different regulatory areas, nor do they account for all the chemicals

humans may be potentially exposed to. Moreover, methodologies developed for regulatory areas with a strong evidence-base in terms of hazard and exposure data (such as pesticides) are difficult to combine with other areas where less information is available and where more pragmatic approaches must be followed, such as the mixture assessment (or allocation) factor (MAF).

Session participants concluded that there is a sense of urgency and maturity in the field of chemical mixtures to proceed with the development of roadmaps for the implementation of mixture risk assessments across regulatory areas. However, it was also recognised that a "one-size-fits-all" approach would not be adequate. Instead, different methods will need to be used in a complementary way to address the different levels of uncertainty, variability and protection that apply across regulatory areas. While more pragmatic approaches (e.g. MAF) may be considered for lower tier assessments, especially in light of lack of data or exposure information, more data-driven approaches (e.g. new approach methodologies (NAMs), cumulative assessment groups) may be used for higher tier assessments. It is therefore necessary to further develop sound approaches for mixture risk assessment, and more research is needed on the integration of human bio-monitoring data in risk assessment. Such new approaches will help to: reduce uncertainties associated with pragmatic approaches currently applied to mixture risk assessments; derive the size of the MAF (Price, 2020); and identify co-exposures, and prioritise associated chemicals (Tralau et al., 2021).

Meanwhile, session participants emphasised that chemicals in food and consumer products should have the highest priority, because these chemicals are expected to be most important sources of exposure to unintentional mixtures. Therefore, the development of EU databases on consumer products and behaviour, similar to the United States Environmental Protection Agency (US EPA) exposure database and chemistry dashboard, should be further explored.

3.2.4.3. New approach methodologies: moving beyond animal testing (session coordinator: George E. N. Kass). Chemical risk assessment has relied for over half a century almost exclusively on data generated by animal testing. Yet, the approach of testing chemicals in rodents (and other animal species) for human safety purposes has been questioned repeatedly. In addition to ethical issues, the transferability of animal data across species is often problematic because of differences in physiology, metabolism and chemical susceptibilities. Therefore, alternatives to animal testing (i.e. NAMs) have been developed and implemented to shift the current paradigm from regulatory chemical risk assessment based on *in vivo* animal testing towards new generation risk assessment (EFSA, 2022e). NAMs include a broad range of *in vitro*, *in silico* and *in chemico* approaches for evaluating potential chemical hazards, identifying modes or mechanisms of action, extrapolating between internal and external doses, and estimating exposure.

Session participants shared experiences gained with the use of NAMs in risk assessment for regulatory purposes. Perspectives from academia, risk assessors, risk managers, and the Organisation for Economic Co-operation and Development (OECD) were given. At the European level, the Chemicals Strategy for Sustainability encourages the exploration of NAMs in risk assessment across all EU chemical legislations (including the standard information requirements under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) and for pesticides and biocides). In the US, an updated Agency Work Plan of the US EPA outlines broad objectives for developing and applying NAMs, as well as long-term and short-term strategies to achieve those goals. At an international level, OECD is taking actions to include molecular and cell-based methods when developing new guidelines for the testing of chemicals, in order to provide harmonised mechanistic information and predict *in vivo* effects. In addition, the OECD's Integrated Approaches to Testing and Assessment (IATA) case studies project provides experts with a platform to share experience on the use of NAMs in a regulatory context. Such case studies illustrate how NAMs can be used to evaluate chemical safety. They serve as a starting point for the development of common understanding, best practices and guidance documents.

Despite these developments, there are a number of challenges to overcome when using NAMs for regulatory purposes. For example, hazard information under REACH must be suitable for both risk assessment and classification, while there is no suggested system for classification based on NAMs data for most endpoints yet. Moreover, in many cases, the endpoints and uncertainties associated with NAMs are qualitatively and quantitatively different than those of traditional approaches, underlining the need to develop new frameworks to build confidence in NAMs approaches used for regulatory purposes. It was also indicated that the validation of NAMs for regulatory purposes and the acceptance of NAM-related applications in regulatory toxicology are resource demanding.

Further dialogue, cooperation and engagement between academia, regulators and the private sector will be crucial for the development and implementation of NAMs in risk assessment. Moreover, NAM-based data should be harmonised, integrated and accessible for sharing by following the FAIR guiding principles for scientific data management and stewardship (Wilkinson et al., 2016).

3.2.4.4. Endocrine disruptors: exploring present challenges and future developments (in memory of Alfonso Lostia) (session coordinator: Maria Arena). A growing number of studies support the hypothesis that many chemical substances (so-called endocrine disruptors (EDs)) can interfere with the normal functioning of the endocrine system, subsequently leading to developmental and reproductive disorders. Currently, at the EU level, scientific criteria for the identification of EDs are implemented only for pesticides and biocides (ECHA European Chemicals Agency, & EFSA European Food Safety Authority et al., 2018). Moreover, the screening of chemicals and decision-making is dominated by the use of vertebrate data in general and, mammalian data, in particular. Both the 2020 report on the fitness check of legislation on EDs (EC, 2020) and the Chemical Strategy for Sustainability highlight that a more consistent approach is needed to identify EDs across all sectoral legislations. In particular, the Chemical Strategy for Sustainability refers to the establishment of harmonised criteria for the hazard identification of EDs across legislations, and mentions the development and uptake of new and alternative methods to accelerate the generation of information on ED properties of substances. Therefore, in this session, advancements in the field of EDs and future possibilities to move to more integrated assessments that incorporate data generated by new technologies (e.g. NAMs) were discussed.

Session participants noted that even though scientific knowledge on EDs has increased significantly, current knowledge (Kortenkamp et al., 2022) and testing strategies (e.g. Crane et al., 2022; Martyniuk et al., 2022) are subjected to limitations. The need to further advance available testing strategies building on alternative methods to vertebrates, such as (quantitative) adverse outcome pathways and networks, IATA and NAMs was acknowledged. Session participants concluded that there is a need to: formalise the way that new methods are validated internationally; and follow a more integrated approach for the ED assessment, as this would enable the integration and extrapolation of evidence across species (Holbech et al., 2020).

3.2.4.5. Microbiomes, chemicals and health: unravelling an intricate triad (session coordinator: Caroline Merten). Research on the microbiome is proceeding at a very fast pace. This research informs about the role that microbiomes plays in host and environmental health, and helps to explore which microbiome-related data (e.g. endpoints, tests) to integrate into future food safety assessments. This session discussed how to integrate knowledge of microbiomes, chemicals and health, and their interactions in risk assessment.

Microbiome structures and dynamics across the food system have

been shown to have both direct and indirect effects on human, animal and environmental/soil health. The gut microbiome, for example, influences human health for good and bad, while an optimal balance within soil microorganisms can improve plant health and soil fertility. It has also been demonstrated that changes to microbiome structures potentially caused by anthropogenic factors (such as pesticides or additives) can have important effects on human, animal and soil health (Chassaing et al., 2022).

Session participants concluded that the microbiome can no longer be overlooked in food safety assessments, requiring further consideration in risk assessment. However, interactions between microbiomes, chemicals and health are complex, and affected by a wide range of factors (Cryan and Mazmanian, 2022). This complicates the determination of the cause of an effect and whether it is adverse or not. Therefore, further research on the interactions between microbiomes, chemicals and health is needed, which should be tailored to regulatory needs. This knowledge may help to define which microbiome-related data must be integrated into future food safety assessments. To this end, further dialogue is needed between regulatory scientists and innovators to account for the latest developments in the field and consider their relevance in a regulatory context.

3.2.4.6. Conclusions and recommendations. The thematic sessions within the Many Ways track emphasised the potential of new technologies and the interconnectivity of different fields of expertise. Developments in the field of AI and NAMs, for example, are likely to play a crucial role in the advancement of food safety assessments (e.g. in the assessment of the combined exposure to multiple chemicals, including EDs). To further promote the cross-fertilisation between relevant fields of expertise, and bridge regulatory silos, session participants called for a better sharing and integration of data. While a wealth of data is available or currently being generated, efforts must focus on making such data more accessible and interoperable. Since a higher level of scrutiny is typically applied to the use of new methods for regulatory purposes compared to traditional ones, adequate validation of such methods would help to build trust and promote their regulatory acceptance, especially if access to the underlying data is promoted. It was also considered that the complex interactions between the microbiome, chemicals and health require further consideration in food safety assessments.

Further details about the main outcomes of the Many Ways track are summarised in Table 5.

Table 5
Summary of the main outcomes of the Many Ways track.

Sessions	Main outcomes
Augmenting human minds: artificial intelligence (AI) and Big Data in risk assessment	• Advance use of Big Data, automation and application of AI for risk assessment by developing and implementing proper infrastructures and data governance. • Explore ways to foster interconnectedness between AI and NAMs. • Improve access to data for all actors, including low-middle income countries. • Test AI systems adopted in risk assessments, from data collection to deployment in production, for validity and bias. • Develop data science skills and AI literacy, and promote AI education to increase trust in AI and better understanding of the risk assessments where AI technology is adopted.
Combined exposure to multiple chemicals: assessing risks across regulatory silos	• Prioritise regulatory domains associated with food and consumer products as they represent the most important sources of exposure to unintentional chemical mixtures. • Promote the development of roadmaps for regulatory implementation across regulatory silos, both in science and policy. • Combine methods developed in the different regulatory domains, and use them in a complementary manner, possibly following a tiered approach.
New approach methodologies (NAMs): moving beyond animal testing	• Foster dialogue, cooperation and engagement between academia, regulators and the private sector for the development and implementation of NAMs in risk assessment. • Build confidence in NAMs approaches used for regulatory purposes. • Harmonise, integrate and make NAM-based data accessible to all. • Tackle unresolved challenges.
Endocrine disruptors (EDs): exploring present challenges and future developments	• Take a more transverse and harmonised approach to identify EDs across all sectoral legislations. • Develop and implement new testing strategies (e.g. for non-EATS – estrogen, androgen, thyroid, and steroidogenesis – pathways/modalities. • Increase reliance on data derived from NAMs to improve mechanistic understanding of ED chemicals, and enable the integration and extrapolation of evidence between species.
Microbiomes, chemicals and health: unravelling an intricate triad	• Tailor research to regulatory needs and the determination of causalities, which will require more rigorous, interconnected studies and models. • Explore further which microbiome-related data must be integrated in future food safety assessments. • Engage regulators and innovators to fill gaps in risk assessment guidelines for emerging microbiome innovations.

3.3. Closing plenary session "Safe and sustainable food systems – How can we get there?" (session coordinator: Yann Devos)

Current food systems need urgent and significant transformation if they are to achieve sustainability targets (Fanzo, 2021). Hans Bruyninckx (EEA) highlighted that food systems are central to the interconnected crises that affect human and environmental health (e.g. unhealthy and unsustainable diets, climate change, biodiversity loss, resource use, pollution). The effects of climate change combined with the increasing demands placed on food production have pushed the environment to its tipping point. He, therefore, called for urgent and simultaneous actions to address these crises, which will entail a significant restructuring of the food system.

With the European Green Deal, the EU set unprecedented sustainability ambitions, calling for transformational change of key societal systems including food systems. However, the transformation of food systems remains an immense challenge. Food systems are complex, but they offer many entry points for change. An avenue that was explored further in the closing plenary session entitled "Safe and sustainable food systems – How can we get there?" is how health assessments could better inform policies designed to shape the transition towards a sustainable and resilient food system that puts the health of people, animals, plants and their shared environment at its core.

Sandra Gallina (EC), Ismahane Elouafi (FAO) and Hans Bruyninckx emphasised that science and technology have a key role to play in underpinning the transition towards a more sustainable and resilient food system, and must remain the foundation on which to build. However, to turn such far-reaching ambitions into action, knowledge from different disciplines must be integrated and multiple food system actors engaged. Therefore, they advocated the adoption of more integrated, cross-sectoral and collaborative approaches for the development of more

actionable knowledge in support of the transformation of food systems (EEA, 2021b; FAO, 2021).

4. Conclusions and recommendations

The "ONE – Health, Environment & Society – Conference 2022" explored how scientific advice related to food safety and nutrition will need to develop to respond to a fast-changing world. The conference also explored how the EU's ENVI Agencies that provide such advice should best prepare for the challenges ahead, and how they can contribute to policy targets and societal demands for safe, nutritious and sustainable food. The diverse topics addressed at the conference were organised around four thematic tracks (One Society, One Life, One Planet and Many Ways) across three interconnected tiers (food safety, One Health and food system sustainability).

Conference participants acknowledged that the scope of food safety assessments, in particular the link to nutritional and food sustainability aspects, has been changing over time. In light of the United Nations sustainable development goals, and the European Green Deal, food is now expected to meet the highest standards of nutrition and sustainability, in addition to being safe, accessible and affordable for all. Hence, food safety must be defined with a broader focus in mind, ensuring that nutritional and sustainability considerations are embedded within the assessment process. Conference participants also concluded that food safety assessments must be further advanced at different levels to remain fit for purpose, and ensure that the health of humans, animals, plants and their shared environment continues to be protected. Each of the thematic sessions during the conference provided specific recommendations to this end.

Growing complexity in science and society requires to embrace new ways of working that connect and integrate knowledge, data and expertise across a wide range of disciplines (both from natural and social sciences), sectors and actors. A "change-as-usual" (instead of a "business-as-usual") mindset must become the default mode of thinking and working to avoid the risk to become overtaken by future challenges. This requires agile and open-minded institutions that: break down silos; enhance cooperation with relevant actors along the food chain; share and make data interoperable; harness new trends in data, technology and science; invest in future preparedness; and engage society as a whole.

One Health provides a valuable conceptual framework for how to address the challenges associated with the growing complexity in science and society. One Health recognises that the health of humans, animals, plants and their shared environment is closely interconnected. It calls for transdisciplinary cooperation across sectors and actors at the local, national, regional and global levels to attain optimal health outcomes. Conference participants agreed that the application of the One Health principles to food safety and nutrition would help to overcome the food safety challenges of today and tomorrow by ensuring the delivery of more integrated, cross-sectoral and collaborative health assessments. Such health assessments would also better inform policies that support the transition towards a sustainable and resilient food system.

Yet, it is not sufficient to merely acknowledge the concept of One Health, it will need to be applied in practice. In recent years, EFSA, together with some of its partner agencies, has successfully applied the One Health principles in the areas of zoonoses, AMR and bee health. Moreover, they have extended this approach to other areas (e.g. environmental risk assessment). Since EFSA, its partner agencies and EU Member States within the food safety ecosystem have access to extensive transdisciplinary data, scientific knowledge and expertise, they could effectively contribute to the development and implementation of One Health policies along the entire food chain by deepening their cooperation.

To make these changes happen, capacities to better understand and address the complexity of systems must be built, literacy and skills for applying One Health developed, recognition of the One Health conceptual framework promoted, and collaborative approaches for developing more integrated knowledge adopted. An institutional culture in which cooperation is valued as desirable and needed must be fostered. Hence, cooperation must become a strategic objective in itself, and be incentivised and rewarded. At the conference, EFSA, committed to play its part in developing the EU's collaborative ecosystem of food safety actors in close cooperation with those actors who have already indicated their interest in being part of it.

At the same time, closer cooperation between institutions is required. Collectively EFSA and its partner agencies can provide greater value for society by delivering more integrated and cross-sectoral advice to EU policymakers that is tailored to the interconnected challenges of today. Hence, the "EU's ENVI Agencies" should demonstrate leadership in moving One Health forward. At the conference, they committed to free the necessary resources to establish a cross-agency One Health task force. This task force will discern what is needed to move transdisciplinary research and cross-sectoral scientific advice on One Health issues forward.

As strongly advocated by conference participants, this is the moment to act by choosing the path to take and defining the speed by which to travel in the application of the One Health principles to food safety and nutrition.

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Data availability

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Appendix A. Supplementary data

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