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The complexity of managing and communicating emerging health risks in food systems

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Abstract

Here we summarize discussions held in 2024, following up on the 2023 Uppsala Health Summit (UHS) 2023 workshop on “Managing Emerging Health Risks in the Feed and Food Chain”. We conclude with recommendations for Swedish and EU stakeholders, for better risk communication and aligned policymaking. These include using structured and transparent approaches for balancing conflicting goals and using understanding of facts, feelings and politics to effectively manage and communicate risks, while acknowledging trade-offs in risks and benefits.

1. Introduction

Food systems are complex and involve multiple stakeholders across the value chain, beginning with production, processing and packaging, and wrapping up with retail, consumption and waste disposal or recycling. From the beginning, a variety of

agricultural inputs, such as fertilizers, including those sourced from recycled sewage sludge, pesticides, herbicides, additives or preservatives, contain substances that, if applied in excess, become a hazard in the food system and pose a threat to human and environmental health.

As a result, risk assessment of food systems must be multidisciplinary and include food safety, nutrition, environmental, economic and social criteria (Országh et al., 2024). When making decisions regarding safety in the food system, it is important that risk managers consider multiple sustainability goals together and not optimize only some parameters. These goals include the “triple planetary crisis” – pollution, biodiversity loss and climate change – as well as food security and social sustainability (Rüegg, 2023). This broad scope is a challenge for the risk manager, who needs input from experts in multiple domains, including but not limited to environmental risk assessment. In the risk analysis process, the factors that are weighed against each other need to be co-defined with relevant value chain stakeholders early in the process, to allow for informed and transparent decision-making.

Moreover, forging policy on food systems without knowing the public's beliefs, attitudes and policy preferences would be imprudent. Knowing public perceptions of the risks present in food is essential to designing clear and transparent risk communication strategies (Rembischevski & Caldas, 2020). Risk perception plays a prominent role in people's judgements and decisions regarding food safety, security, equality and sustainability; individuals' different roles in the food safety system (as consumers, producers, controllers and regulators) lead to different risk perceptions. This has implications for public trust in government and other institutions, as well as for the acceptance of management strategies by the public and other stakeholders.

Communicating risks requires considering certain key aspects of people's thinking: the risk and benefit trade-offs individuals make, the reasons they make certain decisions or engage in certain practices, and the extent to which they understand the risks involved with those practices. A good understanding of these aspects enables risk information to be effectively targeted to specific groups of individuals when addressing specific gaps connected with risky or "dreaded" practices or technologies, where "dread" refers to potentially catastrophic, uncontrollable and involuntary characteristics of risk. For instance, uncertainty and the unknowns regarding exposure to unwanted substances in sewage sludge and subsequent potential health threats exacerbate risk perception towards its use. A combination of contamination sensitivity and risk perception engender dread. Risk information must explicitly address aspects of potential benefits and social needs of the people it serves, for it to correspond with their expressed and revealed preferences (Renn, 2008).

People depend on three fundamental types of risk for guidance: "risk as a feeling", which refers to fast, instinctive and intuitive reactions to danger ("fast system"); "risk as analysis", which involves logic, reason and scientific deliberation to inform hazard management ("slow system"); and "risk as politics", which becomes evident when ancient human instincts and modern scientific analysis clash, or where feelings and facts conflict (Slovic, 2010). Each of these dimensions of risk is useful in explaining different psychological mechanisms or processes of human behaviour, judgement and decision-making under different circumstances. All perceptions have some "affect", or associated emotions or feelings, and "affective reactions" to stimuli are often the very first reactions, occurring automatically and subsequently guiding information processing and judgement (Murphy & Zajonc, 1993).

1.1 Aim and objectives

This report summarizes the key insights from group discussions at a half-day workshop held at the Stockholm Environment Institute (SEI) in December 2024. This workshop is a continuation of the Uppsala Health Summit (UHS) 2023 workshop on "Managing Emerging Health Risks in the Feed-Food Chain" (Andersson et al., 2023). The UHS

2023 workshop focused on risk analysis and communication strategies between risk assessors, risk managers and the public, as well as the identification of key themes such as stakeholder involvement, risk perception, ethical dilemmas, and implications for trade. In this context, the discussions were general with scenarios based in Sweden and in relation to other EU member states.

The aim of this follow-up workshop was to further explore the policy implications and practical applications of the insights from the 2023 workshop, not only in the food chain, but in particular in the sewage sludge management sector, an area of growing concern in Sweden and the EU. Participants in this workshop included more than a dozen experts representing different food value chain stakeholder groups within academia, the private sector, civil society and the public sector. The objectives of the workshop were to discuss:

- challenges and opportunities of managing risks in the food system, including the use of treated sewage sludge as fertilizer in agriculture;
- factors to consider in making trade-offs and balancing conflicting goals in situations of crisis and uncertainty.

Participants were divided into two groups and asked to reflect on how food value chain stakeholders can be better equipped to balance conflicting societal goals in making decisions regarding safety in the food chain and the use of treated sewage sludge as fertilizer in agriculture. Five scenarios based on factual events relevant to Sweden were presented to participants as background information to guide their discussions.

The scenarios are outlined in the next section. Both groups were asked to reflect on scenarios 1–4 during the first group discussion and scenario 5 during the second group discussion. The participants were encouraged to raise and discuss other situations based on their experiences.

Questions were presented to participants to stimulate group discussions, along the following lines:

- In what way do differences between experts, decision-makers and the public, in their perceptions of risk and other consequences, impact decision-making?
- What were the lessons learned from the scenarios, in terms of factors contributing to successful management and maintaining trust?
- To what extent does disagreement on ethical issues and value judgements influence the decision-making process?

For the findings in this report, our primary target audiences are risk managers, risk assessors, risk communicators and policymakers within the food and sewage sludge management sectors, for Sweden in particular and the EU in general.

1.2 Description of scenarios

Of the five scenarios, the four discussed in the first group discussion round centred on harmful biological toxins in grains (rye fungus, cereal mycotoxins) and fruits (fresh berry parasites) and on harmful toxic chemicals in meats (legacy pollution in fish) that have been regulated in the EU. The fifth case study, which was the subject of the second group discussion, focused on harmful substances from fertilizer derived from treated sewage sludge. Emerging risks from these applications are now being considered for regulation, including substances of concern such as microplastics and, in particular, per- and polyfluorinated alkyl substances (PFAS), also known as “forever substances”.

The scenarios were drafted for policymakers and meant to be provocative for discussion. We present them here in abbreviated form.

Scenario 1: *Claviceps fungus*, which infects grain and is also known as ergot, produces toxins (alkaloids) that may cause severe poisoning, best known as the cause of the medieval “Saint Anthony’s fire”. Symptoms include gangrene, convulsions, hallucinations and hormonal imbalances.

In the EU, regulatory limits of 50 µg/kg for ergot alkaloids in milling products from various grain were implemented in 2024. However, several member states, including Sweden, have proposed to postpone implementation of this regulation for some commodities, including rye and some milled products, until 2028 (Nahar, 2024).

Loss of harvests due to ergot alkaloid contamination, which will increase with lower thresholds meant to protect health, threatens primarily the economic sustainability of agriculture in some regions in Europe and raises questions about how to balance undesired substances against factors such as traditional food (bread), positive health effects of full-grain products, sustainability of regional agriculture, and wasted resources (fuel, fertilizers and national or regional self-sufficiency). Another issue is to what extent strict regulations can be enforced in situations where war, blockades or environmental disasters threaten food security.

Scenario 2: Fox tapeworm, *Echinococcus multilocularis*, has become more common in red foxes in Europe. It was discovered in Sweden in 2011, with a prevalence in fox faeces of approximately 1 in 1000. The parasite’s egg can be transferred to humans via dogs’ fur or via fresh berries. The parasite causes serious illness in humans.

Eating fresh berries is associated with a very small probability of ingesting this parasite. Toddlers could be the main target group if berries are indeed a main route of transmission. The possibility of transmission of this parasite to toddlers may trigger feelings of guilt among parents.

Scenario 3: Fatty fish such as herring and salmon from the Baltic Sea contain elevated levels of dioxins and PCBs. Sweden has had a derogation from the EU maximum limits since 2002 (European Union, 2023). The levels of these pollutants are declining in fish (by almost 90% in the past several decades) but are still around regulatory limits set by the EU (Hällén et al, 2020).

Risk-benefit assessments suggest that fatty fish from the Baltic Sea still have a health benefit, since eating fish reduces risk of cardiovascular disease (compared to meat). The main health effect endpoint of consuming dioxins and PCBs is that male children exposed to dioxins in the uterus run a small risk of impaired sperm quality when they are adults.

Depending on the substitution made for Baltic Sea fish in a person’s diet (farmed fish, imported fish, meat), the impact on public health and other Sustainable Development Goals (SDGs) will differ. For example, farmed salmon may have a negative environmental impact in local waters, and imports from low-income countries could affect food security for vulnerable communities in the exporting countries.

Scenario 4: Aflatoxin is one of the most toxicologically potent mycotoxins: it causes cancer and has been associated with stunting growth and immunosuppression. It is common in cereals, including maize, wheat and other grains, which are vital for food security. The UN Food and Agriculture Organization (FAO) estimates that globally, 25% of cereals produced contain mycotoxins at levels that exceed European regulatory limits (Eskola et al., 2020).

Regulations to protect European consumers from risks related to food contamination may result in food shortages in low-income countries, should the EU import more uncontaminated food from external sources. Higher safety standards might also increase ecological and carbon footprints of food production.

Scenario 5: Fertilizers derived from treated sewage sludge present both benefits and risks. In terms of benefits, sewage sludge contains phosphorus (P, for which global supplies are dwindling), nitrogen (N) and humus (organic matter), which are important nutrients and resources for agriculture. Sewage sludge also contains substances of concern, such as heavy metals, pharmaceuticals, microplastics and PFAS. The latter are an emerging family of contaminants linked to cancers, immunodeficiencies, reproductive harms and developmental effects in children (Fredriksson et al., 2022). Concern over PFAS represents an increasingly important factor in the opposition to the use of treated sewage sludge and wastewater, and it presents a serious challenge for policymakers (Wallenberg & Eksvärd, 2018; Furlong et al., 2019; SOU, 2020; Ekane et al., 2021; Johansson & Krook, 2021; Pettersson & Johansson, 2022; Ekman Burgman, 2022; Strengbom & Östman, 2023; Svenskt Vatten, 2024).

2. Summary of group discussions

We summarize the group discussions in the tables below, with scenarios 1–4 in Table 1 and scenario 5 in Table 2. Some general aspects of risk perception and trade-offs were discussed, in addition to the risk factors, associated trade-offs in decision-making, and solutions and recommendations regarding risk communication, as presented in the tables.

Participants mentioned several examples of how acceptable levels of risks were thought to be perceived differently depending on the following factors:

- consumers' expectations of a product (i.e. organic food is expected to be safer/clean)

- source of food items (wild or homegrown food versus food acquired through mainstream market channels)
- awareness of possible risks (actual and perceived)
- the group exposed to a certain risk; for example, the health of children is a major priority.

Priorities, the extent of risk acceptance, and legislation for agricultural inputs vary between regions. For instance, in some low-income countries where there is unequal access to and distribution of safe food, it might be the case that “tomorrow’s meal is the most important”. In other words, the short-term need to ensure food security might outweigh the need to take precautionary measures and choices that protect health or the environment. In addition, certain pesticides that are not allowed in Europe are used in other regions with weak legislation and low safety standards.

Table 1. Key points raised during first group discussion inspired by the scenarios 1, 2, 3 and 4

Challenges and safety concerns; risk factors (actual and perceived)	Trade-offs in decision-making	Solutions and recommendations regarding risk communication
Pesticides including DDT	DDT is a well-known environmental hazard due to historical use, and definitely not safe, but it is still used in some countries since it saves a lot of lives (malaria).	Be prepared to manage situations where the risk-benefit (human health–environment) trade-off is extremely difficult.
Radioactivity	The Chernobyl accident triggered a reassessment of the limits for radioactivity in fish, reindeer meat, and harvested forest products. The social and economic costs of sticking to the 300 Bq/kg were too high.*	A new situation may change the balance between the SDGs. Be prepared to inform the public.
Ergot alkaloids from <i>Claviceps</i> fungus	Strict regulations may threaten the economic sustainability of agriculture in some regions. Who pays to maintain food production if regulations result in high costs? Measures to mitigate risks at farm level (new techniques, change of practices or production system) can be associated with costs, such as decreased production or other consequences.	Be prepared to manage a situation where food safety and food security collide (including risk communication).
Fox tapeworm in wild berries	Very small probability of a bad disease. Toddlers could be the main target group, if berries are indeed a main route. Information may trigger guilt, as an infection in the child could be associated with “bad parenting”.	A message stating “the risk is extremely small” could have the opposite effect due to effects of feelings of dread and guilt.
PFAS in organic eggs	Sometimes it can be challenging to achieve multiple goals at the same time, such as animal welfare (ensuring sufficient supply of amino acids in organic chicken feed through fish meal) and avoiding synthetic additives (used in conventional egg production but not allowed in organic production).	Precautionary principle is important in organic agriculture. Consumers of organic food may have specific expectations and perceptions of risk and safety for the organic agriculture sector.
Arsenic in groundwater	Example from Bangladesh, where the health of people was weighted against the reputation of government	
Environmental degradation threatens future food security	Need to manage and sometimes prioritize between short- and long-term risks.	

*Immediately following the Chernobyl accident in 1986, a limit of 300 Bq/kg was set for radioactivity in food. However, in 1987, the limits for wild fish, game meat, reindeer meat, berries and mushrooms were raised to 1500 Bq/kg, as the costs and social consequences of the strict limits were considered to be too high (Moberg, 2006).

Table 2. Key points raised during second group discussion, inspired by scenario 5

Challenges and safety concerns; risk factors (actual and perceived)	Trade-offs in decision-making	Solutions and recommendations regarding risk communication
PFAS and microplastics in sewage sludge	<p>Balance between risk (and associated societal costs) and investment required for certain solutions (cost-benefit) since upstream solutions (source separation) can reduce risks but are costly for society.</p> <p>Solutions should consider the value of not only P but also organic matter in sludge (possible trade-offs with incineration or extraction of only P).</p>	<p>Scientists must take a leading role in communicating the actual risks to the public.</p> <p>Upstream strategies, e.g. source separation, are key for facilitating reuse of sewage sludge (no-mix systems are easier to handle).</p> <p>Precautionary principle is key in guiding decision-making.</p>
Contamination (of soils) that will affect future generations	The Revaq certification system is effective in reducing the heavy metal content in sewage sludge but does not currently cover all potential or future contaminants.	
Depletion of phosphorus (P) resources in case it is not recycled (through sewage sludge reuse)	Not recycling phosphorus could have an impact on future food production and food security.	

Participants discussed both the risk factors presented in the scenarios and other risks that were brought up. The actual and perceived risk factors discussed were related to human, animal and environmental health. The potential trade-offs in decision-making identified were in many cases related to the achievement of multiple sustainability goals or aspects (environmental, social, economic) for different groups in society or at different spatial and temporal scales. In many cases, the solutions and recommendations regarding risk communication discussed were related to managing and communicating priorities related to these trade-offs.

The actual and perceived risk factors discussed in scenario 5 were related to how contaminants in sewage sludge may affect human and environmental health, alongside the need for recycling phosphorus present in treated sewage sludge and the feasibility and costs of implementing ideal risk management options such as upstream measures to separate sources of wastewater. In the discussions, some existing solutions and those under development for mitigating risks were mentioned. However, opinions on whether such solutions would be sufficient to eliminate risks differed, which reflects the differences in risk perception or acceptance of risk among workshop participants.

Similarly, participants discussed how to balance between societal costs for implementing solutions and the risks associated with not doing so. Regarding decision-making and risk communication, the precautionary principle was identified as an important tool for dealing with uncertainties and unknowns related to public health risks. Furthermore, the role of scientists to clearly communicate actual risks to the public was highlighted.

3. Discussion

We highlight four insights that can be established from the points made in the discussions and outlined in tables 1 and 2: risk is multidimensional; environmental needs can clash with circular economy goals; risk can be “acceptable” or not; and trust is key.

3.1 The different dimensions of risk

Risk is multidimensional in that people perceive hazards in many ways, sometimes not even accepting subsequent risk, depending on their framing. Communication of risk must take this multiplicity of views into account, as much as possible, as must decision-making.

Developing an effective communication strategy about different hazards depends not only on technical risk assessments (“risk as analysis”) related to health or the environment but must also consider consumer perceptions and preferences (“risk as feeling”). People make decisions about choices or the acceptability of treated sewage sludge based on their assessment of both risks and benefits, which may include those related to socio-economic, political and ethical factors (“risk as politics”). People do not rely only on risk management information they receive regarding risk factors; they also depend to an extent on their feelings about the risk factors in making judgements and decisions regarding the purpose for engaging in a practice or consuming certain food types and the level of exposure they can tolerate personally.

These points indicate that risk managers and assessors should effectively incorporate the “risk as a feeling” dimension in

their interventions. The origin and type of food may influence the perceived risk and safety of consumers. For example, consumers of organic food may perceive organic food to be safe. Thus, understanding how individuals differ in, for example, their safety information needs and preferences, how different individuals process risk and benefit information, and how these may vary according to psychological and other individual differences will help risk communicators in developing and effectively communicating messages.

While decision-making typically refers to setting policies, and thus the rules with which farmers, industry and other actors must comply, decisions related to communication or non-communication may have a large impact on the trust in authorities. Predicting the impact of communication will require understanding not only the risk, but also the perception and feelings of the receivers. A challenge in communication and policymaking is that stating that a health risk is deemed acceptable is a near-taboo, especially if it involves children or “dread” factors. Strategies for handling this might be needed to resolve a crisis, especially if health risk should be weighed against the availability of food and a bearable environment in the future, for the same children who might suffer health impacts from consuming these foods now.

“Upstream” measures – controlling what enters the waste stream from the beginning – are important for reducing unwanted substances at the source. The content and quality of sewage sludge depends on what we allow into the system. For instance, many substances reach the sewage system after passing through the body of a human or pet (nutrients and some drugs, for example), or are byproducts from processes such as manufacturing or washing clothes (microplastics). Wastewater from households and industries is channelled through piped systems to wastewater treatment plants where it is mixed to produce sewage sludge. The perception of the feasibility and costs for implementing “upstream” measures to control the emissions of these unwanted substances will have a strong influence on risk acceptance. Thus, common understanding of the risks and benefits alongside the feasibility of mitigation strategies is needed for a fruitful discussion of ethical dilemmas and value judgements.

One challenge to such a holistic view is that the perception of risks, costs and feasibility will be dependent on a person’s ability to interpret complex statistical information. Achieving a common understanding of a multifacet problem may require intense communication between policymakers, experts and stakeholders, in particular in the framing and phrasing of an assessment question, to promote co-production of knowledge. In addition, it requires a system of methods to evaluate the risks that is well harmonized between all stakeholders.

3.2 Circular economy versus non-toxic environment

Risk managers and assessors are confronted with conflicting goals of promoting a circular economy and at the same time

maintaining a non-toxic environment. This is particularly the case with the use of treated sewage sludge as fertilizer in agriculture. Some stakeholders would like to see increased use of treated Revaq-certified sewage sludge in line with expectations to create a more circular economy and favour changes in current legislation. Even though the quality of treated sewage sludge has been greatly improved by the Revaq certification system, some stakeholders still argue against its use in agriculture and point to the actual and potential risks of contamination in the short- and long-term.

To reach national and international objectives related to circular economy and a non-toxic environment, it is important to understand how trade-offs can be managed to facilitate solution-oriented policymaking that takes into account the actual and potential benefits and risks. As highlighted in the workshop discussions, in periods of scarcity and crisis, the next meal will be the priority for people. At the same time, a society must also be able to produce food in the future and cannot afford to pollute soil, harm biodiversity and deplete essential resources (such as phosphorous).

When sewage sludge from a wastewater treatment plant is to be used as a resource in agriculture, the health issues and aspects of risk reduction need to be carefully accounted for in addition to the benefits of nutrient recovery. In the technical improvement of existing wastewater collection and treatment systems, including the Revaq certification system and the design and implementation of new ones, health risk considerations are crucial and should always be an integral part of the planning and decision-making process.

3.3 Precautionary principle versus acceptable risk

The precautionary principle is generally accepted in EU decision-making, and when it comes to approval of industrial processes and substances, it has generally served well to protect human and environmental health in the region. However, there are examples where it leaves the decision-maker stuck. Such situations occur in the agricultural and aquacultural sector, where a contamination event occurred beyond a food-producers’ control, resulting either from industrial processes (dioxins, radioactivity, etc.) or biological agents (mycotoxins). The Chernobyl accident was raised in the discussions as an example where the regulatory limits for radioactivity in Sweden had to be updated so that it would be possible to sell reindeer meat, game meat, berries and mushrooms. In the food sector, the reaction to an out-of-control situation may be to look away, deny or even suppress information, as exemplified by PFAS in Swedish food and drinking water, aflatoxin in African grain or polluted fish in Bangladesh.

At times, the reaction may protect the decision-maker, but there are examples where communication of a risk has triggered fear and irrational behaviour. The perception of risk may be amplified by guilt, particularly if children are exposed. A classic example is vaccination: parents who avoid vaccinat-

ing their children assume that the risk of very harmful side effects from a vaccination is greater than the risk of getting or being harmed by the targeted illness, despite information to the contrary.

3.4 Perceived risk and trust

The Swedish public has a high degree of trust in authorities responsible for providing services vital for life, such as potable water and maintaining a non-toxic environment (*giftfri miljö*). This trust might easily be tarnished by a single mishap or mistake. Even where trust is more resilient, trust in efforts or decisions to reach one goal may not generalize to another (e.g. public health versus environmental protection).

Scientists advocate different views in public, even when this may undermine public trust. In difficult situations, the communicator may have to consider that risk communication and risk perception could affect well-being when the risk: (1) cannot be avoided, (2) can be avoided only by the rich, or (3) is avoided at a high ecological or cultural cost. To maintain trust, the decision-maker must be able to present credible facts as well as convincing ethical and philosophical arguments. The importance of transparency in risk analysis for maintaining trust is reflected in the EU Transparency Directive (European Union, 2019).

4. Recommendations

We highlight the following recommendations from the discussion, for decision-makers, risk assessors, risk managers and risk communicators:

- Use structured and transparent approaches for balancing conflicting goals.
- Tailor risk communication programs or campaigns for different groups, as risk means different things to different people.
- Harmonize methods of risk analysis and promote transparency in risk analysis and decision-making to maintain trust, as stressed in the EU Transparency Directive (European Union, 2019).
- Understand not only the facts (natural science) but also the feelings and politics (psychology and social science) involved, to effectively manage and communicate risks.
- Have constructive discussion on ethics and value judgments in making trade-offs, by establishing a common understanding of the risks and benefits of different options under consideration in a co-creation process, stressing the importance of a framework for managing situations with multiple conflicting goals.
- Prepare for future crises by understanding what would make the public accept a higher health risk to protect other important societal goals.

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Uppsala Health Summit (UHS) is an international arena for dialogue, exploring possibilities and implementation challenges associated with advancement in medicine and public health.

Stockholm Environment Institute (SEI) is an international non-profit research institute that tackles environmental and sustainable development challenges.

The Swedish International Agricultural Network Initiative (SIANI) is a global, open and inclusive network that supports and promotes multisector dialogue and action around our vision of sustainable, rights-based and inclusive food systems.

You can find more information about the three organizations at: www.uppsalahealthsummit.se, www.sei.org, www.siani.se.

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