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Technical assistance in the field of risk communication

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Abstract

This report assesses peer-reviewed and grey literature on risk communication concepts and practices, as requested by the European Commission to support the implementation of a 'General Plan for Risk Communication', i.e. an integrated framework for EU food safety risk assessors and risk managers at Union and national level, as required by the revised EU General Food Law Regulation. We conducted a scoping review of social research studies and official reports in relation to risk communication in the following areas: understanding and awareness of risk analysis roles and tasks, reducing misunderstanding of the different meaning of the terms 'hazard' and 'risk', tackling misinformation and disinformation, enhancing confidence in EU food safety, taking account of risk perceptions, key factors in trade-offs about risks, audience segmentation and tools, channels and mechanisms for coordinated risk communications. We structured our findings as follows: i) definitions of key concepts, ii) audience analysis and information requirements, iii) risk profiling, models and mechanisms, iv) contributions to communication strategies. We make several recommendations for consideration by the Commission, both in terms of actions to support the design and implementation of the general plan, and research needs that we consider crucial to further inform appropriate risk communication in the EU. EFSA carried out a targeted consultation of experts and a public consultation open to all interested parties including the general public, in preparing and finalising this report.

Keywords: risk communication, risk perceptions, trust, audience analysis, risk profiling, misinformation, disinformation

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Summary

The Transparency Regulation introduces amongst others a new provision that empowers the European Commission to adopt, by means of an implementing act, a General Plan for Risk Communication (GPRC) to achieve the objectives and the general principles for risk communication set out in the revised General Food Law Regulation. The general plan should promote an integrated risk communication framework followed both by the risk assessors and the risk managers in a coherent and systematic manner both at Union and national level.

In preparing the GPRC, the Commission is required, amongst others, to closely cooperate with EFSA and the Member States. Through its expert Working Group on Social Research Methods and Advice and based on social science evidence and approaches, EFSA was requested to provide technical assistance in the field of risk communication to the Commission as a contribution to the implementation of the GPRC.

In response to the request, we identified and reviewed relevant scientific and grey literature, including existing frameworks, evaluated this evidence and provided our advice in the form of this scientific report. The report is complemented by three outsourced tasks to complete the evidence base in response to the Commission's request. These tasks include mapping and reporting on: i) large-scale engagement models and tools; ii) communication tools and channels; iii) communication capacities and processes at national/Union level of risk assessors and risk managers. These tasks were conducted in parallel with this review and, where appropriate, used as sources or referred to in this report.

To answer the broad questions and issues outlined in the terms of reference, we deemed a scoping review the most appropriate approach and prioritised existing reviews as sources of information. We sourced the data from academic research databases mainly comprising peer-reviewed literature. To identify relevant literature, we carried out an initial broad search on the databases Google scholar, PubMed, Scopus and Web of Science in February and March 2020. EFSA also held a targeted consultation to assist the Working Group in filling data gaps and identifying additional evidence sources in a structured and targeted manner to keep the process streamlined. EFSA also held a public consultation on the draft scientific report, which was open to all interested parties, including the general public, and which generated many additional references to help us finalise this report.

We summarised the findings extracted from our review of literature and formulated our advice for the requester on the specific questions in the mandate. We determined to describe the evidence base and to formulate our findings, conclusions and recommendations according to the purpose of the information requested in the mandate.

First, we defined key concepts in the terms of reference and clarified those for which the literature was ambiguous. Second, we described key aspects of audience analysis including factors influencing risk perceptions, trade-offs in risk decisions and approaches for segmenting audiences. We followed this with an assessment of how to tailor information to audience needs and summarised available tools and channels for this purpose. Third, we explored tools for combining the key factors in structured approaches to risk communication, namely generic risk profiling and risk communication models described in the literature. We evaluated the limited available literature on existing models for coordinated risk communication at supranational/EU/national levels involving both scientific advisory bodies and decision makers.

The final part of our assessment provides information for use in developing communication strategies on key issues highlighted in the Transparency Regulation: 'foster public understanding of the risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome,' 'take into account risk perceptions of all interested parties,' 'the ambiguity in the public perception of the difference between hazard and risk' and 'contribute to the fight against the dissemination of false information and the sources thereof'.

We provided conclusions on each of the specific questions in the mandate throughout the report and summarised the most important findings from our review in the overall conclusions. Finally, we make several recommendations for consideration by the Commission, both in terms of actions to support the design and implementation of the GPRC, and research needs that we consider crucial to further inform appropriate risk communication in the EU. These include, among others, ways to test a proposed framework for generic risk profiling, work on common communication platforms between risk assessors and risk managers and practical ways of tackling false information in the realm of food safety.

Table of contents

1. Introduction

1.1. Background

Article 1 point 2 of Regulation (EU) 2019/1381 of the European Parliament and of the Council of 20 June 2019 on the transparency and sustainability of the EU risk assessment in the food chain (hereinafter 'Transparency Regulation')[1] amongst others introduces a new Article 8c to Regulation (EC) No 178/2002 (hereinafter 'General Food Law Regulation').[2]

The latter new provision empowers the Commission to adopt, by means of an implementing act, a general plan for risk communication in order to achieve the objectives and the general principles set out in the General Food Law Regulation, as amended by the Transparency Regulation.[3]

The general plan should promote an integrated risk communication framework followed both by the risk assessors and the risk managers in a coherent and systematic manner both at Union and national level. It should:

a) Identify the key factors to be taken into account when considering the type and level of communication activities needed;
b) Identify the different types and levels of communication activities and the appropriate tools and channels to be used for risk communication purposes;
c) Establish appropriate mechanisms of coordination and cooperation to strengthen coherence;
d) Ensure an open and participatory dialogue with all interested parties.

In preparing the general plan for risk communication, the Commission is required, amongst others, to closely cooperate with EFSA and the Member States. Through its expert Working Group on Social Research Methods and Advice, EFSA is able to provide technical input based on social science evidence and approaches on the principles and implementation of risk communication, as defined in the Transparency Regulation. In addition, given its experience in this context, EFSA can also provide technical assistance on how risk communication can improve public understanding of the difference between hazard and risk.[4]

EFSA could provide technical assistance in the field of risk communication. Such assistance would relate to the results of scientific assessments used as a basis for risk management actions, while acknowledging that evidence from risk communication science may not always allow the complete separation of risk assessment and risk management considerations. However, this input should not deal with situations specifically covered by the general plan for crisis management,[5] insofar as is possible to separate risk communication and crisis communication.

In 2012, EFSA first published a best practice Risk Communication Handbook, titled 'When Food Is Cooking Up a Storm - Proven Recipes for Risk Communications (last updated in 2017),' a practical tool for risk communicators working in EU food and feed safety. In 2019, EFSA further published guidance on the communication of scientific uncertainties. Continuing this trend as a source of best practice on risk communication and given the experience to date, EFSA could provide technical assistance in the field of risk communication.

1.2. Terms of Reference as provided by the requestor

In the context of Article 31 of the General Food Law Regulation, EFSA is requested to provide technical assistance to the Commission based on the following Terms of Reference (henceforth 'TR'):

1) Describe the science behind the concepts of 'awareness' and 'understanding' as referred to in the new Article 8a(a) of the General Food Law Regulation as amended, to provide guidance for risk communication aimed at 'raising awareness and understanding' of the specific issues

[1] Regulation (EU) 2019/1381 of the European Parliament and of the Council of 20 June 2019 on the transparency and sustainability of the EU risk assessment in the food chain and amending Regulations (EC) No 178/2002, (EC) No 1829/2003, (EC) No 1831/2003, (EC) No 2065/2003, (EC) No 1935/2004, (EC) No 1331/2008, (EC) No 1107/2009, (EU) 2015/2283 and Directive 2001/18/EC. OJ L 231, 6.9.2019, p. 1, to be found at: https://eur-lex.euiODa.eu/legalcontent/EN/TXT/PPF/?urUCELEX:32019RI381&from=EN

[2] Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603189780600&uri=CELEX:32002R0178

[3] See new Articles 8a and 8b of the General Food Law Regulation, respectively, as amended.

[4] Recital (6) of the Transparency Regulation.

[5] Recital (9) of the Transparency Regulation.

in risk analysis (of food and feed safety), including links between awareness/understanding and behaviour with respect to risks;

2) Provide guidance for risk communication that may 'foster public understanding of the risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome,' as stated in Article 8a(e) of the General Food Law as amended, with a focus on public willingness to understand both the nature of science and also the value of evidence-based regulatory science;
3) Define 'appropriateness' as referred to in Article 8b(a) of the General Food Law as amended, with respect to target audience segmentation, to 'ensure that accurate and all appropriate information is exchanged in an interactive and timely manner with all interested parties, based on the principles of transparency, openness and responsiveness';
4) Regarding identification of the relevant factors for risk communication activities, as referred to in Article 8c(2)(a) of the General Food Law as amended read in conjunction with recital (10) of the Transparency Regulation:

    a) Identify the 'key factors' to take into account when considering the type and level of risk communication activities needed, including factors that influence how EU citizens assess whether a risk or a trade-off is acceptable and the factors that influence this determination;
    b) Define 'risk perception' as referred to in Article 8b(c) of the General Food Law as amended, and factors influencing risk perception[6] to provide guidance for risk communication on how to 'take into account risk perceptions of all interested parties';
    c) Identify social, cultural and psychological factors to explain 'the ambiguity in the public perception of the difference between hazard and risk,' as stated in Recital (6) of the Transparency Regulation, to support risk communication that can clarify and improve public understanding of the difference between hazard and risk;
    d) Provide guidance on how to take account of the identified 'key factors' in defining the 'types and levels of risk communication activities' and 'appropriate main tools and channels,' referred to in Article 8c(b) of the General Food Law as amended;
    e) Based on these factors, explore the possibility to create 'generic risk profiles' corresponding to the different workflows of risk analysis procedures, and especially for regulated products.[7]

5) Regarding the identification of the different types and levels of communication activities and the appropriate tools and channels to be used for risk communication purposes, as referred to in Article 8c(2)(b) of the General Food Law as amended:

    a) Carry out a comprehensive mapping of all different types and levels of engagement and communication activities and the appropriate tools and channels depending on the different target audiences; this mapping should provide an overview of advantages/disadvantages of the different tools and channels taking into account the relevant risk factors and include 'best practices' based on literature review and input from existing research, where relevant;
    b) Provide guidance for risk communication (including types and levels of communication activities) that can 'contribute to the fight against the dissemination of false information and the sources thereof' as required by Article 8a(i) of the General Food Law as amended, in relation to risk analysis of food and feed safety; explore the effectiveness of the different engagement and communication activities;

6) Regarding the establishment of appropriate mechanisms of coordination and cooperation, as referred to in Article 8c(2)(c) of the General Food Law as amended:

[6] E.g. whether the risk stems from a new/novel source, whether it is the subject of diverging scientific opinions risk management decisions, or of public concern).

[7] For background reference, these 'generic risk profiles' should aim at a) providing a generic mapping of the elements that would need to be assessed and/or considered both at risk assessment and risk management level, on the basis of the above-mentioned factors, according to available knowledge and past experiences; b) provide preliminary assessments – based on existing knowledge, if any – of any associated benefits associated with the relevant risks, e.g. actual or expected benefits, their magnitude and importance, who benefits and how, who may be in disadvantage and how, potential trade-offs etc.; and c) identify overall sensitivity of the subject matter, taking into account concerns, expectations and most importantly risk perceptions.

a) Carry out a comprehensive capacity and process mapping of existing structures for risk communication at national and Union level in the European Union, including both risk assessment and risk management public authorities;
b) Identify and evaluate existing models for coordinated risk communication at supranational/EU/national levels involving both international/EU/national scientific advisory bodies and decision makers in the food safety area or other sectors.

1.3. Interpretation of the Terms of Reference

EFSA responded to this request through a combination of scientific evaluation of existing literature and of procurement activities, as follows:

1) As indicated in the Commission's request, EFSA's expert Working Group on Social Research Methods and Advice will review scientific and grey literature, including existing frameworks, in answering questions 1, 2, 3, 4a-e, 5b and 6b, evaluate this evidence and provide its technical advice in the form of a scientific report of EFSA. In cooperation with the Commission, EFSA will consult interested parties (e.g. institutional partners, stakeholders, scientific community) on a draft version of the report prior to its finalisation and publication. The estimated timeframe for this activity includes a consultation in mid/late-2020 and finalisation of the scientific output in March 2021.
2) EFSA will procure services to carry out the mapping activities referred to in Question 5a and in Question 6a, as chartered under its 'Relationship Management Project,'[8] specifically, carrying out three outsourced activities focused on: i) Large-scale engagement models and tools; ii) Communication tools and channels; iii) Communication capacities and processes at national/Union level of risk assessors and risk managers. The results of these outsourcing activities will be made publicly available. The estimated timeframe for completion of these activities is March 2021.
3) Following finalisation of the activities outlined in points 1 and 2, and in cooperation with the Commission, EFSA will, together with its national partners in the Communications Expert Network, revise and update the Risk Communication Handbook 'When Food Is Cooking Up a Storm – Proven Recipes for Risk Communications'. The estimated date for completion of this activity is December 2021, pending the Commission's development of the General Plan for Risk Communication, as required under the new Article 8c of Regulation (EC) No 178/2002.

Applicability of this report. We interpreted the scope of risk communication and the roles of various actors in EU food safety, e.g. risk assessors, risk managers, to apply principally to public bodies with regulatory roles within the EU food and feed safety system, i.e. EFSA, the European Commission and national risk assessors and risk managers. Whereas individuals or organisations representing consumers, businesses and other interested parties may also be considered to be under an obligation, e.g. to follow the principles and objectives of risk communication, their risk communication may be influenced by other factors such as economic considerations or advocacy. Therefore, we kept the scope within the explicit purposes of this mandate, i.e. support implementation of the GPRC framework for assessors and managers at Union and national levels.

2. Data and methodologies

2.1. Data

To answer to the broad questions and issues outlined in the terms of reference, we deemed a scoping review the most appropriate approach and prioritised existing reviews as sources of information (see Section 2.2 Methodologies for more details). We sourced the data used from academic research databases mainly comprising peer-reviewed literature. The first search resulted in 342 references identified, selected based on the title and the abstract. We tagged each reference with the name of the keyword used for the search. We performed an in-depth reading of the abstracts, which resulted in the exclusion of 111 references as non-relevant. The Working Group experts checked the list of excluded papers again and decided to retain 22 references as relevant. After excluding

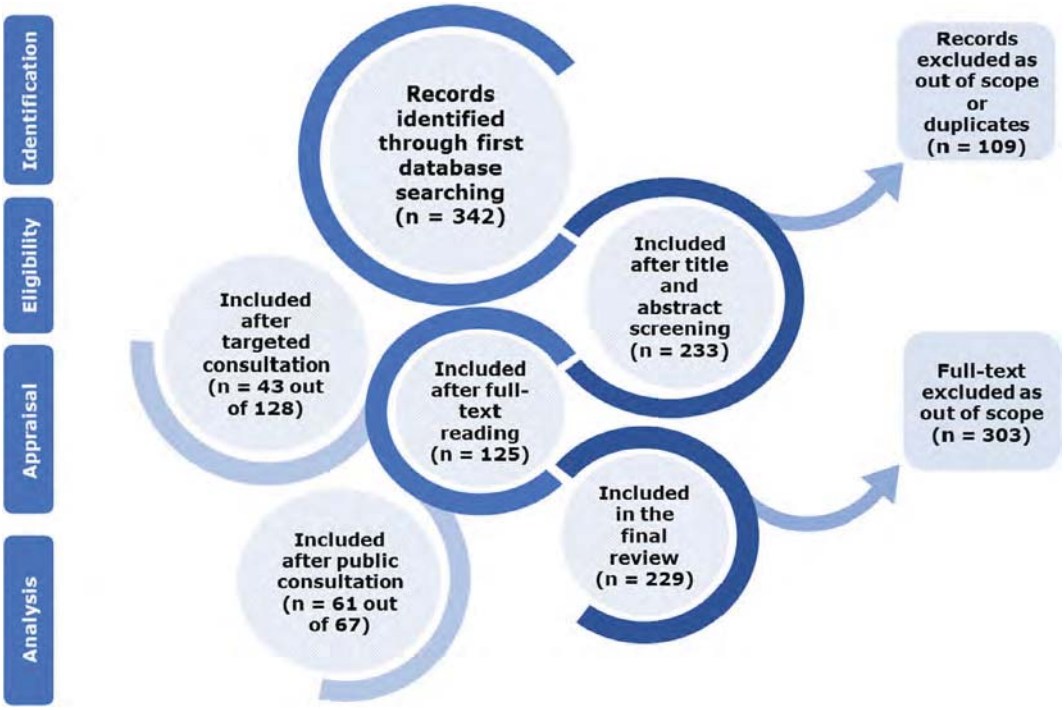
[8] An internal EFSA project set up to manage organisational changes required to implement new provisions of Regulation (EU) 2019/1381. Work Package 4 on 'Risk communication' includes the outputs referred to in Section 1.3 as well as other deliverables. For more information: https://www.efsa.europa.eu/en/stakeholders/transparency-regulation-implementation

duplications (n = 20), the final tally of papers for full-text reading was 233. Since 10 papers were relevant for two topics, they were read by two reviewers, helping also to mitigate potential bias in the review. We added four additional references on the topics of risk perception and hazard and risk after the initial search. Two of them were published after the date of the first search, one was retrieved from the list of references of an included paper on the difference between hazard and risk and one was identified through a second search on the topic of risk perception. Five additional papers on the topic of false information were included after the first search to fill the gaps identified in the literature reviewed.

EFSA held a targeted consultation to assist the Working Group in filling data gaps and identifying additional evidence sources in a structured and targeted manner to keep the process streamlined. Thirteen risk communication experts with past involvement at EFSA or proposed by members of the EFSA Advisory Forum were contacted for their support. The targeted consultation was held from 3 August to 3 September 2020 and resulted in a total of eight answers. The targeted consultation helped to identify 124 additional references which we took into consideration and included where relevant (see Section 2.1.1 and the Technical report on the outcome of the targeted and the public consultations (EFSA, 2021a) for a more detailed overview).

EFSA held a public consultation on the draft scientific report calling on risk communication and science communication experts and specialists – including practitioners at national, EU and international risk assessment and risk management public authorities – to review and comment on the draft. The public consultation was held from 19 November 2020 to 24 January 2021 and resulted in a total of 27 interested parties submitting 220 comments. A detailed description of the process and how the comments were taken into account is provided in the Technical report published as a supporting document to this scientific report. The public consultation helped to identify 67 additional references which were all reviewed and included where relevant (see Section 2.1.1 and the Technical report on the outcome of the targeted and the public consultations (EFSA, 2021a) for a more detailed overview).

A summary of the whole process, broadly following the principles of the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement (Moher et al., 2009) is summarised in Figure 1.



Source: Adapted from the PRISMA Flow Diagram, Moher et al. (2009).

Figure 1: Overview of the literature review process

2.1.1. Scientific literature

Awareness and understanding. We reviewed a total of 29 references on the science behind the concepts of awareness and understanding (TR 1). We considered three out of 29 papers relevant to the topic of public attitudes to risk analysis and three relevant to the topic of risk perception. Our analysis of the content of the papers in the review showed a lack of formal definition of the two concepts. Moreover, scarce consideration is given to psychological processes underlying decisions, including cognitive, motivational and emotional processes, and a limited use of existing and well-validated conceptual models. To fill these gaps, we consulted handbooks together with additional references from the literature on health literacy and conceptual models in the field of public health emergency preparedness communication literature. Additionally, the experts consulted during the targeted consultation suggested nine references dealing with the definition of the terms 'awareness' and 'understanding'. Lastly, the public consultation further helped in identifying three additional references.

Public attitudes to and confidence in risk analysis. There were 25 references on the topic of public attitudes to risk analysis and how to enhance confidence in its outcome (TR 2). We considered three out of 25 papers relevant to the topics of awareness and understanding, and one relevant to the topic of risk perception. The data extraction revealed a lack of consistency in the definition of trust and confidence and the presence of a tight relationship between the concepts of risk analysis and risk communication. Regardless of these data issues, we found the literature to be adequate to answer TR 2. We received an additional 19 references through the targeted consultation, specifically dealing with questions concerning the role and responsibilities of risk managers in the risk analysis process, the nature of science in risk analysis and the value of evidence-based regulatory science. An additional seven references were suggested in the context of the public consultation.

Appropriateness (audience segmentation, information types). We retrieved 43 references on the definition of appropriateness in terms of target audience segmentation to ensure information exchange based on transparency, openness and responsiveness (TR 3). One paper out of the 43 was also relevant to the topic of risk perception and one other paper to coordinated communications. The review and data extraction were sufficient to answer TR 3, providing guidelines, golden rules and recommendations for risk communication. We received 13 additional references on the topic of audience segmentation from the targeted consultation. Specifically, these concerned differences in targeting institutional partners and stakeholders and the wider public. Lastly, the public consultation provided an additional five references.

Key factors (risk or trade-off acceptance). We reviewed 31 references for identifying the key factors when considering the type and level of risk communication activities needed, with a focus on risk or trade-off acceptance (TR 4a). One paper out of 31 was also relevant to the topic of risk perception. The data extraction revealed the presence of a long list of factors to consider, many of them overlapping with the literature on risk perception. Overall, the papers identified were sufficient to answer TR 4a. We received 17 additional references relevant to this question from the targeted consultation. Specifically, these regarded a potential categorisation of factors to adopt, research on the stability of factors over time and research on the quality of factor measurement. An additional two references were suggested by interested parties through the public consultation.

Risk perception. We found 86 references for defining risk perception and the factors influencing it to provide guidance for risk communication on how to take into account risk perceptions of all interested parties (TR 4b). Three papers out of 86 were also relevant to the topics of awareness and understanding, one was relevant to the topic of 'public attitudes towards risk analysis', one to 'appropriateness' and one to 'key factors'. We included two additional papers after the initial search, one resulting from a second search of the literature and one published after the date of the initial search, suggested by an external expert who collaborated with EFSA in the past. Therefore, a total of 88 articles were read in full. After full-text reading, we judged 18 articles non-relevant for this report.

We assessed extensive literature on risk perception, providing a comprehensive understanding of factors able to influence the public's perceptions. Nevertheless, we note that the main focus of the papers reviewed is the general public/consumers, without considering other stakeholders and interested parties.

We received 11 additional references from the targeted consultation. These were useful for gaining insights on practical recommendations on how to take into account risk perception in risk communication. Finally, eight references were provided in the context of the public consultation.

Hazard vs. risk. We retrieved two references on the social, cultural and psychological factors to explain the ambiguity in the public perception of the difference between hazard and risk (TR 4c). The full-text reading revealed that both papers were not relevant to the question; however in screening the references of one of the two papers, we identified one relevant article on how the conceptual difference between hazard and risk is appraised by risk assessors and risk managers. In addition, we found no references on the public's perception of the difference between hazard and risk. We received six references from the targeted consultation, which helped to fill this data gap. An additional four references were suggested by interested parties through the public consultation.

Risk communication activities. We were able to use the evidence collected for answering the other TRs (in particular TR 4a on key factors) to respond to TR 4d requesting guidance on how to take account of the identified key factors in defining the types and levels of risk communication activities and appropriate main tools and channels.

Risk profiling. We were able to use the evidence collected for answering the other TRs (in particular TR 3 on appropriateness) to respond to TR4e requesting us to explore the possibility to create generic risk profiles corresponding to the different workflows of risk analysis procedures. We received one additional scientific paper potentially relevant to this question from the targeted consultation. One further reference received in the context of the public consultation was deemed relevant for risk profiling.

False information. Our first search identified 17 references on providing guidance for risk communication that can contribute to the fight against the dissemination of false information and the sources thereof (TR 5b). A second search conducted to fill some gaps identified in the literature resulted in the addition of five more papers. The literature reviewed highlighted the need to distinguish between misinformation and disinformation and to avoid the term 'fake news'. Overall, we deemed the papers satisfactory to answer TR 5b. We received nine further references from the targeted consultation. These helped us to understand if there are any specific tools that deal with misinformation/disinformation on food and feed safety and identify cases of misinformation/disinformation relevant to risk analysis/communication. The public consultation helped to identify four additional references.

Coordinated communication. We gathered nine references on the topic of existing models for coordinated risk communication at supranational/EU/national levels involving both international/EU/national scientific advisory bodies and decision makers in the food safety area or other sectors (TR 6b). The papers mainly described conceptual models for risk communication, which we used in our answer to TR 4d. One reference resulting from the search on appropriateness was relevant to this topic. EFSA asked other European agencies and international bodies for their support in identifying models for coordinated communication, but we did not receive any relevant references as a result. We received 14 references from the targeted consultation, four of which were relevant to the topic. Lastly, we received 11 additional references in the context of the public consultation.

2.1.2. Grey literature

Appropriateness (audience segmentation, information types). We consulted a joint handbook by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) in answering TR 3. We also included the findings of an EU-funded project called Mapping Controversies on Science for Politics (MACOSPOL) identified through the public consultation.

Communication tools and channels. We consulted a report by the UK Food Standards Agency (FSA) to address this topic. Additionally, we included a report on social media monitoring by the European Centre for Disease Prevention and Control (ECDC).

Risk profiling. EFSA consulted national communications specialists belonging to the EFSA Communications Experts Network (CEN) and social researchers from the International Social Science Liaison Group (ISSLG). This resulted in including the risk profiles developed by the German Federal Institute for Risk Assessment (BfR) and those by the New Zealand Food Safety Authority (NZFSA). Moreover, the experts consulted through the targeted consultation suggested two joint reports by FAO and WHO.

Coordinated communication. We included a report from the Joint Research Centre (JRC) and a report from the World Meteorological Organization (WMO) relevant to this topic. Additionally, the targeted consultation helped to identify examples coming from the International Risk Governance Council (IRGC).

Other grey literature was consulted for the definitions of risk communication and crisis communication, i.e. reports from the US Department of Homeland Security, the United States Centers for Disease Control and Prevention (CDC) (suggested via the public consultation) and the Organisation for Economic Co-operation and Development (OECD), and for the definition of disinformation, i.e. a report from the Government Communications Service.

2.2. Methodologies

To identify relevant literature, we carried out an initial broad search on the databases Google scholar, PubMed, Scopus and Web of Science in February and March 2020. We selected the following search terms and alternative terms (in parentheses), based on our analysis of the TRs and the questions to answer: awareness (appraisal), understanding, risk perception (fear, hazard vs. risk, perceived probability), risk analysis, risk assessment, confidence, willingness (education level, economic constraints, interest), transparency, openness, response/responsiveness (literacy capacity), factors that influence risk communication (communication channel, communication source, information source, tools), appropriateness (economics of information, cost/benefit analysis, audience segmentation/target audience), interactive, risk communication, trade off, acceptability of risk, influence, misinformation (debunking).

We combined the search terms in the following search strings: Search Term AND risk, Search Term AND review, Search Term AND risk AND review, Search Term AND food safety, Search Term AND risk AND food safety, Search Term AND risk AND food safety AND review, Search Term AND risk communication.

We split the search terms equally among the members of the Working Group on Social Research Methods and Advice – external experts and EFSA staff – who conducted searches independently following agreed standards.

We selected the papers on the basis of the title and the abstract, according to five criteria. First, we included only studies in English. Second, the studies needed to cover at least one of the questions in the TRs. Third, they could be systematic or scoping reviews, handbooks and experimental studies; however, priority was given to existing reviews. Fourth, for studies within reviews or non-review papers, we considered only studies with empirical evidence. Fifth, the timeframe for concepts started from the 1980s until the day of the search, while for communication aspects we took into account literature published in the last 10 years. We consulted books and book chapters in some specific cases, e.g. to provide formal definitions of concepts or to fill gaps in the literature. Some book chapters were also suggested by the external experts in the targeted consultation.

All full texts of the identified papers were uploaded to the reference management software 'Mendeley' developed by Elsevier. Subsequently, EFSA staff reviewed the abstracts to check the relevance of the articles for the report, excluding those not relevant to the TRs, e.g. those not mentioning risk communication and papers only focusing on risk management or crisis communication. Only articles published in peer-reviewed journals were included. The resulting list was reviewed by the Working Group experts who either accepted or discarded the assessment based on their knowledge of the topic and the literature.

We divided the final list of included papers per topic and assigned them to an expert and/or staff for full reading. Any papers either authored or jointly authored by one or more members of the Working Group were reviewed by a non-author of the paper from among the external experts. We used a shared template to summarise the findings extracted from the papers and report the most significant information. The full reading allowed us to establish which papers were the most and least relevant (or non-relevant) in answering the TRs and identifying articles relevant for other topics within the TRs. Where we identified gaps, the experts provided additional references especially in the form of academic books or framework models from the health promotion field.

To achieve a comprehensive overview of the scientific literature, EFSA carried out a two-step consultation process. First, after completing the findings extraction, we asked additional external experts who had previously provided advice on risk communication best practices to EFSA to address important gaps identified in the literature. Second, EFSA held a public consultation on the draft scientific report itself, during which we asked the additional experts to provide their feedback.

While the approach followed has numerous strengths, it is worth highlighting the limitations of the applied methodologies. First, the purpose of a scoping review is to offer an overview of the available research evidence without producing a summary answer to a specific research question. Scoping reviews are useful for answering broad questions in a more structured way. The difference with

systematic reviews lies also in the absence of a quality checklist for assessing papers, but reliance on shared inclusion and exclusion criteria. As stated above, to overcome this issue, some papers were read by two reviewers. The targeted and public consultations also helped to ensure inclusion of the most relevant literature to the terms of reference. Second, the timeframe of the literature search was fixed, therefore papers published after that date might have been missed. Again, the targeted and public consultations which were held after the database search allowed for inclusion of additional papers published after the original timeframe. Third, the inclusion criterion for literature in English only might have precluded relevant literature in other languages from our review.

3. Assessment

In this section, we summarise the findings extracted from our review of literature described in Section 2 and formulate our advice for the requester on the specific questions in the terms of reference. We determined to describe the evidence base and to formulate our findings, conclusions and recommendations according to the purpose of the information requested, as follows:

- Provide definitions of key concepts in the mandate and clarify these where the literature is not always in agreement;
- Evaluate key aspects of audience analysis – factors influencing risk perceptions, trade-offs in risk decisions and approaches for segmenting audiences; followed by an analysis of how to tailor information to audience needs and a summary of tools and channels available for targeting information to specific audiences;
- Explore tools for combining the key factors in structured approaches to risk communication: generic risk profiling and risk communication models; and consider the evidence on mechanisms of coordinated communications; and
- Provide information for use in developing communication strategies on issues highlighted in the mandate: 'foster public understanding of the risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome,' 'clarify and improve public understanding of the difference between hazard and risk' and 'contribute to the fight against the dissemination of false information and the sources thereof'.

Figure 2 previews the structure of Section 3 and is intended to aid the reader to navigate the various subsections and flows of information.

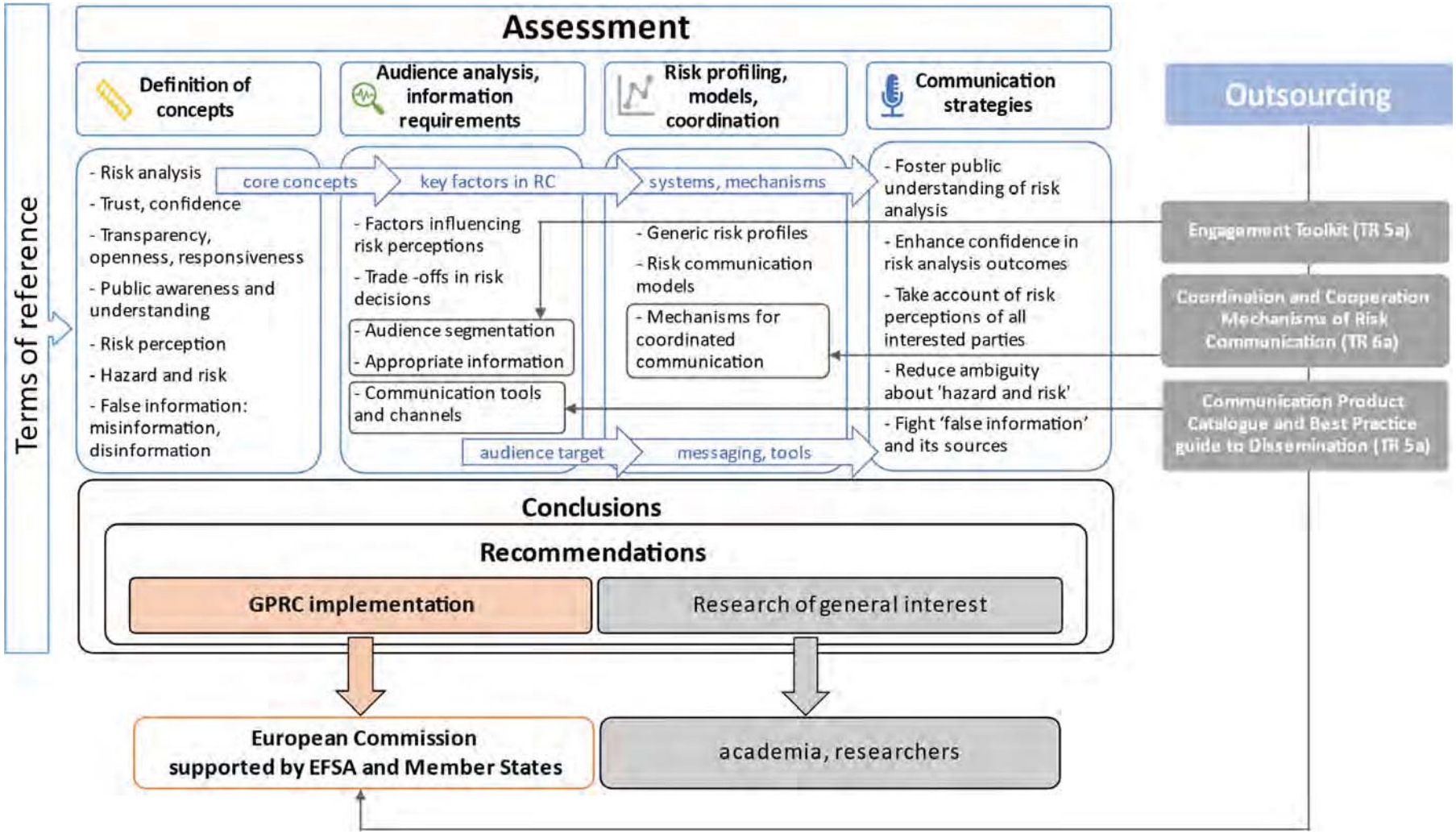


Figure 2: Overview of the scientific report structure, related outputs and the main information flows

3.1. Definitions of key concepts

In this section, we define key concepts referred to in the TRs based on findings from the literature and/or definitions specified in European legislation and/or global frameworks. As stated in Section 1.3 Interpretation of the Terms of Reference, we consider the scope of these definitions and their applicability to be limited to public bodies with regulatory roles within the EU food and feed safety system, i.e. EFSA, the European Commission and national risk assessors and risk managers.

3.1.1. Risk analysis: assessment, management, communication

The three interconnected components of risk analysis – risk assessment, risk management and risk communication – are fundamental concepts in this report. All three elements and the overall risk analysis process for EU food safety are defined in the General Food Law Regulation, which established the EU food safety system and EFSA in 2002. The Transparency Regulation introduced elements to further clarify and/or broaden aspects of the definitions. These EU legal definitions, described below, are the default references for this report since fulfilling the terms of reference and supporting the implementation of the future GPRC expressly relate to the EU institutional framework for food safety risk analysis. However, we recognise that the design of legal definitions is inherently influenced by procedural requirements and objectives that may omit some epistemological qualities of the terms. Therefore, we included relevant findings from literature to clarify the understanding and use of the terms more broadly. Further, we identified potential ambiguities in the literature, which we report below to avoid possible confusion or misunderstandings about these concepts and the applicability of the evidence within the framework of this mandate. Specifically, we discuss and clarify the following sources of possible ambiguity about definitions identified in the literature:

- risk analysis and risk assessment
- risk communication and crisis communication
- communication and engagement

Risk analysis and risk assessment. The EU definitions of risk analysis and its three component parts are derived from those adopted by the United Nation's Codex Alimentarius Commission (CAC, 1997, 2006). Article 2 of the General Food Law Regulation sets down that,

- 'risk analysis' means a process consisting of three interconnected components: risk assessment, risk management and risk communication;
- 'risk assessment' means a scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation[9];
- 'risk management' means the process, distinct from risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors, and, if need be, selecting appropriate prevention and control options;
- 'risk communication' means the interactive exchange of information and opinions throughout the risk analysis process as regards hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, feed and food businesses, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.

As stated above, the terms 'risk analysis' and 'risk assessment' are distinct. Risk analysis is an umbrella term that describes the whole risk process, from risk assessing hazards to managing the risks identified and communicating any sensitive risk-related findings and risk management measures. According to the glossary of the Society for Risk Analysis, risk analysis is a 'Systematic process to comprehend the nature of risk and to express the risk, with the available knowledge. Risk analysis is often also understood in a broader way, in particular in the SRA community: risk analysis is defined to include risk assessment, risk characterisation, risk communication, risk management, and policy relating to risk, in the context of risks of concern to individuals, to public and private sector organisations, and to society at a local, regional, national or global level' (SRA, 2018).

[9] Hazard identification in food safety involves identifying biological, chemical, and physical agents capable of causing adverse health effects. Hazard characterisation defines the nature of those adverse health effects when the agents are present in food and feed. Exposure assessment determines who, or what, has been exposed to a hazard and quantifies the amounts involved. Risk characterisation concludes on the likelihood that an agent will cause harm taking into account the nature of the hazard and the extent to which people, animals, plants and/or the environment are exposed to it.

In the food safety community, the application of the FAO/WHO approach is further clarified as involving the estimation of risks to human health and safety, the identification of appropriate control measures to address the risks and communication with stakeholders on both the risks and the measures applied to control them. The process aims at providing food safety regulators with the information and evidence they need for effective decision-making, thus contributing to improved food safety and public health.

Article 5 of the EU Food Law Regulation, which sets out its general objectives, notes that it 'shall pursue one or more of the general objectives of a high level of protection of human life and health and the protection of consumers' interests, including fair practices in food trade, taking account of, where appropriate, the protection of animal health and welfare, plant health and the environment'. To this end, the responsibilities of EFSA also extend to assessments of animal health and welfare and plant health, where these have a direct or indirect impact on the safety of the food and feed supply chains.

Analysis and assessment, however, are words often used in the layman's lexicon in a non-scientific capacity and as such are frequently used interchangeably. Notably, in academia and research, risk assessment and risk analysis are terms that apply to a wide range of fields, not only food safety. As these terms exist in the realms of cyber security, health, business and law, to name just a few, it is unsurprising that at times discrepancies in their use emerge in literature, resulting in possible uncertainty about their meaning in the food safety context.

Freund and Jones define risk analysis as a component of a larger risk assessment process in the context of the factor analysis of information risk (FAIR) methodology (Freund and Jones, 2014). Conversely, the United States National Institute of Standards and Technology (NIST), which is largely concerned with information security, defines 'risk assessment' as synonymous with 'risk analysis' (NIST SP 800-137 under Risk Assessment CNSSI 4009). By comparing just these two examples taken from the numerous definitions and understandings of the terms, it becomes clear that the meaning attributed to them differs across and even within sectors.

With regards to food safety, genetic modification of crops is a topic of intense debate, and this debate emerges in part from confusion between 'risk assessment' and 'risk analysis' (Johnson et al., 2007). Johnson et al. (2007) argue that both scientists and members of the public can misunderstand the roles of scientific risk assessment and risk analysis and that this can potentially have a negative impact on public trust in regulatory science. Clarifying these misunderstandings must be an objective of this report.

It is imperative that the meaning of 'risk assessment' and of 'risk analysis', as they relate to food safety, as understood by the public and by specific interested parties, is taken into account in communication to the public, and that future guidance on food safety related risk communication involves methods to strengthen public understanding of the terms to prevent the emergence of distrust in risk analysis outcomes. Our advice on risk communication to foster public understanding of the risk analysis process and enhance confidence in its outcomes is discussed in Sections 3.4.1 and 3.4.2.

Risk communication and crisis communication. Recital (9) of the Transparency Regulation, which calls for the establishment of a 'general plan on risk communication', also states that it 'should not deal with situations specifically covered by the general plan for crisis management'. The Background to the terms of reference (Section 1.1) adds the caveat that the requested technical assistance should respect this distinction 'insofar as is possible to separate risk communication and crisis communication'. Hence, it is important to clarify the applicability of these two terms, while also bearing in mind that much literature is ambiguous about this separation.

The legal definition of risk communication, as stated above, is somewhat broad and does not fully capture different levels of interactive exchange: 1) the dissemination of public information about risks to consumers or other affected groups; 2) the dialogue within and between risk assessment and risk management; 3) engagement with interested parties affected by risk analysis outcomes (FAO/WHO, 2016). The risk communication requirements of each of these functions may vary, affecting, e.g. the technical degree of the discourse, operational mechanisms used, the timing and frequency of exchanges. The content of risk communication provides information about the risk (and benefits) and the context, i.e. the nature of the hazard, who or what is affected and how severely, the type of exposure (e.g. short term or long term), and the ability of individuals or public authorities to control the risk. Risk communication must also adhere to the core principles of transparency, openness and scientific independence, which include explaining any scientific divergences among different advisory bodies and the impact of scientific uncertainties on the assessment conclusions and on any subsequent

risk management measures (EFSA, 2012). Hence, this report includes findings relevant to all three streams of risk communication described above as far as possible and the related factors (e.g. trade-offs, risk perceptions).

Before attempting to differentiate crisis communication from risk communication, it is important to note that the Transparency Regulation introduced new provisions to clarify the objectives and general principles of risk communication specifically as they relate to the EU food safety system (see Table 1).

Table 1: Objectives and General principles of risk communication

Article 8a	**Article 8b**
Objectives of risk communication	General principles of risk communication
Taking into account the respective roles of risk assessors and risk managers, risk communication shall pursue the following objectives:	*Taking into account the respective roles of risk assessors and risk managers, risk communication shall:*
a) raise awareness and understanding of the specific issues under consideration, including in cases of divergences in scientific assessment, during the entire risk analysis process; b) ensure consistency, transparency and clarity in formulating risk management recommendations and decisions; c) provide a sound basis, including, where appropriate, a scientific basis, for understanding risk management decisions; d) improve the overall effectiveness and efficiency of the risk analysis; e) foster public understanding of the risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome; f) ensure appropriate involvement of consumers, feed and food businesses, the academic community and all other interested parties; g) ensure appropriate and transparent exchange of information with interested parties in relation to risks associated with the food chain; h) ensure the provision of information to consumers about risk prevention strategies; and i) contribute to the fight against the dissemination of false information and the sources thereof.	a) ensure that accurate and all appropriate information is exchanged in an interactive and timely manner with all interested parties, based on the principles of transparency, openness and responsiveness; b) provide transparent information at each stage of the risk analysis process from the framing of requests for scientific advice to the provision of risk assessment and the adoption of risk management decisions, including information on how risk management decisions were reached and which factors were considered; c) take into account risk perceptions of all interested parties; d) facilitate understanding and dialogue amongst all interested parties; and e) be clear and accessible, including to those not directly involved in the process or not having a scientific background, while duly respecting the applicable legal provisions on confidentiality and protection of personal data.

For example, Article 8a as amended by the Transparency Regulation makes specific mention of a role for risk communication in the context of scientific divergence. The EU Food Law Regulation sets down the need to identify and where possible resolve divergence among different scientific assessment bodies and is addressed by a specific procedure. However, in the general context of communication, specific attention has to be paid to explaining any such scientific divergence (as of 2018 there had been only 12 cases) to non-scientific audiences. Divergences can be caused by scientific factors and institutional contexts, e.g. differing responsibilities and protection goals, resulting in the use of different data sets and methodologies, therefore risk communication should seek to clarify these factors and provide consistent messages from all the institutions involved (Boholm, 2019).

These new provisions are fundamental in ensuring an unambiguous understanding of risk communication as it relates to EU food safety. Also, the contents of Table 1 decisively shaped the Terms of Reference (Section 1.2) and are therefore extensively discussed throughout Section 3 Assessment below.

Regarding crisis communication, EU food safety legislation does not provide a precise epistemological definition to easily demarcate it from risk communication more generally. To an extent, the distinction is driven by the regulatory need to define the circumstances in which a risk becomes an 'incident' or a 'crisis' thereby triggering the necessary organisational and procedural responses in those situations. Therefore, while separation may be somewhat artificial, we consider it necessary to provide

technical clarification to the best extent possible so that the two 'general plans' can coexist efficiently and effectively.

Relevant articles of legislation and European standards help to construct a viable definition of crisis communication. The General Food Law Regulation classifies crisis communication as an integral component of crisis management. Article 55 establishes the need for a 'general plan for crisis management' to deal with 'emergencies' and which specifies 'the practical procedures necessary to manage a crisis, including the principles of transparency to be applied and a communication strategy'. Commission Decision (EU) 2019/300[10] establishes the General Plan for Crisis Management for food and feed safety. Recital (16) states that,

> 'evidence-based, real-time communication to the public and to trade partners is essential to contribute to protecting public health by avoiding further spread of risks and to restoring confidence in the safety of food or feed not affected by an incident.'

In terms of which situations constitute 'emergencies' Article 2 states they involve 'direct or indirect risks to public health deriving from food and feed, in particular in relation to any hazard in food and feed of biological, chemical and physical nature, which are not likely to be prevented, eliminated or reduced to an acceptable level by provisions in place […]'. The terms crisis and incident are sometimes used interchangeably such as in Recital (19) which states a crisis depends on the 'seriousness and extent of the incident in terms of public health impact, the relevant consumer perception and political sensitivity' and indicates specific conditions: the source of the incident or outbreak is still uncertain, was intentional (e.g. bioterrorism or side effect of fraud) or a repeat of past incidents after which follow-up measures were insufficient. The United States Centers for Disease Control and Prevention defines an emergency as 'any public health event or incident presenting risk to life, health, and infrastructure […]' and that this encompasses both 'crisis' and 'disaster' situations (CDC, 2018). The European standard for crisis management[11] defines crisis, more precisely, as an 'unprecedented or extraordinary event or situation that threatens an organisation and requires a strategic, adaptive and timely response in order to preserve its viability and integrity' and incident as an 'adverse event that might be, or could lead to, a disruption, loss, emergency or crisis', both of which feature in our conclusions. It also distinguishes between them on the basis of such factors as their predictability, impact, degree of media scrutiny. The future ISO 22361 standard on crisis management is expected to distinguish crisis – including elements of existential threat, surprise and short decision-making time – from emergency, based on organisational tolerance levels, i.e. 'an emergency for one organisation can be considered a full-blown crisis in another'.[12] The Organisation for Economic Co-operation and Development (OECD, 2016) states risk communication 'needs to be done before a hazardous event occurs, to inform citizens and businesses about their potential exposure and to encourage them to invest in precautionary measures' whereas emergency and crisis communication needs 'to inform people once the event is imminent, has already begun or has just occurred'.

Articles 21 and 22 of Regulation (EU) 2019/300 stipulate the objectives of the communication strategy during 'incidents', mainly relating to crisis management measures and interaction with affected operators, third countries and international partners. Communication should include: consistent and coordinated messages; effective communication on risks; updates on the ongoing nature of investigations and precautionary measures in situations of uncertainty; provision of reliable evidence to support decisions and measures; reassurances about products not affected by the incident; and information on successful measures taken, e.g. withdrawal of affected batches. The crisis ends once factors causing it are fully resolved, or it may be downgraded to 'incident' status (which requires 'only an enhanced coordination at the Union level').

In the literature, several authors discuss 'risk communication' primarily in relation to high-impact disaster hazards, e.g. extreme weather incidents, industrial accidents or radioactive waste (Höppner et al., 2012; Verroen et al., 2013; Otto et al., 2018) which easily meet the criteria for emergency situations. Several typologies exist to distinguish the various phases of risk communication which help

[10] Commission Implementing Decision (EU) 2019/300 of 19 February 2019 establishing a general plan for crisis management in the field of the safety of food and feed, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32019D0300

[11] CEN/TS 17091:2018 on 'Crisis management - Guidance for developing a strategic capability', https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT:62265&cs=145D51B76D14672B45644D295E04E6F64

[12] Minutes of the 32nd meeting of the EC Community Capacity in Crisis Management (C3M) Inter-Service Group (27 November 20).

to delineate non-crisis 'peacetime' efforts from emergency or incident-related crisis communication. In the natural hazards' literature, risk communication follows a cycle of prevention/preparation, warning, emergency response and, finally recovery (Höppner et al., 2012), where the latter three steps belong to crisis communication, implying peacetime communication is concerned principally with prevention and preparedness. Similarly, other authors differentiate 'ongoing communication' from 'incident communication' (Charlebois and Summan, 2015), or 'pre-crisis communication' from 'crisis/emergency communication' (Heath et al., 2019) which addresses the urgency of a crisis situation and empowers decision-making (CDC, 2018). Also, crisis communication is 'focused on image and reputation restoration', while risk communication concerns 'information presentation, persuasion and strategic messaging' (START, 2012). The authors of a study related to industrial incidents took the opposite approach, describing risk communication as applying to emergency situations (the 'hot phase') and crisis communication intended for prevention (the 'cold phase') (Verroen et al., 2013). Cairns et al. recognise the 'indistinct definitions and overlaps' between risk communication and crisis communication in the literature and in practice, but a need for different strategies. Therefore, they propose definitions of their own,

> 'crisis communication is 'directive and precise and deals with visible hazards', risk communication is 'innately indeterminate because it is the communication of uncertainty' and is not 'instructive' rather a discourse – the exchange of ideas between various stakeholders about possible future threats.' (Cairns et al., 2013).

However, this definition is problematic not least given communication of uncertainties around food safety risks is widely considered more critical during emergencies. FAO/WHO state 'food safety situations that require urgent communication to prevent or reduce the risks of significant harm are often associated with many gaps in knowledge' and that 'this should be acknowledged and explained, together with what is being done by risk assessors and managers to address the uncertainty (FAO/WHO, 2016).

Communication and engagement. Question 5a of the TR (see Section 1.1) refers to 'types and levels of engagement and communication activities' in relation to their use for 'the purposes of risk communication'. The revised EU Food Law Regulation (Table 1, above) states among the objectives of risk communication (Article 8a) is to '(f) ensure appropriate involvement' of interested parties and to '(g) ensure appropriate and transparent exchange of information' with them. Further, the principles (Article 8b) state that it should '(d) facilitate understanding and dialogue amongst all interested parties.' We interpret these texts as implying that 'engagement' is the instrument by which to ensure the 'involvement' of various interested parties and an 'exchange of information' within a framework of multi-directional dialogue. 'Communication' facilitates 'understanding' and thus enables informed dialogue, e.g. by providing information that is 'appropriate and transparent'.

Literature defines engagement in different ways; it can be considered as an overarching concept including public 'communication', 'consultation' and 'participation' (Rowe and Frewer, 2005) or it could be seen as a separate concept from 'involvement' or 'participation', but with overlapping areas (e.g. citizen science at the crossroads of 'engagement' and 'participation', with elements of both) (Woolley et al., 2016). In the EU food and feed safety risk assessment process, current engagement activities aim both to provide interested parties (e.g. stakeholders) with a better understanding of the scientific decision-making processes and to improve the quality of scientific outputs by accessing new sources of scientific information (EFSA, 2016). Given that 'regulatory science is shaped by interactions – sometimes conflicting – within 'network-like constellations' of different actors' (Felt and Fochler, 2010, cited in Smith et al., 2019), the demand for participatory approaches requires not only that interaction takes into account societal concerns and perspectives but that the open dialogue adds value to the scientific process (Smith et al., 2019). This represents a shift in line with the concept of knowledge co-production – an alternative to 'controversy' when understanding the relationship between science and society – acknowledging the production of knowledge as a collective endeavour (Jasanoff, 1996; JRC, 2013). Such an enlarged concept of the expertise available to the risk analysis process has to address concerns, such as the representativeness of all interested parties, in order to generate a shared and trusted technical and science-driven knowledge pool that can help overcome conflicting perceptions of risks (Palma-Oliveira et al., 2018).

In the context of risk communication, engagement ensures the involvement of interested parties and the exchange of information among them within a framework of open dialogue. As such, it should be built on principles of openness and transparency, as underlined in principle (a) of Article 8b (Table 1).

Further evidence regarding engagement and communication as means of delivering appropriate information to different audience groups, is presented in Sections 3.2.3 and 3.2.4, below.

Conclusions

Based on the above discussions, we propose to clarify these terms for use in this report to avoid possible misunderstanding, based on the legislation in the first instance with supporting points from the literature, as follows:

- Risk analysis is an umbrella term that describes the whole risk process, from risk assessing hazards to managing the risks identified and finally communicating any sensitive risk-related findings and risk management measures.
- Risk analysis is a process that produces knowledge that informs how to understand, assess, characterise, communicate, manage and govern risk.
- A risk assessment is a scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation.
- The assessment branch of the analysis process aims at providing food safety regulators with the food safety related information necessary for effective decision-making, thus contributing to improved food safety and public health.
- In food safety terms, the demarcation between the two terms is clear: 'risk analysis' is a process consisting of three interconnected components: risk assessment, risk management and risk communication; 'risk assessment' is a component of risk analysis, and it is the scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation.
- Risk management is the process, distinct from the scientific risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors in order to select appropriate prevention and control options. Risk Management often includes completing a cost/benefit analysis.
- Risk communication is 'the interactive exchange of information and opinions throughout the risk analysis process as regards hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, feed and food businesses, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.'
- Risk communication involves different levels of interactive exchange: 1) the dissemination of public information about risks to consumers or other affected groups; 2) the dialogue within and between risk assessment and risk management; 3) engagement with interested parties affected by risk analysis outcomes.
- Whereas risk communication is mainly a discourse of ongoing communication intended to prevent and prepare for possible future risks, crisis communication deals with immediate hazards and takes place within pre-crisis, emergency or post-crisis situations, such as food-borne incidents or outbreaks, which pose a risk to public health, consumer perception or may be politically sensitive.
- Generally, a crisis is an unprecedented or extraordinary event or situation that threatens a population, organisation or system, and requires a strategic, adaptive and timely response to preserve safety, viability and integrity.
- An incident is an adverse event that might be, or could lead to, a disruption, loss, emergency or crisis.
- In the context of risk communication, engagement ensures the involvement of interested parties and the exchange of information among them within a framework of open dialogue.
- The demand for participatory approaches requires not only that interaction takes into account societal concerns and perspectives but that the open dialogue adds value to the scientific process. This concept is in line with that of knowledge co-production, and must be characterised by representativeness of all interested parties, in order to generate a shared and trusted knowledge pool.

3.1.2. Trust and confidence

Recital (4) of the Transparency Regulation states that 'it is necessary to ensure transparent, continuous and inclusive risk communication throughout the risk analysis, involving Union and national risk assessors and risk managers. Such risk communication should strengthen citizens' trust that the

risk analysis is underpinned by the objective of ensuring a high level of protection of human health and consumers' interests.'

Following the definitions of risk analysis, risk assessment, risk management and risk communication above (Section 3.1.1), we considered it necessary to clarify additional concepts in the EU Food Law Regulation, which are important for this report: trust and confidence (this section); and openness, transparency and responsiveness (Section 3.1.3).

Within much of the literature concerning the various aspects of risk analysis, trust and confidence are treated as distinct but often related and at times inextricably linked concepts that play a role in the value the public places on risk analysis outcomes. In more general terms, trust plays a role in the public's confidence in most things including, e.g. people or institutions. We noted, however, that the distinction between trust and confidence may not operationalise across all languages as it does in English; e.g. the terms trust and confidence can both be translated as 'vertrouwen' in Dutch and 'Vertrauen' in German. As the methodology adopted in this scoping review included only literature that was published in English, the issue of a lack of distinction in other languages has not emerged or been addressed in this report.

As trust and confidence are among the most important factors to affect public attitudes to the risk analysis process; e.g. a lack of trust in an organisation or process – such as risk analysis – can negatively 'impact the adoption of new technologies, generate political resistance to policies, and impede changes in behaviour that might otherwise be beneficial' (Hobbs and Goddard, 2015). It is for this reason that having consistent and cohesive definitions of them is of the utmost importance. Comparing findings across studies can be made difficult by the inconsistency among definitions and thus among the logic and understanding that underpins studies.

The literature on trust is copious, with authors often linking trust to related concepts such as trustworthiness (O'Neill, 2018), credibility (Frewer, 2003; Cho et al., 2017) or confidence (Khan et al., 2017; Siegrist, 2019). Examination of trust also includes considerations of belief (Visschers and Siegrist, 2008; Lam et al., 2018) as well as willingness to open oneself to another party (Auger, 2014).

Sapp et al. (2009) (as cited by Arnot et al. (2016)) claim that 'Confidence, or shared values, was three to five times more important than competence for consumers in determining who they will trust in the food system'. Fiske and Dupree (2014) understand competence to be another term for expertise and argue that competence/expertise and trust are related to credibility, especially communicator credibility (see Section 3.4.2 Enhance confidence in risk analysis outcome); this highlights the close links between concepts such as confidence, trust, competence and credibility. Confidence and trust are overlapping concepts that display a level of interdependency that makes distinguishing between the two difficult at times. To some, confidence is required for trust to exist and vice versa.

De Jonge et al. (2004) argue that trust is frequently based on social relationships between individuals or between an individual and institutions (as supported by Kasperson et al., 1992; Slovic, 1993; Siegrist et al., 2000); on the other hand, one can have confidence in anything: a person, an institution or a concept, e.g. food safety (Siegrist et al., 2003). Trust is a term that has generated numerous definitions, varying from the detailed and nuanced (where trust is conceptualised to exist in different forms, such as cognitive trust, emotional trust and behavioural trust (Kasperson et al., 1992) to the general (it is defined as 'faith or confidence in a person or institution' (Cho et al., 2017)). Therefore, it is necessary for clarity to use specific definitions for the meaning of the terms 'trust' or 'confidence' within this discussion.

As there are no cohesive and consistent definitions of either trust or confidence across the papers we reviewed, this paper will use the definitions by Siegrist (2019) who distinguishes three types of trust: general trust, social trust and confidence. According to Siegrist (2019), social trust is based on the judgement of similarities in intentions and values (i.e. people tend to trust people or organisations with values similar to theirs) while confidence is based on past experiences. While this conception of trust is no more or less correct than another, this definition encompasses many of the traits found within other definitions, and thus can bridge the gaps found among the various conceptions.

Specifically, Siegrist argues that general trust is underpinned by personality traits, such as openness or optimism and is defined as 'a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another' (Rousseau et al., 1998, cited in Siegrist, 2019, p. 2). Social trust and confidence are described in the Trust, Confidence and Cooperation (TCC) model, which assumes that social trust and confidence influence one's willingness to cooperate, e.g. to accept certain outcomes (Siegrist et al., 2005). Social trust is related to individual values and is often formed in relation to actors with whom one interacts indirectly, such as regulatory institutions. Social trust is based on the judgement of similarities in intentions and values

between the public and entities or actors such as institutions or bodies. Confidence, however, is based on prior knowledge, experience, performance or other accumulated evidence that suggests that future events would occur as expected. Ultimately, the most important fact to highlight is that according to the TCC model, social trust has a causal impact on confidence (Earle and Siegrist, 2006).

It is important to distinguish between these three components and acknowledge the importance of all of them in the context of risk communication. In many recent fora, regulators have used trust and social trust as well as trust and confidence interchangeably. This is to be avoided as studies show that the relationship between risk perceptions and trust differs depending on which of the three types of trust is being measured (Siegrist, 2019).

According to Slovic (1993), trust is fragile, and it can be destroyed in an instant. The asymmetry principle posits that negative events exert a higher impact in decreasing social trust compared to positive events in increasing social trust. However, research on the stability of trust (Cvetkovich et al., 2002) revealed that trust and distrust are perseverant. In two studies the authors found that both positive and negative news and initial general trust affected the level of trust. Individuals with pre-existing distrust in an organisation showed less trust following both positive and negative news events. Additionally, individuals low in pre-existing general trust judged negative news as more informative than good news. This finding confirms that beliefs are resistant to change and, when trust or distrust are established, people will accept information that confirm their beliefs, while discarding information that contradict their beliefs (Slovic, 1987).

In relation to trust, and specifically applied to the food system, Arnot et al. (2016) identified three elements that drive trust, i.e. i) confidence, ii) competence and iii) influential people (family and friends, but also doctors and veterinarians). The authors also introduced the concepts of social license and social control. Social licence is given when an organisation operates in agreement with the ethics, values and expectations of the stakeholders. When public trust is lost the social license is replaced with social control, i.e. regulation, legislation, litigation or market action put in place to make sure that performance is at the level of expectations of stakeholders and regulators. To maintain trust, it is essential to rely on 'systems and practices that are ethically grounded, scientifically verified, economically viable and clearly communicated' (Arnot et al., 2016), and to overcome distrust, structural and procedural approaches should be implemented (Balog-Way et al., 2020) (see Section 3.4.2 Enhance confidence in risk communication). Ultimately, the reputation of public institutions and systems is 'determined by cumulative experiences and historic accounts of trustee–trustor relationships' (Rousseau et al., 1998).

Conclusions

- Definitions of trust are varied and inconsistent, but overall it is clear that levels of public trust and confidence can be increased through certain acts, such as increasing transparency and tailoring risk communications.
- The distinction between trust and confidence may not operationalise across all languages as it does in English; e.g. the terms trust and confidence can both be translated as 'vertrouwen' in Dutch or 'Vertrauen' in German.
- Beliefs can be resistant to change; once trust or distrust is established, people accept information that confirm their beliefs and discard information that contradict them.
- Trust and confidence are distinct concepts; trust is frequently based on social relationships, but one can have confidence in anything: a person, an institution or a concept. Confidence is often based on prior knowledge, experience, performance or other accumulated evidence that suggests that future events would occur as expected.
- Regulators use trust and social trust as well as trust and confidence interchangeably. This is to be avoided as studies show that the relationship between risk perceptions and trust differs depending on which of the three types of trust is being measured.
- Trust, when applied to the food system, is driven by three elements: competence, confidence and influential people.

3.1.3. Transparency, openness and responsiveness

The Transparency Regulation refers to transparency and openness as key principles of risk communication and in the 'appropriate exchange of information'. We discuss the definitions of these terms here, and in Section 3.2, we discuss how they can be applied in the context of delivery of appropriate information to different audience segments.

Transparency. Auger (2014) defines transparency simply as 'providing the evidence behind decisions and actions' and claims that 'transparency helps to restore trust and diminish reputational risk or damage'. Transparency must be increased throughout the risk assessment and risk management processes and risk communication must be clearer, more open and ultimately more understandable. Increasing transparency does not necessarily mean making sweeping changes to procedures, but rather could involve simply explaining better the procedures already in place. Schreider et al. (2010) state that 'existing guidance concerning criteria elements of transparency related to the risk assessment process must be more widely disseminated and applied'.

Access to information is a major contributor to real and perceived transparency. To ensure transparency, risk governing structures and processes should be accessible and assessable by any interested parties, including the lay public, experts or stakeholders (Devaney, 2016). The risk analysis process must be open to scrutiny at every stage; increased transparency, by its nature, should provide the public with opportunities to scrutinise the values and activities comprised in the risk analysis process, including the values applied to specific processes of risk communication, risk management and risk assessment (Frewer, 2004; Van Kleef et al., 2007).

In the discussion paper on transformation to an 'Open EFSA', transparency is described as *'the quality of being clear, obvious and understandable without doubt or ambiguity, thereby contributing to increased understanding of the actions of Union administrations.'* (EFSA, 2014, p. 10).

'Openness', as a term often used in relation to transparency – and sometimes as the definition, according to Auger (2014) – is defined as 'always acknowledging problems and uncertainties' (Menon and Goh, 2005, cited in Auger, 2014).

Frewer and Miles (2003) describe honesty and openness as determinants of trust. Frewer (2000) defines 'honesty' as the degree to which a communicator will be truthful in the information they communicate; De Jonge et al. (2010) describe it more simply as a 'dimension of trust', thus supporting the recommendation that it should be included in any strategies that aim at enhancing confidence.

Van Kleef et al. (2006) notes that their research into perceptions of food risk management among key stakeholders saw honesty, and truthfulness in general, emerge as a 'driver of trust'. They found through their research into risk communication that, as indicated in Section 3.1.2, trust is multidimensional – one dimension of trust relates to the characteristics of the source of information such as the extent to which the source is perceived to possess knowledge and expertise, is open and honest with the information it provides to the public, and is primarily concerned with public welfare. This finding is supported by numerous pre-existing sources, such as Kasperson et al., 1992, or Peters et al., 1997 (cited in Van Kleef et al., 2007).

Alternatively, Rawlins (2009) describes openness as 'incorporating concepts such as sincerity, credibility, openness, truthfulness, consistency, disclosure, and candidness' (Rawlins, 2009, cited in Auger, 2014, p. 328). In the EU risk analysis system, transparency and openness have also been considered within the context of public access to European documents. Recital (2) of Regulation (EC) 1049/2001[13] states that *'openness enables citizens to participate more closely in the decision-making process and guarantees that the administration enjoys greater legitimacy and is more effective and more accountable to the citizen in a democratic system.'*

Supported by technological advancements, openness of institutions to enable citizen participation has often been translated into availability of relevant data to interested parties. In such cases, communicating through 'open data' should meet the standards of 'intelligent openness' (The Royal Society, 2012) which calls for information that is: i) accessible and easily located; ii) comprehensible and usable to those that wish to analyse it; and iii) assessable so that judgements can be made accordingly.

Responsiveness. The literature we analysed provides limited definition of the concept of 'responsiveness' and, where available, it mostly discusses it in the context of crisis communication. In addition, responsiveness can be interpreted both as a 'reactive' or 'proactive' term in relation to food safety risk communication – the former in response to a crisis event; the latter when communication is in response to target audience needs (see Section 3.2.4).

Nevertheless, we found that the complex nature of responsiveness can be unpacked by considering ethical perspectives of the term (Bryer, 2007). Specifically, responsiveness could be 'control-centred' (e.g. in response to rules or norms), 'discretionary' (e.g. in response to an individual request) or

[13] Regulation (EC) No 1049/2001 of the European Parliament and of the Council of 30 May 2001 regarding public access to European Parliament, Council and Commission documents: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32001R1049

'deliberate' (e.g. embracing new ways of thinking through collaboration with stakeholders). For the purpose of this report, we consider the latter, i.e. 'deliberate' responsiveness to be the most relevant of these as a guiding principle for risk communication. As defined by Bryer, such responsiveness has the objective of responding to audience demands in the institutional ecosystems of partners and stakeholders.

Conclusions

- Transparency is about providing evidence behind decisions and actions taken. It calls for clear information that can contribute to increased understanding of the risk analysis process.
- Openness is reflected in the opportunity of interested parties to participate in the risk analysis process and, together with honesty and transparency, acts as an important determinant of the trustworthiness of regulatory bodies. When openness is translated into the concept of open data, it requires information provided to be accessible, comprehensible, useful to and assessable by interested parties.
- Responsiveness should be seen as organised delivery of communication in a timely manner, meeting the target audience needs through collaboration in the network of institutions and interested parties.
- In the context of ensuring transparent and open communication described in the Transparency Regulation, these principles must apply along the entire risk analysis process. This therefore includes access to information about internal processes, access to and understanding of specific risk assessment findings or management actions, engagement of interested parties along these processes through appropriate consultative fora as well as communication of risk assessment findings and risk management decisions.

3.1.4. Public awareness and understanding

In this section, we describe the science behind the concepts of 'awareness' and 'understanding', including links between awareness/understanding and behaviour with respect to risks. In Section 3.4.1, we provide guidance for risk communication aimed at 'raising awareness and understanding' of the specific issues in risk analysis (of food and feed safety).

Awareness. Few of the articles we reviewed provide a formal definition of 'public awareness'. They refer to awareness as a 'conscious perception' of food properties (Brown et al., 2011) or as 'the knowledge about specific threats and preventive behaviours' (Savoia et al., 2013), linking the concept of awareness to food-based dietary guidelines as well as to public health emergency preparedness. These definitions, however, seem to confuse awareness with knowledge. The American Psychological Association Dictionary (Van den Bos, 2015) defines awareness as 'The accurate reportability of something perceived or known', although it is possible to be aware of something without being explicitly conscious of it. Knowledge, in the traditional sense, stands for the mental representation of a state of affairs that accurately corresponds to the actual state of affairs (i.e. 'true') (Henriques, 2013). Yet, research in social sciences and psychology has demonstrated that human knowledge is inherently shaped by the way the social context legitimises certain ideas in various historical, cultural and political situations, and by the way the human mind organises and constructs perceptions. Those influences are much better accounted for when awareness is seen as a process, and not only as an outcome.

Understanding. 'Understanding' is defined as the process of gaining insight into or of comprehending the meaning or significance of something, such as a word, concept, argument or event (APA, 2015). Hence, being aware of something and understanding something are two related, but different cognitive processes. Similar to the distinction between knowledge and awareness, a distinction can be made between objective and subjective understanding. Objective understanding is observer and situation independent, whereas subjective understanding is the meaning someone attaches to the information and includes the extent to which he or she believes to have 'understood' that information. Since understanding is to a large extent a question of inferences, objective and subjective understanding may be quite different (Grunert and Wills, 2007). In epistemological terms, the difference between objective and subjective ways of understanding information corresponds to the conflict between an understanding of information as a thing than can be (objectively) understood, vs. an understanding of it as a subject- and situation dependent sign (Hjørland, 2007).

Psychological processes. The above descriptions underscore the importance of acknowledging the psychological processes which underlie awareness and understanding as elements of everyday decision-making regarding food, food risks and food safety. These processes have been studied

extensively in cognitive psychology, and are increasingly used to elucidate related topics, such as health literacy (i.e. a person's competence to access, understand, appraise and apply health information to make judgements and take decisions about health; Sørensen et al., 2012), but are rarely used to inform population studies on emergency preparedness (Savoia et al., 2013). Analyses of cognitive processes with regard to food risks have been conducted, specifically on genetically modified food, but we did not find systematic reviews covering these processes. The psychological processes that are involved in shaping these competences include cognitive (e.g. acquiring and processing information, appraising risks, decision making), as well as motivational (e.g. expectancies, attitudes, perceived norms, perceived competence, metacognition and self-determination) and emotional processes (e.g. negative affect, mood). Similarly, consumer research (e.g. Engel et al., 1968) identified the processes that determine product choice, showing how consumers relate perceived information about products to their pre-existing knowledge, and use this to infer meaning about a product and to evaluate whether it has any positive or negative significance to them, which according to attitude and motivation theories is considered a prerequisite for the information to have any effect on their behaviour (Grunert and Wills, 2007). Thus, becoming aware of and understanding information is not a passive phenomenon whereby a person 'receives' information, but an active (though mostly unconscious) cognitive process that mobilises information processing strategies and is influenced by motivational and emotional factors.

Based on this literature, we may consider the psychological processes that are involved in accessing (i.e. becoming aware) and understanding risk information.

1) As people by definition obtain information from different, often contradicting information sources, accessing information involves, first and foremost, a selection process. This includes selecting sources of information, selecting information from these sources and judging the importance of different aspects of the information.
2) This selection process is influenced by the social and cultural context and by emotions (Estes, 2014). This inevitably introduces a selection bias whereby more attention is paid to some information than to other. Often-occurring forms of selection bias are availability and accessibility bias (i.e. the tendency to pay more attention to information that is available or easy to access), attentional bias (i.e. the tendency to pay attention to some features while ignoring others) and confirmation bias (i.e. the tendency to seek information that confirms the beliefs one already holds, and to ignore or discard information that contradicts these beliefs or that is ambiguous).
3) Like accessing information, understanding information is an active process, whereby new information is considered and reflected upon and connections are made with already available knowledge stored in the memory, to develop a meaningful and coherent synthesis. This involves the activation of cognitive schemes through which information is filtered, classified and assimilated.
4) The activation of these cognitive schemes to understand and appraise the information and judge the importance of possible measures is again subject to a series of biases. In the context of food risk, the most important ones are arguably negative information bias (i.e. the tendency to attach more importance to negative than to positive information, resulting in 'catastrophic thinking'), positive information bias (i.e. the tendency to consider oneself less at risk of negative consequence, causing 'unrealistic optimism') and familiarity or recency bias (i.e. things that are familiar or recent are more easily retrieved from memory and therefore more easily considered as 'true') (Van den Broucke, 2014).

The biases that are operational in risk information processing add to the fact that different groups of people use different mental or conceptual frameworks to understand and evaluate risk. Perceived risk is therefore inherently subjective, in the sense that it can mean different things to different people. Social scientists even reject the notion of 'real' or 'objective' risk, arguing that risk cannot be measured independently of our minds and cultures (Finucane and Holup, 2005).

To ensure that communication about risks is effective it is therefore critical to understand and account for these cognitive processes and the biases they may entail (Colley et al., 2019). In this regard, it is important to make a distinction between *heuristics* and *biases*. Heuristics are defined as mental shortcuts that people use to make judgements and take decisions. They refer to what Tversky and Kahneman (1974) call the 'automatic system' of information processing, as opposed to the 'reflective' (thought-through or deliberative) system. In everyday life, heuristics are useful, as reflecting on every alternative would be too cognitively laborious and time-consuming. However, since they

involve a simplification of information, heuristics can also lead to biases, i.e. systematic errors in thinking when information is processed and interpreted. In other words, a cognitive bias is a systematic error that can result from the use of heuristics. We discuss heuristics and biases further in Section 3.2.1 on Factors influencing risk perception.

Conclusions

- Becoming aware of and understanding information regarding food, food risks and food safety is an active, and often unconscious, cognitive process that mobilises information processing strategies and is influenced by motivational and emotional factors.
- The biases that are operational in risk information processing add to the fact that different groups of people refer to different mental or conceptual frameworks to understand and evaluate risk, which makes perceived risk inherently subjective. Since risk cannot be measured independently of our minds and cultures, the notion of 'real' or 'objective' risk is not useful.
- Understanding the cognitive and decision-making processes that underlie behaviour related to risks is critical for developing risk communications that are appropriately targeted and formulated.
- Population-based studies on emergency preparedness and risk responses in general are rarely supported by theoretical models of behaviour change.

3.1.5. Risk perception

Few of the studies we reviewed provide a definition of risk perception, mostly referring to it as a 'value judgement' and reporting that 'risk is a social construct, meaning different things to different individuals' (Finucane, 2002). More extensive definitions state that 'Risk perception describes the process of mentally representing and assimilating the likelihood of adverse events that are connected with certain objects or activities and that might occur in the future' (Renn and Swaton, 1984) or that 'Risk perception includes people's beliefs, attitudes, judgements and feelings, as well as the wider cultural and social dispositions they adopt towards threats to things that we value' (Pidgeon, 1998).

The different definitions share the view that risk perception is inherently subjective (Finucane, 2002), it is about opinions (Slovic et al., 1982) and it is determined by multiple factors other than statistical calculations of risk (Cole and Withey, 1981).

While in the literature on emergency preparedness, food risks and food safety the terms 'risk perception' and 'perceived risk' are often used interchangeably, we note that in the health behaviour literature the two terms have distinct meanings. Boholm and Corvellec (2011) in the 'Relational theory of risk' posit that risk objects are hazards that are identified as potentially harmful and objects at risk are considered as something of value that needs to be protected, e.g. life, nature, principles or a state of affairs. In their view, risk perception refers to the psychological process, whereas perceived risk is the outcome of that process where an individual connects the risk object with the object at risk.

Perceived risk influences behaviour, as highlighted in health behaviour and behaviour change models. The Health Belief Model (see also Section 3.2.1) assumes that health behaviour is determined by four types of cognitive constructions or 'beliefs', namely perceived susceptibility (i.e. vulnerability to risk), perceived severity, perceived benefits and perceived barriers (Oxford Research Encyclopaedia, 2017). Perceived susceptibility and severity are also included in the Protection Motivation Theory (Maddux and Rogers, 1983) which maintains that these two variables contribute to people's perceived threat, which in turn is crucial for behaviour change. When people perceive a threat as serious and consider themselves vulnerable to the threat, and when they feel confident that they can perform an action (self-efficacy) and that this action will mitigate the threat (response efficacy), they will adopt the suggested (protective) behaviour. As highlighted in the Oxford Research Encyclopaedia (2017), these theories are relevant to health and risk communication as they can help in designing a risk communication message.

In the context of the present report, we adopted the term risk perception when discussing the psychological process, while perceived risk is used when talking about the result of this psychological process.

Our discussion of the 'factors influencing risk perception' is in Section 3.2.1. and our guidance for risk communication on how to 'take into account risk perceptions of all interested parties', is in Section 3.4.3.

Conclusions

- Risk perception refers to beliefs, attitudes, judgements and feelings; it is about opinions and it is influenced by multiple factors other than statistical calculation of risk.
- Even if the terms 'risk perception' and 'perceived risk' are used interchangeably in the literature, risk perception refers to the psychological process, while perceived risk is the outcome of that process.

3.1.6. The concepts of 'hazard' and 'risk'

The General Food Law defines hazard as a 'biological, chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect'. The term 'risk' is defined as 'a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard'. The key difference between hazard and risk is that risk is the product of hazard plus exposure. In simple terms, while many dangerous things (hazards) exist, if you do not come into contact (exposure) with them, you will not be harmed (there is no risk).

While these two concepts are clearly defined and separated in the field of risk analysis, there appears to be ambiguity when using these terms in other contexts. As we report in Section 3.4.4 'Reduce ambiguity of the perceived difference between hazard and risk', people do not fully understand the difference between these two terms, as sometimes they are used interchangeably including by risk communicators.

Research by Slovic et al. (2016) highlights how 'expert' judgements of risk differ markedly from the judgements of laypeople'. The experts' judgements of risk are related to statistical or calculated frequencies, whereas the risk judgements of lay people are only moderately related to this.

As reported in the literature (Young et al., 1990), risk is sometimes defined in terms of statistical likelihood or probability (objective risk), and sometimes, it is used as a synonym for danger or threat (subjective risk). Some findings from risk perception research (Slovic et al., 1979, cited in Wogalter et al., 1999, p. 160) seem to indicate that hazard-risk evaluations are determined by the objective likelihood or probability of encountering potential hazards. On the contrary, other research (Wogalter et al., 1991, cited in Wogalter et al., 1999, p. 160) shows that hazard–risk judgements are not related to objective likelihood, rather they refer to a subjective assessment of the severity of injury. The studies conducted by Wogalter et al. (1999) found out that hazard–risk judgements about consumer products are influenced by the severity of the consequences.

According to Aven and Renn (2010), 'there is no agreed definition of risk' (p. 2). However, the Society for Risk Analysis Glossary (SRA, online) defines risk in relation to the consequences (effects, implications) of an activity with respect to something that humans value. The consequences are often seen in relation to some reference values (planned values, objectives, etc.), and the focus is often on negative, undesirable consequences. There is always at least one outcome that is considered as negative or undesirable. This definition is somewhat similar to the one of Rosa (1998, cited in Aven and Renn, 2010, p. 3), i.e. 'Risk is a situation or event where something of human value (including humans themselves) is at stake and where the outcome is uncertain'. Another definition by the International Risk Governance Council also introduces the concept of uncertainty: 'Risk is an uncertain consequence of an event or an activity with respect to something that humans value' (IRGC, 2005).

Aven and Renn (2010) suggest adapting these two definitions by Rosa and IRCG and argue that 'Risk refers to uncertainty about and severity of the consequences (or outcomes) of an activity with respect to something that humans value'. Our guidance for risk communication that can clarify and improve public understanding of the difference between hazard and risk, is in Section 3.4.4.

Conclusions

- Hazard is a 'biological, chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect', while 'risk' is 'a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard'.
- The definitions of risk vary across the literature, some of them referring to statistical likelihood or probability (objective risk) and others adopting the term as synonym of danger or threat (subjective risk).
- While the concepts of 'hazard' and 'risk' are separate and have different meanings in risk analysis, there is ambiguity about hazard–risk judgements made by members of the general public and even experts sometimes use these terms interchangeably.

3.1.7. 'False information': misinformation, disinformation

There is increasing concern about the spreading of unreliable or unverified information that can influence public opinion and impact on people's behaviour and choices. Despite the wide diffusion of the term 'fake news' in the public debate, its definition remains vague and blurred. The colloquial term 'fake news' is nowadays in common use. However, the more formal concept of 'false information' brings under a single umbrella at least two different notions, i.e. misinformation and disinformation.

Misinformation refers to inadvertently spreading inaccurate or misleading information, e.g. owing to journalistic mistakes (Schaewitz et al., 2020). More generally, misinformation may refer to any piece of information that is 'initially processed as valid but that is subsequently retracted or corrected' (Lewandowsky et al., 2012).

Disinformation is 'the deliberate creation and dissemination of false and/or manipulated information that is intended to deceive and mislead audiences, either for the purposes of causing harm, or for political, personal or financial gain' (GCS, 2020).

This distinctive conceptualisation is useful to tailor appropriate and effective counterstrategies. However, one should bear in mind that it is sometimes difficult in reality to draw the line between both, since in many cases a co-occurrence of the two forms can be observed. One could also trace a parallel with the growing problem of food fraud, i.e. an action 'intentionally causing a mismatch between food product claims and actual food product characteristics, either by deliberately making claims known to be false or by deliberately omitting to make claims that should have been made' (Morin and Lees, 2018). In this regard, the 2013 incident where horse meat was found in products marketed as beef products shed light on the need for a plan to deal with food fraud in every Member State, which at that time were not adequately prepared for such a large-scale scandal (Andersson et al., 2020).

Our guidance for risk communication that can 'contribute to the fight against the dissemination of false information and the sources thereof' is in Section 3.4.5.

Conclusions

- The terms 'fake news' and 'false information' bring under a single umbrella at least two different notions, i.e. misinformation and disinformation which need to be differentiated in order to tackle them.
- Misinformation refers to inadvertently spreading inaccurate or misleading information, while disinformation is 'the deliberate creation and dissemination of false and/or manipulated information that is intended to deceive and mislead audiences'.
- In practice, a co-occurrence of the two forms can be observed and therefore distinguishing one from the other is not straightforward.

3.2. Audience analysis and appropriate information

In this section, we examine three key aspects of audience analysis – the array of factors influencing risk perceptions, the trade-offs made by receivers and providers of risk communication in relation to taking risk decisions and different approaches for segmenting audiences according to different combinations of these factors. We follow this with an analysis of considerations about how to tailor information to audience needs, including message and content development, delivery and engagement. Finally, we describe the findings from the literature on tools and channels to use for certain objectives and to target different audiences.

3.2.1. Factors influencing risk perceptions

We discuss the factors influencing risk perception in three groups, describing their characteristics: the hazard being communicated, the recipients of risk communication and the social and cultural context.

The hazard. The psychometric approach (Fischhoff et al., 1978; Slovic et al., 1985; Slovic, 1998) sees risk as a social construct influenced by the qualitative characteristics of hazards. These can be reduced to three main dimensions, namely 'dread', 'familiarity' (or knowledge) and 'exposure'. Dread refers to the extent to which a hazard is feared, uncontrollable, fatal, not equitable, it poses high risk to future generations, it is not easily reduced, it is involuntary and potentially catastrophic. Familiarity includes the extent to which a hazard is unknown, unobservable, unfamiliar and has delayed consequences. Exposure reflects the number of people exposed to the risk. Krewski et al. (1987)

argue about the existence of a 'small level of risk' that a majority of people would accept. For instance, there is some evidence that annual risks of one in a million chances are not considered with serious concern. At the other end of the spectrum, there are risks sufficiently high to be deemed unacceptable by most people. These refer to annual risks of death in the order of one in a thousand or one in a hundred.

The sub-dimensions of dread and familiarity vary across the literature reviewed, in particular the content of 'dread' is quite heterogeneous, as it covers up to nine factors (fatal vs. non-fatal; global vs. local impact; involuntary vs. voluntary; uncontrollable vs. controllable; unfair vs. fair; catastrophic vs. unclustered victims; future vs. current generations; increasing vs. decreasing; not easily reduced vs. easily reduced) and it is a mix of emotional reactions and the severe consequences of the hazard (Sjöberg, 2003). For instance, a study by Bouyer et al. (2001) found a 10-factor risk perception structure organised as a function of the kind of hazard instead of the qualitative characteristics of the hazards. Sjöberg (2003) maintains that the importance of 'dread' found in psychometric studies is due to the role played by severe consequences and not by emotions.

Sjöberg (2001, 2002) also explored if risk perception influences attitude towards risky technology, as suggested by the psychometric approach. The findings highlight that attitude towards technology is mostly determined by the possibility to replace the technology, the belief that it might have yet unknown consequences, and have effects involving a destructive relationship with nature.

Interestingly, a recent study replicated the seminal work of Fischhoff and Slovic (Fischhoff et al., 1978; Slovic et al., 1985; Slovic, 1998) examining risk perception of eleven food-related hazards, many of which were new compared to the first studies adopting the psychometric approach, e.g. 3D-printed food and lab grown meat (Jenkins et al., 2020). This study confirmed that risk perceptions are complex and pertain to many qualitative characteristics, i.e. level of knowledge, likelihood/seriousness of harm to health, as well as to more affective characteristics like worry. The authors found that two main components labelled 'dread' and 'knowledge' explained a substantial proportion (80.8%) of variance in risk judgements.

A similar conceptualisation of risk perception can be found in Sandman's formula according to which risk is a function of hazard and outrage. This formula is adopted by the CDC (United States Centers for Disease Control and Prevention) in its Crisis and Emergency Risk Communication (CERC) manual (2018). In the author's view, the hazard is the risk as defined in risk assessment, i.e. the product of magnitude and probability, whereas outrage refers to what the public is worried about. Sandman (1993) identifies 12 components of outrage which mostly overlap with the factors considered by the psychometric approach: 1) voluntary vs. coerced; 2) natural vs. industrial; 3) familiar vs. exotic; 4) not memorable vs. memorable; 5) not dreaded vs. dreaded; 6) chronic vs. catastrophic; 7) knowable vs. not knowable; 8) controlled by the person vs. by others; 9) fair vs. unfair; 10) morally irrelevant vs. morally relevant; 11) trustful vs. untrustful source; 12) responsive vs. unresponsive process. The public is more likely to accept the risk (and therefore feel less outraged) if it is voluntary, natural, familiar, not memorable (in the sense that they do not hold a negative past experience with the risk), not dreaded, chronic, knowable (which means that there is no uncertainty), controlled by the person, fair, morally irrelevant, it derives from a trustful source which interacts in a responsive manner with concerned citizens. In addition to these 12 factors, Sandman recognises eight other factors: 1) effect on vulnerable populations; 2) delayed vs. immediate effects; 3) effect on future generations; 4) identifiability of the victim; 5) elimination vs. reduction; 6) risk–benefit ratio; 7) media attention; 8) opportunity for collective action. The public feels more outraged if the risk affects vulnerable populations, such as children, if the effects are immediate, if it harms future generations (long-term effect), if the victim is identifiable, if the risk could be totally removed (but no action is taken), if the risks outweigh the benefits, if the media amplifies the risk and when other people are outraged as well, which could lead to a collective action against the risk.

The recipients. These include five categories: i) demographics, ii) personality traits, iii) direct experience, iv) perceived benefit and v) heuristics and biases.

Demographics. One research study suggests that people who perceive greater exposure to the hazard are more fearful. This might be the reason why some women, people with lower levels of education and income, younger people and ethnic minorities report to perceive hazards as being more dreadful (Savage, 1993). Additional research confirms that women tend to perceive more risk from a hazard than men and that people with lower income and members of ethnic minorities perceive that they are excluded and would appreciate to be more involved in risk management decisions (see Frewer, 2000). In relation to age, data described in the papers reviewed suggest that older individuals generally express more concern towards health and environmental risks and age-related illnesses

(Savage, 1993). However, a study by Mou and Lin (2014) showed a weak correlation between income and education level and risk perception about food safety. In the context of food safety, the terms 'health literacy' and 'food literacy' might be more appropriate than education. Health literacy refers to the ability to understand and process health-related information to make informed/appropriate health decisions and promoting good health. Food literacy focuses more on the importance of selecting, preparing and eating food, as well as applying food-related information and interacting with complex food systems (Truman et al., 2020). The literature on health literacy and food safety is still scarce, however it would be a relevant concept to investigate in relation to risk perception.

Personality dispositions and traits. The literature reports the existence of personality dispositions, attitudes and traits that distinguish people who are risk-averse from people who are risk-seekers (see Renn and Swaton, 1984). Other individual characteristics reported in the literature include food technology neophobia and disgust sensitivity (Siegrist and Hartmann, 2020). Food technology neophobia is defined as a personality trait that affects consumers' willingness to accept new food technologies and disgust is a mechanism that induces people to avoid pathogens and diseases.

Anxiety has also been investigated as a psychological trait influencing risk perception: people with a higher (trait) anxiety showed higher scores for common individual hazards, pollutants and outdoor activities (Bouyer et al., 2001). Emotional stability is another personality trait included in at least one study on risk perception (Sjöberg, 2003) showing that higher emotional stability was related to lower perceived risk, both general and personal.

A recent review of 40 years of risk perception research (Siegrist and Árvai, 2020) also considers value orientations such as egoism, altruism and biospherism (i.e. attention and care towards the environment). High altruism and biospherism have been found to be associated with low perceived risks. In the case of climate change, high biospherism and egoism have been found to be associated with high perceived risks.

Direct experience. For natural hazards, past direct experience plays a role (Barnett and Breakwell, 2001; Wachinger et al., 2013). These latter authors (Wachinger et al., 2013) identified the presence of a 'Risk perception paradox' in natural hazards, defined as a weak relationship between risk perception and personal actions to reduce the risk. Three potential reasons to explain this paradox are provided. First, individuals understand the risk but accept it since the perceived benefits outweigh the potential negative impacts. Second, individuals understand the risk, but they feel to have no agency for their own actions, therefore the responsibility for action is transferred to someone else. Third, individuals understand the risk but have insufficient resources to affect the situation. For instance, De Marchi and Scolobig (2012) found a tendency to underestimate, minimise or deny hydro-geological risk in residents living in dangerous areas. They identified four clusters of people: first, those who avoid information and evidence out of fear; second, those that are not aware of being at risk; third, those that are aware but accept the risk; fourth, those that are overconfident in risk management and risk reduction measures. The authors explain these attitudes in light of the 'safety paradox' and 'efficiency paradox', i.e. the higher the measures put in place to reduce the risk (of flooding), the more people feel safe and do not take personal action, resulting in a potentially higher risk in the case of extreme events. (Further approaches to segmenting audiences, considering their risk perception, is presented in Section 3.2.3).

The 'Motivational Hypothesis' (Weinstein et al., 1998) focuses on the motivation to reduce the risk and can be seen to complement the 'Risk perception paradox'. According to this hypothesis, the higher the perceived personal risk, the greater the motivation to act. This hypothesis, which the authors call Hypothesis I, implies that initial perceptions of risk influence subsequent action. Hypothesis II affirms that after taking a precaution, people believe their risk is lower than it had been before.

These theories might be taken into account for behaviour change interventions; however, this goes beyond the scope of the present overview.

Perceived benefit. The literature reports the existence of an inverse relationship between risk and benefit (Finucane et al., 2000; Siegrist et al., 2000; Bearth and Siegrist, 2016), i.e. the higher benefit is perceived, the less risk and vice versa. It has been suggested that it might be possible to change perceptions of risk by changing perceptions of benefit and to change perceptions of benefit by changing perceptions of risk. Alhakami and Slovic (1994) report preliminary data revealing that providing information intended to increase the perceived benefits of various technologies led to a decrease in the perceived risks of those technologies. Perceived benefit is highly relevant in understanding risk perception of genetically-modified (GM) foods (Gaskell et al., 2004). These authors analysed the Eurobarometer survey on biotechnology (INRA, 2000) and identified four groups of respondents in perception of riskiness and usefulness of GM foods, namely 'trade-off', 'relaxed',

'sceptical' and 'uninterested'. Interestingly, the majority of the sample (i.e. 60%) belonged to the sceptical group where individuals see no benefits in GM foods and only risks.

Heuristics and biases. Research has investigated the role of heuristics and biases (see also Section 3.1.4 above). Overall, the following heuristics and biases are reported in the literature of risk perception (for a more extensive overview see Tversky and Kahneman, 1974; Kahneman, 2011).

- Anchoring bias: Disposition to anchor to the first piece of information received and make judgements or take decisions based primarily on that information.
- Availability bias: Tendency to perceive an event as more probable and frequent if it can be imagined or recalled easily.
- Representativeness heuristic: Propensity to estimate the probability of an event by whether this event is representative of similar events stored in memory.
- Overconfidence bias: Predisposition to be very confident in one's own judgements.
- Optimistic bias ('It won't happen to me'; Slovic et al., 2016): Tendency to consider themselves personally immune to many hazards.

In addition to the most common heuristics, some authors also consider affect and trust.

Affect refers to the inclination to tag objects and events with varying degrees of affect and use them in the process of making judgements (Finucane et al., 2000; Slovic et al., 2004). In Slovic and Peters' view (2006), people judge a risk not only by what they think about it but also by how they feel about it. If their feelings towards an activity are favourable, they tend to judge the risks as low and the benefits as high; if their feelings towards the activity are unfavourable, they tend to make the opposite judgement – high risk and low benefit (i.e. the affect heuristic).

In addition to considering affect as a heuristic, affects, emotions and feelings have been researched as factors that influence risk perception. The Risk-as-Feelings hypothesis (Loewenstein et al., 2001) posits that responses to risky situations and decision-making result from emotional influences, including feelings such as worry, fear, dread or anxiety. These emotional reactions to risks depend on a variety of factors, such as the vividness with which consequences can be imagined, personal exposure to or experience with outcomes and past history of conditioning. The authors distinguish between anticipatory emotions which are immediate visceral reactions to risks (e.g. fear, anxiety, dread) and anticipated emotions that are typically not experienced in the immediate present but are expected to be experienced in the future. The model they propose highlights the role of anticipatory emotions and gut feelings in decision making, while, according to them, previous theories focused on anticipated emotions.

Trust (see also Section 3.1.2 on trust and confidence) refers to the inclination to substitute a target attribute with cues that indicate trust in the source of this information, based on value similarity, i.e. perception that own values are similar to the ones of another person or institution (Siegrist and Hartmann, 2020). In a recent review of the literature, Siegrist (2019) describes a model according to which trust influences risk and benefit perceptions and the latter two constructs influence the acceptance of a technology (e.g. gene technology or nuclear power).

Credibility is another term used in the literature to refer to trust, specifically to interpersonal trust, i.e. the perceived presence or absence of particular traits in the source (Trumbo and McComas, 2003). This study investigated how credibility affects the way people process information and how they subsequently perceive risks. The findings revealed that higher credibility for industry and the state predicts lower risk perception, whereas credibility for citizen groups predicts greater risk perception. Additionally, perceiving high credibility for industry and the state, and low credibility for citizen groups, promotes heuristic processing and lower risk perception. On the contrary, perceiving industry and the state to have low credibility promotes greater systematic processing and perception of greater risk.

Social and cultural context. These include two categories: i) social factors and ii) cultural factors.

Social factors. The Social Amplification of Risk Framework (SARF, Kasperson et al., 1988) refers to the influence that social factors have on individual and group perceptions. The framework represents an attempt 'to combine the dualistic nature of risk as both an objective event as well as a social construct' (McComas, 2006). According to this theory, social amplification works through two main stages, i) the transfer of information about the risk and ii) the response of the society (so-called 'ripple effects', Kasperson et al., 2003, cited in Wardman and Löfstedt, 2018, p. 5).

First, informational mechanisms include volume, dispute, dramatisation and symbolic connotations of the information. Large volume of information flow can act as a risk amplifier and dispute, i.e. debates among experts, increases public uncertainty, doubts about whether the hazards are

understood and decreases the credibility of official spokespersons. Dramatisation takes place when erroneous information sources find access to the mass media and, the symbolic connotations of the information from media and informal personal networks affect people's estimates of the main causes of harm, injury or death. Even if nowadays social media allow increasing the spread of a message, Wardman and Löfstedt (2018) argue that this may not necessarily directly correspond to greater risk amplification as the dynamics of digital communications are difficult to grasp. As we explain further in Section 3.4.5 Fight dissemination of 'false information' and its sources, the transmission of risk messages in social media can often be affected by distortion, manipulation and fragmentation, together with facing powerful competition from other content for attention. This decreases the control that can be exerted on the information and requires a proficient use of a wider range of communicative competencies and skills (Wardman and Löfstedt, 2018).

Second, response mechanisms to the information received act through four major pathways: heuristics and values, social group relationships, signal value and stigmatisation. Heuristics and values, as mentioned above, are simplifying mechanisms to evaluate risk and to shape responses. These processes, while permitting individuals to cope with a risky world, may sometimes introduce biases that cause distortions and errors. Social group relationships include social and political groups who influence member responses and interpretation of risks. Signal value reflects what that event signals or portends. High-signal events suggest that a new risk has appeared or that the risk is different and more serious than previously understood. Stigmatisation refers to the negative imagery associated with specific environments and risks.

Risk amplification and attenuation can take place not only in response to passive information transfer, but also through purposeful knowledge (co-) production and exchange. This can happen when communities attempt to reflect or reinforce risk understandings and concerns across places, at different levels and over time (Wardman and Löfstedt, 2018).

Cultural factors. The Cultural Theory of Risk Perception (Douglas and Wildavsky, 1983, cited in Sjöberg, 1998, p. 137) postulates the existence of four basic worldviews, i.e. hierarchical, fatalistic, individualistic and egalitarian which reflect beliefs about the functioning and values regarding society and play a crucial role in judgements people form about risks. The four worldviews are based on the idea that people are either group or individual oriented and they either prefer adhering to many rules to control human behaviour or believe that few rules are sufficient. In the field of GM foods and new technology (Finucane, 2002), research showed that groups that hold a hierarchical world view, that is they support superior or subordinate social relationships and detest civil disobedience, tend to focus on the opportunities offered by industrial and technological risks. In contrast, groups belonging to an egalitarian world view, who support broad distribution of power and wealth and detest ranked role differentiation, tend to focus on the threats presented to their social structure.

A study by Bouyer et al. (2001) found that people who are more fatalistic score lower on risk perception to pollutants. On the other hand, individuals holding an egalitarian or individualistic world view show higher scores for risk perception to pollutants.

The cultural approach to risk perception has been debated and some authors (see Sjöberg, 2003; Siegrist and Hartmann, 2020) maintain that, while plausible in theory, there is a lack of data in support of this influence.

One direction of research tried to integrate the cultural theory and the psychometric approaches, resulting in so-called 'cultural cognitions', with the aim of explaining public disagreements on various issues, e.g. nuclear power, nanotechnology and vaccines (Kahan et al., 2011, cited in Balog-Way et al., 2020, p. 11). Research adopting this approach revealed that individuals with hierarchical and individualistic 'cultural outlooks' were in significant disagreement with those with egalitarian and communitarian outlooks. Cultural cognition theory has received critiques as it fails to define culture and does not consider trust and value similarity. While it suffers from the shortcomings of the cultural theory and the limitations of the psychometric approach, it contributes to stress the crucial role played by culture in risk perception.

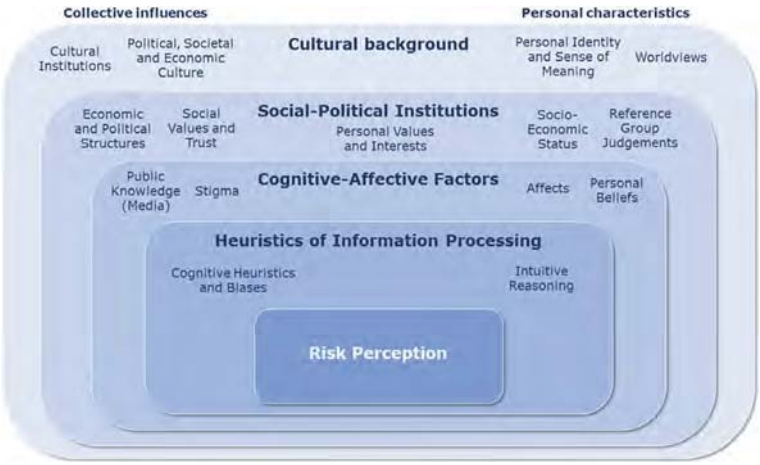
Table 2 provides an overview of all the factors influencing risk perception identified through the literature reviewed.

Table 2: Schematic overview of the factors influencing risk perception

Category	Factors
The hazard	**Qualitative characteristics of the hazard** 'Dread', 'Familiarity' (or knowledge) and 'Exposure' (Fischhoff et al., 1978; Slovic et al., 1985; Slovic, 1998)
The recipients	**Demographics** Age, Gender, Education/Health literacy, Socio-economic status, Ethnic group (Savage, 1993; Frewer, 2000)
	Personality dispositions and traits Risk-averse vs. risk-seekers (Renn and Swaton, 1984) Food technology neophobia and disgust sensitivity (Siegrist and Hartmann, 2020) Anxiety (Bouyer et al., 2001) Emotional stability (Sjöberg, 2003) Values orientations and attitudes (Siegrist and Árvai, 2020)
	Direct experience For natural hazards, past direct experience plays a role (Barnett and Breakwell, 2001; Wachinger et al., 2013)
	Perceived benefit Inverse relationship between risk and benefit, i.e. the higher benefit is perceived, the less risk and vice versa (Finucane, 2000; Siegrist et al., 2000; Bearth and Siegrist, 2016)
	Heuristics and biases Anchoring, Availability, Representativeness, Overconfidence, Optimistic bias (Tversky and Kahneman, 1974; Kahneman, 2011) Affect (Finucane et al., 2000; Slovic et al., 2004) Trust/Credibility (Siegrist and Hartmann, 2020)
Social and cultural context	**Social factors** Social Amplification of Risk Framework (Kasperson et al., 1988)
	Cultural factors Cultural Theory of Risk Perception (Douglas and Wildavsky, 1983)

Risk perception models. In order to provide a comprehensive picture of the factors influencing risk perception, some models have been developed.

An inclusive model summarising the factors influencing risk perception can be found in a Report produced for the European Commission's Directorate-General for Environment (2014). This model, called 'The Nested Influence Diagram for Risk Perception' adapted from Renn and Rohrmann (2000), displays the 'layers of factors, which are both individual and collective, both innate and learned and which interact to ultimately make up how people perceive risk' (see Figure 3).



Source: Adapted from European Commission (2014).

Figure 3: The Nested Influence Diagram for Risk Perception

Another comprehensive model designed by Van der Linden (2015) to conceptualise the risk perception related to climate change was adopted in a recent article by Dryhurst et al. (2020). In an attempt to integrate the extensive risk perception research, the so-called 'Climate Change Risk Perception Model (CCRPM)' includes four main areas: 1) cognitive factors (e.g. people's knowledge and understanding about risks), emotional and experiential factors (e.g. personal experience), social-cultural factors (e.g. the social amplification of risk, cultural theory, trust and values) and relevant individual differences (e.g. gender, education, ideology). These are shown in Figure 4. The model proved to be able to explain risk perception of COVID-19, showing that experiential and socio-cultural factors explained most of the variance compared to cognition (knowledge) and socio-demographic characteristics (Dryhurst et al., 2020). Prosocial vs. individualistic values and a measure of social amplification (i.e. hearing about the virus from friends and family) demonstrated to be influential as well.

Source: Adapted from Van der Linden (2015).

Figure 4: Climate Change Risk Perception Model (CCRPM) displaying the main factors influencing risk perception

Theories from the field of health behaviour and health promotion might provide a framework to place the factors described so far into a wider perspective (for a more extensive overview see Glanz and Bishop, 2010). It is important to note that these models intend to explain behaviour change in the field of health, such as smoking or dieting.

One of the most often-used theories in this field is the Health Belief Model (Rosenstock, 1974), which argues that people's decisions about whether to act depend on the i) perceived susceptibility to the risk, ii) perceived severity of the risk, iii) perceived benefits of the protective action, iv) perceived barriers v) exposure to factors that prompt action (cue to action), vi) confidence in their ability to successfully perform an action (self-efficacy).

A second widely used theory is the Theory of Planned Behaviour (Ajzen, 1991; see also Frewer et al., 2016), which postulates that engaging in a behaviour is contingent on the intention to take action, which in turn depends on a positive attitude toward a particular behaviour (based on beliefs of behavioural outcomes), subjective norm (beliefs about whether individuals who are significant to the person approve or disapprove of the behaviour) and perceived control (the belief that one is capable of performing the behaviour).

While both the HBM and the TPB, as well as related models, focus on individual, psychological determinants of behaviour, the Social Ecological Model (Sallis et al., 2008) focuses on multiple levels of influence, i.e. individual, interpersonal, organisational, community and public policy and the suggestion that behaviours both affect and are influenced by the social environment.

Conclusions

- Many of the papers reviewed adopted the psychometric approach, which focuses on three qualitative characteristics of the hazards which influence risk perception, namely dread, knowledge and exposure.
- A similar theory is the concept of risk as a function of hazard and outrage, this latter composed of 12 characteristics plus an additional eight features.

- Factors that have been studied as variables influencing risk perception are the characteristics of the recipients, social factors and cultural factors.
- The characteristics of the recipients include demographics, personality dispositions and traits, direct experience, perceived benefit, heuristics and biases.
- The main heuristics and biases considered are anchoring, availability, representativeness, overconfidence, optimistic bias, affect and trust (or credibility).
- Social factors are explained in the Social Amplification of Risk Framework and cultural factors have been considered by the Cultural Theory of Risk Perception.
- All these factors are included in validated models of risk perception, such as the Nested Influence Diagram for Risk Perception and the Climate Change Risk Perception Model.

3.2.2. Trade-offs in risk decisions

The study of how people make their decisions about risks and the factors that influence this determination recognises the existence and the importance of trade-offs, regardless of the disciplinary perspective.

By trade-offs, we refer to situations where: 1) the outcomes of risk-related decisions involve both benefits and costs; and 2) the extent of these gains and losses and their distribution across stakeholders are not known with certainty.

Decision makers follow their preference structure, but the ultimate outcomes of their decisions are uncertain (probabilistic) because information is often less than perfect and resource constraints (money, time, knowledge, etc.) further increase the complexity of making choices. Thus, it is not immediate – and sometime unfeasible – to identify the choice associated with the best balance between benefits and costs and agents make many decisions in situations of bounded rationality or bounded self-control (see e.g. Simon, 1986). We distinguished between two broad categories of trade-offs in relation to risk communication. The first category refers to trade-offs faced by the recipients of the risk communication, in their processing and use of the information, and the associated costs and benefits. The second category refers to trade-offs faced by the risk communicator when deciding whether and how to communicate information about a target risk, in relation to the desirable and undesirable outcomes of communication.

Trade-offs faced by audiences. Within the first category, the recipients of the risk communication are confronted with a variety of potential trade-offs that can affect the effectiveness and usefulness of the communication effort, to the point that the additional information conveyed through risk communication might reduce a recipient's welfare. In other words, there are situations where more information does not necessarily lead to better decisions and increase the individual or societal well-being (Sunstein, 2019). More specifically, consumers struggle to compare/quantify different benefits and costs, such as the risk reduction from avoiding a particular food they like vs. the associated hedonic costs from non-consumption (e.g. foregone opportunities).

Strategies for effective risk communication need to consider the various types of trade-offs and their effects on information processing and choice. Table 3 provides a summary of findings from the food (safety) literature.

Table 3: Summary of findings on trade-offs faced by the target audience of risk communication

Trade-off focus	Main findings
Coexistence of optimism and pessimism within the same individual, i.e. they are two co-existing and separate concepts and not opposite endpoints of the same scale (De Jonge et al., 2007)	Optimism about the safety of food depends on trust and consumer confidence in the safety of product groups, whereas pessimism is also influenced by experience with food allergy or intolerance, and trait worry. Consumer perceptions about the safety of food may not be directly related to perception of their control over food safety. A stronger relationship of perceived personal control with optimism and pessimism is expected for those hazards where consumers are more in control.
Judgements on risk preferences of other people, empathy vs. lack of identification (Harvey et al., 2006)	When 'judges' identify with, or empathise with the target subjects', egocentrism dominates (e.g. they project their own risk preferences); when empathy is lacking or the target subjects are very different, then judgements are biased towards risk neutrality.

Trade-off focus	Main findings
Convenience vs. risk when using chemicals in household products (CHP) (Lee and You, 2020)	People do not use risk information on products that they perceive to be safe or familiar (frequent use, convenience). The efficacy belief is a key moderator (higher perceived efficacy leads to higher risk avoidance). Lower socio-economic groups and the absence of children affect attitudes and behaviours in relation to CHP.
Relevance of social norms, potential conflicts between food safety norms and social (relationship) norms (Scholderer and Veflen, 2019)	Food safety norms and social norms operate in an additive manner but in opposite directions. Social norms have slightly stronger absolute effects, resulting in a net effect of increased risk-taking.
Availability/familiarity of risk and biases in risk perceptions (i.e. an event is judged as likely/frequent if instances of it are easy to imagine or recall, as frequent events are easier to recall) (Slovic et al., 2016)	Communicating a low-probability hazard increases its perceived probability regardless of what the evidence indicates; once formed, people's beliefs are persistent in spite of contrary evidence, and they affect the interpretation of new evidence.
Cognitive vs. hedonic costs and benefits, welfare effects of unwanted information (Sunstein, 2019)	Considering information-related hedonic gains and losses, on balance people may not be willing to pay for information, or would even be willing to pay something not to receive information. Demand for information (and its welfare effects) vary individually, and personalised (targeted) disclosure is preferable.
Costs of processing the information vs. the cost of acquiring information (Verbeke et al., 2007)	Even with free information, consumers may refrain from acquiring more information if the required resources (e.g. time and effort) to process information are too high compared to the marginal expected benefits from information.
Conflicts between previous beliefs and new information (nutritional vs. food safety characteristics of seafood) (Verbeke et al., 2008)	Consumers accept uncritically information that is congruent with their prior belief (e.g. health benefits of seafood consumption), whereas they assess critically conflicting information (food safety-related health risks). Risk-only messages (without presenting the benefits) are more likely to increase risk perception.

Trade-offs for communicators. Within the second category, risk–risk trade-offs (Graham and Wiener, 1997; Hansen et al., 2008; Löfstedt and Schlag, 2017) arise when communication about the selected risk (i.e. the primary focus of the risk-reduction effort) may unintentionally increase the countervailing risk, to the point that communication might generate an overall net risk increase. The countervailing risk is the chance of an adverse outcome that results from an activity whose ostensible purpose is to reduce the target risk, where the latter is the primary focus of the risk reduction efforts (Graham and Wiener, 1997). For example, Verbeke et al. (2008) explore the trade-offs implied in communication aimed at reducing the risk of non-communicable diseases by promoting fish intakes, and the related increase in hazards associated with environmental contaminants in fish, especially for some specific population groups. Graham and Wiener (1997) conclude that the risk–risk trade-off should be addressed by promoting fish consumption, while targeting the environmental issue directly at the source (reduce contamination) rather than through communication. Recently, other trade-offs have emerged due to the growing relevance of sustainability issues along the food chain, and more specifically on potential conflicts between the benefits of food waste reduction and risks for food safety (Guillier et al., 2016; Kasza et al., 2019).

How risk–risk trade-offs are accounted for in risk communication decisions strictly depends on the mandate, or, more broadly, on the philosophical approach of the mandate. Martin and Stewart (2019) distinguish four distinct orientations: 1) the precautionary principle; 2) acceptable level of harm that a risk poses; 3) free 'rational' choice under bounded rationality; 4) libertarian paternalism. Under the precautionary principle, even when there is scientific uncertainty about the risk or potential trade-offs, public bodies have a mandate to provide information and the emphasis is on the consideration of uncertainties and trade-offs in calibrating communication. When the emphasis is on free choice and (bounded) rationality, even when risk–risk trade-offs are not explicit, the balance between the benefits and costs of risk communication from a societal perspective might favour the decision not to communicate. More specifically, it is argued that under high scientific uncertainty (hence potentially incomplete and inaccurate information) and the potential for false alarms and desensitisation driven by

excess information, risk communication may become socially counterproductive and erode trust (Martin and Stewart, 2019, chapter 8). Furthermore, evidence from economics suggests that the optimal degree of publicity (i.e. the size of the targeted population) depends on the precision of announcements (Cornand and Heinemann, 2008). These findings imply that while public information should be provided to the maximum grade of precision, in cases when precision is low, communication should be targeted only to the most relevant groups.

Similarly, in situations where the actual risk is known to be very low, but public concern is high, the trade-off for the risk communicator might be between the goal of avoiding overreaction to a small risk (see e.g. Löfstedt, 2006; Slovic et al., 2016) and the need to build public trust by providing information about it (Hooker et al., 2017). Findings suggest that consistency in evidence-based risk communication and commitment to rigorous research is a key factor in maintaining public trust, even when low risks are communicated under uncertainty. Some evidence also suggests that individuals are willing to accept high levels of scientific uncertainty when the benefits to risk ratio is large (Löfstedt and Schlag, 2017 and references therein). The communication of uncertainty also implies trade-offs where simplicity of the scientific discourse may need to be sacrificed to gain transparency (Fischhoff and Davis, 2014) (see also Section 3.2.4 Appropriate information in risk communication). Finally, policy makers often face a situation where social risk preferences are unknown, and need to communicate complex risk management decisions that involve trade-offs between different risks, with further communication complexity when different risks affect different target populations (Johnson, 2014).

Conclusions

- People face a variety of trade-offs in their decision-making processes, and the ultimate effects of risk communication may be heavily influenced by those trade-offs, as discussed in examples listed below.
- Benefits of information vs. costs (e.g. costs of processing information; hedonic costs, etc.): people tend to ignore risk communication when the information is complex or it affects hedonic experiences negatively, and the perceived benefits of information are limited.
- Existing personal beliefs and social norms vs. new information: people undervalue risk communication on new risks when it goes against pre-existing beliefs or it conflicts with social norms, especially when it concerns habitual behaviours.
- Another category of trade-offs is faced by risk communicators when countervailing risks exists; how these trade-offs are dealt with depends on the remit of the risk communicator (i.e. whether risk assessors or risk managers).
- Communication of low risk when public concern is high implies a trade-off between the objective of building trust and the need to avoid unnecessary alarm, especially in conditions of high uncertainty: strong commitment to rigorous research and evidence-base communication helps to address this type of trade-off.

3.2.3. Approaches to audience segmentation

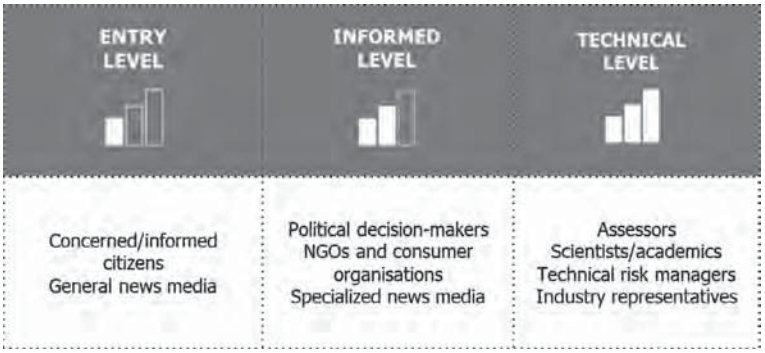
The Transparency Regulation notes that 'risk communication should strengthen citizens' trust that the risk analysis is underpinned by the objective of ensuring a high level of protection of human health and consumers' interests.' For the purpose of this report, risk communication which meets this objective is assumed to be 'appropriate'.

The food safety communication ecosystem is complex. Most risk communication issues that involve food safety directly concern and have implications for different regulatory bodies, the food industry, civil society organisations and individuals (FAO/WHO, 2016). All of these actors are more likely to be receptive to risk communication information if it is timely and relevant to their potentially differing requirements. This implies a need for the segmentation of audiences to allow bespoke targeting. In fact, most authors agree on the importance of segmentation to understand target audiences better and shift away from a one-size fits-all approach.

As we noted previously, risk communication takes place throughout the risk analysis process. As such, it is not limited to the communication of risk assessment findings and risk management decisions, but also includes the process of dialogue, making the decisions of regulatory bodies more collective and transparent and offering platforms for stakeholder participation (Briggs, 2009). The stakeholders in risk analysis – defined as an individual, group or organisation that can affect or be affected by another organisation (Friedman and Miles, 2002) – range from scientists, policy makers, the food and feed industry and non-governmental organisations to concerned individuals and the

general public. However, the literature on audience segmentation focuses widely on the examination and targeting of the general public rather than groups such as academics and professionals, governments, media or industries (Sato et al., 2020). One possible explanation is that by researching the public at large, knowledge, values and interests of different stakeholders tend to be captured within representative samples of the population, offering a snapshot regardless of one's potential role in the risk analysis process. Nevertheless, we have tried to provide both the stakeholder management and the general public perspective within our analysis.

Lessons from EFSA show that, when communicating about scientific risk assessments, key audience categories may be clustered according to their scientific literacy and temporal relationship with the regulatory body. This results in three broad clusters – 'entry', 'informed' and 'technical' levels (see Figure 5) – for which communications content can be adapted, as well as the choice of communication products and channels (EFSA, 2019b). This mapping brings together the stakeholder and the general public aspect of communication.



Source: Adapted from EFSA (2019a).

Figure 5: Mapping EFSA's target audiences for external communication

Stakeholder management perspective. The concept of applying a stakeholder approach to the work of organisations originates from management literature, and relies on the premise of an interested party, regardless of the type of interest (e.g. financial or non-financial). It calls for consideration of all stakeholders in the operating environment of an organisation, suggesting a mapping exercise and includes segmenting these according to their specific objectives (Freeman, 1984). Such an approach has since been widely applied across both private and public sectors; and increasingly so as part of the engagement work of regulatory scientific bodies such as the US Food and Drugs Administration (FDA), EFSA or the German Federal Institute for Risk Assessment (BfR) whose work tends to have significant societal influence (Dendler and Böl, 2020).

Health promotion literature offers some possible ways of applying stakeholder theory that can be relevant for risk analysis. Specifically, it refers to considering the salience of the stakeholder and the position of the stakeholder in the organisational network when mapping target stakeholders (Kok et al., 2015). For example, stakeholders in a mutual institutional relationship (e.g. risk assessor and risk manager under the same authority or within the same regulatory system) differ from stakeholders who are part of a broader ecosystem in which the relationship is based on principles of legitimacy (e.g. open dialogue between a regulatory body and members of civil society).

Distinction can also be made according to the structure and 'proximity' to the risk. Those directly affected could be organised (e.g. politically organised groups with an interest in the outcome) or act as individuals (e.g. members of vulnerable, affected communities). Others may be seen as part of the 'observing' public (e.g. scientists, media) or 'general' public (all those part of public opinion on the underlying risk) (IRGC, 2020). Even though the content of communications is synchronised, different approaches across these groups help to deliver the same (variant of) the communication message to meet their different information needs. Work carried out by EFSA in response to question 5a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, point 2.i; EFSA, 2021b), notes that segmentation of audiences in the food safety ecosystem may benefit from a classification that considers the degree of engagement with an organisation (in this case, EFSA) as well as the nature of interaction. To that end, the report proposes that entities in such an

ecosystem be classified as: i) customers, ii) partners, iii) stakeholders; and iv) the (general) public (see Figure 6).

Source: Adapted from EFSA (2021b).

Figure 6: Different EFSA audiences and degrees of engagement

General public perspective. When analysing the general public, different groups in society see and react to risks differently and this presents a challenge for risk communication in the area of public health or food safety (Shaw, 2003). Specifically, in the context of food safety, the role that information sources have in the communication process varies heavily across substantial parts of the general public, resulting in heterogeneous information-acquisition patterns (Kornelis et al., 2007). And while the population appears heterogeneous in terms of understanding and knowledge of food risks, it is also possible that there are several homogenous subgroups within the population with similar information needs (McCarthy et al., 2007). Assuming that the underlying goal of risk communication is to provide useful, relevant and accurate information in a particular format for a particular audience (Fitzpatrick-Lewis et al., 2010), the goal of segmentation is to identify the correct determinants of these 'particular audiences', to then be able to tailor communication messages.

The types of risks that food safety regulators assess and communicate about differ; most common mandates are related to biological and chemical contaminants or foods produced using new technologies. For some, such as in EFSA's case, they also cover assessments related to animal health and welfare and environmental impact. Therefore, we complemented the literature on segmentation and targeting in risk communication, which mostly covers empirical research conducted to inform communication of risks related to food handling, food-borne illnesses and food contamination, with studies related to perceptions and attitudes in the area of animal welfare as well as reviews related to communication of environmental health risks. Table 4 shows factors used to arrive at population segments in food safety risk communication across the studies we analysed.

Table 4: Overview of studies analysed and factors considered in audience segmentation

Segmentation factors considered (as defined in the reference)	Reference
Three different measures of knowledge: best-practice knowledge; food safety knowledge; and food science knowledge	Who is at risk and what do they know? Segmenting a population on their food safety knowledge (McCarthy et al., 2007)
Food safety information sources (intended use and quality); Personality traits (worry about food safety, health value, perceived health control and perceived risks)	Consumer selection of food safety information sources (Kornelis et al., 2007)
Food safety knowledge related to domestic food handling (subjective and objective); Behaviour in terms of safe food preparation; Risk perception	Poultry consumers' behaviour, risk perception and knowledge related to campylobacteriosis and domestic food safety (Bearth et al., 2014)

Segmentation factors considered (as defined in the reference)	Reference
Food safety knowledge (basic and advanced); Conscious behaviour related to food safety (while shopping and at home)	Possibilities of targeting in food chain safety risk communication (Süth et al., 2018)
Food safety concerns/risk perceptions; Trust; Desire for a high level of regulation; Acceptance for number of people who get food-borne illnesses; Preference for the right to purchase safe/unsafe food	Segmentation of US consumers based on food safety attitudes (Kennedy et al., 2008)
Perceived importance of product attributes at purchase; Beliefs about current state of animal welfare; Consumption patterns; Subjective and objective knowledge; Opinions on information related to animal welfare; Attitude towards the topic	Segmentation based on consumer's perceived importance and attitude toward farm animal welfare (Vanhonacker et al., 2007)
Food safety attitudes; Trust towards public and private sources of information; Willingness to pay for food safety information	Consumers' attitudes, trust and willingness to pay for food information (Nocella et al., 2014)
Food safety attitude/values; Concerns regarding potential terrorist events in the food chain	Segmenting consumers for food defence communication strategies (Degeneffe et al., 2009)

The empirical studies we analysed segmented audiences based on one or more of the following factors: i) food safety knowledge; ii) use of food safety information sources; iii) perceived food safety risks and iv) trust in different actors in the food safety system. Systematic reviews confirm similar approaches. For example, when designing effective messages for microbial food safety hazards, literature suggests that understanding the target audiences can only be achieved through the following: i) determining consumer knowledge and attitudes; ii) considering sociocultural factors; iii) recognising individual perceptions; and iv) identifying appropriate media for distribution (Jacob et al., 2010). A review of communication related to a broader field – environmental health risks – also concludes that the factors that impact uptake or risk communication can be grouped into four categories: i) personal risk perception; ii) previous experience with risk; iii) sources of information and iv) trust in the sources of information (Fitzpatrick-Lewis et al., 2010).

Socio-cultural factors may also play a role in understanding differences among different population segments. For example, both sociodemographic and psychological determinants of consumers' use of different information sources in the context of food safety have been observed (Nan et al., 2017). However, the analysis of sociocultural factors often comes as a second step in providing insights into audiences, rather than serving as a segmentation criterion as such. Personal experience with, or relevance of a food safety issue to oneself, is more important for consumers to comply with risk information, than characteristics based on demographics (Ueland, 2019).

Conclusions

- Segmentation is key to understanding the characteristics of different target audiences and to then tailor communication messages to them.
- Limited literature is available on the segmentation of stakeholders in the regulatory environment. Lessons from health promotion suggest that salience and position in an organisational network can be used to map target stakeholders. Further, distinction can be made based on the proximity of different stakeholders to a specific risk and their organisation structure.
- A mapping model, developed by EFSA, which clusters audience categories into 'entry', 'informed' and 'technical' may also serve to categorise stakeholders for development of appropriate communication material. Regarding degrees of engagement, a recent report from EFSA proposes that entities in the food safety ecosystem be classified as: i) customers, ii) partners, iii) stakeholders; and iv) the (general) public.
- For the general public, depending on the specific type of risks in question, one or more of the following factors should be considered in segmentation: i) food safety knowledge; ii) personal risk perception; iii) use of food safety information and information sources and iv) trust in information coming from different actors from farm to fork.

- Consideration of sociodemographic and cultural factors is important in providing insights into identified segments but is not recommended as a segmentation criterion per se.

3.2.4. Appropriate information in risk communication

In line with the objectives stated in Table 1, the aims of risk communication could be summarised as comprising two key parts: to provide information about a food risk or safety issue, and to educate recipients towards safer behaviour (EFSA, 2012, cited in Ueland, 2019, p. 71). While the risk communication responsibilities of regulatory bodies vary and may encompass one or both of these parts, providing information about a food risk or safety issue, grounded in scientific evidence, is a common task for many food safety institutions worldwide. Given the terms of reference, this report focuses primarily on the first of these parts and considers it an 'exchange of information' within a framework of multi-directional dialogue, and not as the unidirectional provision of information.

A common assumption, based on a so-called 'information model', is that people seek as much information as possible to interpret a risk (see also Section 3.3.2 Risk communication models). This, however, may not hold true, especially not in today's information ecosystem (Thaler, 2016, cited in Smith et al., 2019, p. 6). Our experiences build perception biases that in turn play a key role in defining our risk attitude – more so than existing pieces of information about the topic that may have been communicated with the purpose of 'building knowledge' (Smith et al., 2019). Therefore, 'appropriate' communication cannot be based solely on the simple information seeking approach and must take into account the underlying factors that influence attitudes to risk.

Numerous studies in the field of risk communication provide findings that seek to improve the impact of communication, considering the source it comes from, the way messages are crafted and delivered and the way audiences interact with the sources of information.

Recital (4) of the Transparency Regulation states,

> 'it is necessary, [...] to ensure transparent, continuous and inclusive risk communication throughout the risk analysis, involving both risk assessors and risk managers. Risk communication should place particular emphasis on explaining in an accurate, clear, comprehensive, coherent, appropriate and timely manner not only risk assessment findings themselves but also how such findings are used to help inform risk management decisions along with other legitimate factors, where relevant.'

Indeed, explaining why actions are protective and being transparent about why people are asked to change their behaviour are key ingredients to impactful communication. Together with the openness of communication by regulatory bodies, they contribute to fostering trust (Bish et al., 2010; Poortvliet and Lokhorst, 2016) and reassuring citizens about the fair and democratic nature of decision-making (Bouder et al., 2015). However, communicating science and technical information to the public can be counterproductive if the delivery is too complex or verbose. Since raising the general scientific literacy of all society is a task beyond the remit of risk communication, information needs to be tailored to different levels of scientific literacy and numeracy and disseminated via the audience's preferred channels including trustworthy mediators who filter and render risk information more understandable (Frewer et al., 1996). This may at times require highlighting those pieces of information that are not considered crucial by the scientific community but that audiences can relate to, as they may interpret science subjectively, in line with their own values and identities (De Marchi, 2015; Verbeke et al., 2007; see also Section 3.4.1 Foster public understanding of risk analysis).

There is growing interest and dedication of resources to good practice benchmarking in risk communication by academia and public institutions (Cairns et al., 2013). The literature summarises and evaluates the effectiveness of a wide range of techniques and strategies for risk communication. We examine 'appropriate information' first in terms of its content and then in terms of its delivery based on the principles of openness and transparency.

Content. Communicators transfer substantive knowledge, trigger psychological and behavioural responses and contribute to social cohesion and resilience through tailored content. For society and communities within society, risk communication content can aid the development of 'social capacities' to deal with potential hazards/risks (Höppner et al., 2012).

- Knowledge – discover the hazard and potential risk, how to prevent or recover from it, those affected or influencing the outcome, laws and institutions, values, norms and beliefs of those involved;

- Attitudinal/motivational – raise alertness to hazards/risks, motivate prevention and recovery, willingness to be informed about risks, receive advice from authorities and instil self-beliefs to reduce vulnerability to adversity;
- Social/organisational – professional and organisational skills to develop trustful relationships among actors, strengthen networking and cooperation;
- Emotional/mental – skills to develop psychological preparedness for dealing with distress, worry and trauma (during crises), including stress management and self-assessment of mental and emotional health.

Knowing how information is sought and processed helps to determine how content should be conceived, developed and delivered. In this sense, for risk communication content to be **appropriate**, the literature points to the importance of tailoring communication to the target audiences (Covello, 2003; Fitzpatrick-Lewis et al., 2010). In simple terms, once audience segmentation is complete, two main questions should lead the development of communication content: i) What to communicate (key messages and information to include) and ii) how to communicate (choice of appropriate communication channels) (Degeneffe et al., 2009).

Target groups. Some authors go further and propose developing of communication content strategies, specific to identified target population segments. Süth et al. (2018), exploring possibilities of targeting in food chain safety risk communication on a representative sample of the Hungarian population, propose such a strategy be defined along four parameters: i) appropriate messages; ii) communication channels; iii) solution to reach; and iv) expected result. Kornelis et al. (2007), examining consumer selection of food safety information sources, argue that matching communication objectives with distinct information-acquisition patterns helps optimise the effectiveness or risk communication. Kennedy et al. (2008), segmenting US consumers based on food safety attitudes, argue that appropriate communication content should put the risk of food-borne illnesses into perspective and attempt to increase consumer trust in food chain actors. A number of authors argue that risk communication should consider the distribution of risks across different groups and target vulnerable populations (Graham and Wiener, 1997; Verbeke et al., 2007; Frewer et al., 2016). Findings also suggest that risk communication can be more effective when targeting consumers that are least confident about food safety (De Jonge et al., 2007).

Ultimately, based on varying combinations of factors used for audience segmentation, the communication objectives and the way content is presented may vary across different target groups. As previously noted, such an approach is taken to meet the different information needs across segments, delivering an audience-tailored variant of the same communication content. We summarise examples from papers included in this review in Table 5 on how content requirements can be determined by setting communication objectives for specific audience groups defined through segmentation.

Table 5: Examples of communication objectives and content types tailored to target groups

Segment example	Communication objective	Content requirements
'Disinterested youngsters' **Low basic food safety knowledge and not paying attention to food safety and nutrition** **(Süth et al., 2018)**	Develop basic knowledge and awareness	Eye-catching, brief information
'Social-source information users' **Moderate interest in food-safety information, using social network as their main information source – tend to be concerned** **(Kornelis et al., 2007)**	Present food safety information as input for social interplay	Bundle food safety information with popular conversation topics, such as articles about fashion, lifestyle or entertainment
'Apprehensive consumers' **Mostly concerned about food safety and number of people that may experience food-borne illnesses** **(Kennedy et al., 2008)**	Alleviate 'probability neglect' and misconceptions about the frequency and severity of food-borne illnesses	Include estimation of number of people who are affected by food-borne illnesses, the most frequently responsible agents in outbreaks and how to recognise the symptoms

Risk analysis phases. One can also examine the diverse purposes and requirements of communication content during the different phases of the risk analysis process. Communication should start early and occur often (especially when public concern is high, but the risk is low), with a clear plan to address early overreactions (Hooker et al., 2017). Table 6 provides a differentiation of the types of risk communication needed during different phases of risk analysis, along with the description of its purpose and audience type (Renn, 2009a).

Table 6: Summary of 'risk communication requirements for each stage of the food safety governance cycle' (Renn, 2009a)

Phases	Communication objective	Content requirements (audience)
Framing ***(problem-formulation)***	• ensure a common understanding of the problem • consider alternative frames • overcome organisational and communications barriers	• explain terms used and overall risk–benefit context (all) • ensure sufficient opportunities for feedback (stakeholders) • recognise different legal norms and institutions
Assessment ***(technical/scientific)***	• exchange facts and arguments in characterising a risk or assessing concerns • transparently inform people about the process	• mainly technical (external scientists/experts and stakeholders) • describe sources of information, milestones, expected end date (stakeholders, general public)
Evaluation ***(tolerability/ acceptability decision)***	• ensure all relevant values and arguments for subsequent decision-making are considered • improve mutual trust and credibility among actors • explain how information was weighed-up including alternative opinions • provide a clear, logical justification for trade-offs • be accessible to feedback from the general public • be available to discuss evaluation process with media	• communicating all risk info relevant in trade-offs (decision makers, stakeholders, public) • communicate quality of evidence base and related uncertainties • risk perception variables, opportunities, perceived benefits and risks • provide media statements of expert assessments in suitable format for target audience (media, public)
Management ***(decision-making)***	To businesses that need to comply with safety measure that they are: • *effective* (meet safety goal) • *efficient* (least costly option) • *fair* for all interested parties • *ethical* (food safety risk is real) • *feasible* (legally and technically) To consumers required to change behaviours/raise awareness: • provide individuals with sufficient information about the risk, the evaluation process and uncertainties to make decisions for themselves and society	• simple accessible language, flexible enough to adapt to different channels • complete info on risk and risk reduction options, fully contextualised • behavioural measures needed for risk reduction • vulnerable/affected groups • measures for reducing uncertainties • free of jargon • openness to feedback

Table footnote: The audience is included in parenthesis only where this was provided in Renn (2009a).

Even if many of the principles described apply to communication across target audiences (e.g. provision of critical information that is missing or misunderstood), message selection should consider the specific needs of different segments, as well as the phase of the risk analysis process. For example, informed and technical audiences may require content that includes specific information on the process of risk analysis, such as the assessment/evaluation timeline, main milestones or identification of opportunities to provide input or feedback. This varies from information needs when communicating the results of risk assessment, which will require, e.g. a notion of the quality of the

evidence base and related uncertainties, as well as media statements in suitable formats (Renn, 2009a, see Table 6).

Subject area. Appropriateness of communication messages may also vary according to the area of work. For example, in the area of microbiological hazards and food-borne illnesses, evidence suggests that appropriate risk communication is that which challenges complacency, considers risk perceptions and associates with the lifestyle of the audience (Jacob et al., 2010). This finding suggests that examination of risk perception should inform audience segmentation efforts when communicating about this particular class of risks.

In the area of animal health and welfare, ethics and societal values seem to play a greater role in the literature, given that the appraisal on this topic is influenced by the perceived respect/non-respect of animal conditions in farms. In addition, consumers' concern about the link between healthiness, safety and quality of products and the level of animal welfare and environmental sustainability increases sharply: this 'new' sensitivity needs to be considered and addressed when communicating about animal welfare and studying perceptions thereof (Verbeke, 2009; Cornish et al., 2016; Evans and Miele, 2019; Alonso et al., 2020). In terms of designing appropriate communication content, according to a Eurobarometer survey conducted in 2016, a large majority of Europeans agree that information campaigns are a good way to positively influence the attitudes of younger people towards animals (European Commission, 2016 Special EB 442).

Message selection. When discussing what to communicate, literature suggests that knowing how someone is exposed to a risk helps them to relate to the 'variable of interest' (Fischhoff, 1998), e.g. less frequent consumption of large fatty fish will reduce exposure to harmful contaminants such as dioxins or methylmercury. Also, two crucial components for understanding risks need to be communicated, i.e. the likelihood of effects and their potential adverse impact on individuals or populations. Tools to communicate probabilities include visual aids such as a probability scale (Fischhoff, 1998) and standardised formulations for verbal and numerical expressions (EFSA, 2019b).

Risk communication should provide 'critical information that is either missing or available but misunderstood'. Identifying the facts to communicate can be done by comparison of the risk decisions people face with their current beliefs, e.g. their risk perceptions (Fischhoff, 1998). Such facts may even 'enlighten the receiver', therefore, the target group must be able to grasp its meaning (Renn, 2010). Excluding the facts that people want to know about will reduce the impact of the entirety of information provided. Also, people reject facts if they perceive them as having been filtered or distorted to manipulate audiences (Fischhoff, 1998). Inundating readers with 'poorly selected and presented facts' disengages or antagonises them (Fischhoff, 1998), e.g. information slips in medicine boxes (Renn, 2010). Finally, the concept of information avoidance must also be considered – the fact that individuals may avoid information that is not consistent with their cognitions can be a barrier to effective risk communication (Gaspar et al., 2016). Different strategies may be proposed for 'avoiders' and 'non-avoiders' (see Section 3.3.1 on direction of influence of cognitive dissonance on risk perception).

Communicating scientific uncertainty is a somewhat contested requirement of risk communication. Uncertainty reflects a representation of best knowledge at the specific point in time and must be carefully considered during risk analysis (Renn, 2015). EFSA's attention to uncertainty analysis and communication is extensive and derives from a commitment to transparency about the quality of scientific evidence used (linked also to how evidence is appraised and integrated) in assessments: 'scientific conclusions must be based on evidence, which requires consideration of uncertainties affecting the evidence; decision-makers need to understand the degree of certainty or uncertainty affecting each assessment, as this determines how much they should rely on it when making decisions; EFSA's Founding Regulation states that risk assessments should be undertaken in a transparent manner, which implies transparency about uncertainty and its impact on conclusions.' (EFSA Scientific Committee, 2018a). Yet, uncertainty may also reduce confidence in the assessed cause-effect relationship of potential risks, as such it is an important phenomenon to be considered when developing appropriate communication. Some studies acknowledge that risk communication should consider welfare effects and consequences on trust in situations of scientific uncertainty (Palenchar and Heath, 2007), noting that noisy public announcements may be detrimental to welfare (Cornand and Heinemann, 2008). However, we found that most authors suggest to acknowledge uncertainty (e.g. Hooker et al., 2017), avoid communication of certainty or zero risk, explain certain and uncertain aspects (Löfstedt, 2006), be clear about what is unknown and controversial within the scientific community (Brunk, 2014) and categorise scientific uncertainty (Löfstedt and Schlag, 2017). EFSA follows such approaches through its guidance documents, which, in addition to the above aims, call for quantifying uncertainty to the extent possible (EFSA Scientific Committee, 2018b) to reduce

ambiguity and for communicating the uncertainty to explain the relative likelihood of the possible outcome(s) in assessment conclusions (EFSA, 2019b). When uncertainty is high and the assessed risk has a potentially high impact, decision makers can take precautionary measures based on several factors as opposed to on purely scientific grounds.

Trade-offs should also be considered in communication. We found that literature addressing this aspect of risks suggests informing the public about individual and voluntary risk–risk trade-offs (Hansen et al., 2008) and demonstrating that public concerns and risk perceptions about acceptable risks are understood and considered (Brunk, 2014). Regulators should also consider the differential impact of risk vs. benefits communication (Cope et al., 2010) and be aware that risk-only messages and negative information have stronger effects than neutral/balanced or positive information (Verbeke et al., 2007; Verbeke et al., 2008; Verbeke, 2008).

Presentation of content. *Framing* is an important concept for appropriate communication content. Investigated in-depth by Tversky and Kahneman in terms of how different presentation of information or phrasing can impact the response to a particular message (Tversky and Kahneman, 1974; Kahneman, 2011), framing is recognised as a heuristic to consider in the design of risk communication. Literature suggests that frames are effective in 'increasing people's knowledge and their motivation to act'. Negative 'loss or fear' frames 'promote the acceptance of mitigation measures' and encourage people to inform themselves about their vulnerability. Positive 'gain' frames (i.e. positive consequences of action) can trigger motivation to act (Höppner et al., 2012). Nevertheless, different ways of framing risks in communication may lead to different perceptions (Freudenstein et al., 2020) and therefore use of framing techniques in communication must attempt to minimise the 'outcome-reporting bias', i.e. provision of selective information only, that can overgeneralise risk perceptions (Freudenstein et al., 2021).

Risk comparisons – when unfamiliar risks are compared with more familiar ones – can help to overcome perceived technical literacy or numeracy barriers to understanding risk information. Comparisons help to simplify communication and improve learning if used cautiously. However, the technique can backfire if the comparison is perceived to 'oversimplify or trivialise people's concerns' (Wardman and Lofstedt, 2009). A determining factor in whether or not individuals consider the comparisons valid is trust in the information source (Johnson and Chess, 2003; in McComas, 2006).

Similarly, *Storytelling* helps to encode messages and render them mutually understandable to individuals across society 'because humans experience and understand episodes in life as 'narratives with main and supporting characters, a beginning, middle and end' (Fisher, 1987). There is evidence from the natural hazards area that narrative in risk communication helps individuals to prepare for and prevent potential risks, boosting resilience (Heath et al., 2019). The use of 'cartoon-like characters used in public information services to inform and 'nudge' citizens to develop risk prevention and emergency capacities can also be effective because of their 'mass appeal' and ability to transmit messages that 'motivate groups with lower literacy/numeracy and cognitive skills including children' (Heath et al., 2019).

Communication messages that are clear, concise and informed by research on public opinions, perceptions and fears will be better understood by the public. Risk communicators should demonstrate that they understand and sympathise with the anxieties of the target audience by conveying a risk message that addresses their specific feelings (Lundgren and McMakin, 2013, cited in Cho et al., 2017). More generally, communicated messages should also be jargon-free to reduce confusion and increase understanding, e.g. failure to report risk quantitatively leaves people to interpret the intended meaning of terms such 'small risk' or 'large risk' using their own potentially quite different 'values or normative assumptions' (Wardman and Lofstedt, 2009). Messages should contain supporting data and utilise easy-to-understand visualisations as diagrams to effectively convey the message (Cho et al., 2017). Employing these guiding principles within strategies designed to foster understanding should help to achieve the communication objectives. Regulators are encouraged to be consistent in messages and avoid multiple voices across food risk communicators (Cope et al., 2010).

In terms of education, Tonkin et al. (2019) demonstrate that communicating effectively and broadly about food regulation during both times of crisis and non-crisis, and providing simple explanations of how risk is regulated can be useful in fostering understanding of the risk analysis process. Demonstrating the preparedness of the risk analysis system by explaining the intricacies of the process in simple terms may also contribute to instilling public confidence and trust, and to maintaining trust during food risk incidents (Tonkin et al., 2019). Information and education strategies should be implemented to reduce the impact of 'overload' (Van Kleef et al., 2006) and to prevent the emergence of negative associations with experts sharing new or updated opinions. The level of information available to the public, in addition to the perceived effort put into educating the public on risk analysis matters, are associated with positive

assessments of risk management related to food (Van Kleef et al., 2006). This indicates that information and education should be the driving force in the goal to foster understanding.

Höppner et al. (2012) summarises the recommended criteria that are necessary for good risk communication (see Table 7).

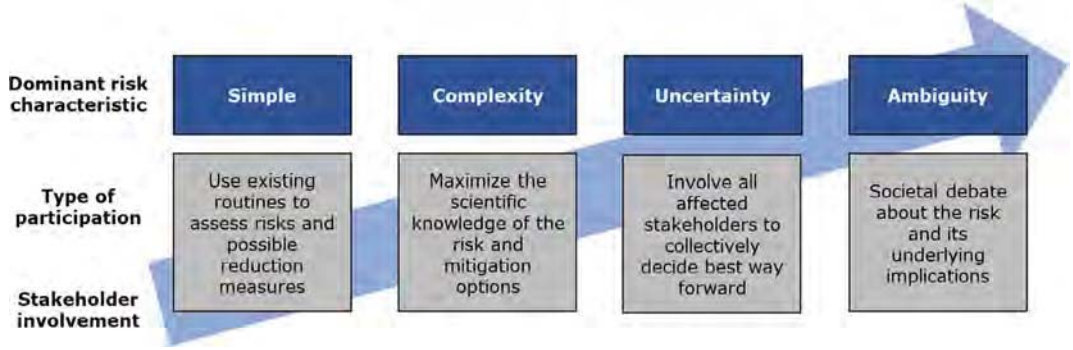
Table 7: Checklist of good risk communication (adapted from Höppner et al., 2012)

General criteria of good risk communication	Criteria of good one-way communication	Criteria of good two-way communication
• A communication scheme, strategy or programme are in place • The purposes and objectives of communication efforts are clear • The roles, responsibilities and resources of the involved actors are clear • It is clear who the 'audience' is • Communicators have analysed the key characteristics, perceptions, concerns and knowledge of the audience • The communication modes, channels and tools match with the purposes, the situation and the needs of the audience • The communication process and the outcomes are evaluated	• Communication is repeated and ongoing rather than one-off • Clear, simple and unambiguous language is used rather than purely technical or statistical terms and probabilities • The information is consistent and supports people in their search for more information • Communication gives clear advice on how to behave • A mix of verbal, written and visual communication to gain people's attention without appearing superficial or simplistic • Additional information should be placed in the community and local people help to disseminate and champion information • Information is accessible for special groups and is provided in multiple languages • Communicators work proactively with the media • Uncertainty is communicated openly • Communicators use 'windows of opportunity' after a hazard event that might increase the general openness for information • Adequate resources to design and conduct communication professionally should be allocated	• There are adequate financial resources and time for the process • A written interaction/participation plan exists • Involvement should start early and run throughout the risk management process • Organising bodies should be committed to listening to, and acting on the issues raised • Organising bodies should actively communicate how the stakeholders' or the public's contributions influence their work and decisions • Relevant stakeholders should be carefully identified and equally represented in the process • All relevant information and decisions should be openly communicated and made available to the participants • All stakeholders should have equal access and capacity to participate • Dialogic communication tools should be led by a neutral and professional moderator or mediator

Appropriate delivery of information based on principles of transparency and openness is closely linked to the open dialogue with interested parties along the risk analysis process. As mentioned in Section 3.1.1, such dialogue is an integral component of two-way communication. Lessons from research in the health area suggest that the likelihood of interested parties to take appropriate action and accept recommendations from regulatory bodies increases in case of their involvement in the underlying decision-making process (e.g. through patient forums) (Tam et al., 2005; Holmes, 2008; Bish et al., 2010) and for communications designed in a way that takes into account their risk perceptions or priorities (Vaughan and Tinker, 2009). In addition, dialogue and long-term communication are more 'suited to influencing people's attitudes' towards risk management measures and 'increasing their social/organisational and emotional/mental capacities' (Höppner et al., 2012). Empathy and concern, if genuinely expressed, can help build trust with the public (Sparks and Shepherd, 1994; Frewer et al., 1996, cited in Charlebois and Summan, 2015, p. 159).

Risks assessed and managed by regulatory bodies vary and are embedded in a larger context of social, financial and economic risks and opportunities – often denominated as 'systemic risks' (Renn and Klinke, 2004). They pose three main challenges to risk analysis – complexity (number of factors to be considered when analysing the risks), uncertainty (where science cannot provide an exact answer given the best knowledge available at that time) and ambiguity (differences in values among

interested parties regarding a specific risk) (Renn, 2015; IRGC, 2020). Different combinations of these three risk characteristics can help define the 'appropriate' level of stakeholder involvement in the risk analysis process. As described in Section 3.2.1, the involvement continuum follows the complexity of the risks, with highly ambiguous risks requiring involvement of all actors to expose, accept, discuss and resolve differences in views. Figure 7 describes the interaction of risk characteristics and the proposed increase in stakeholder involvement moving from simple to ambiguous risks.



Source: Adapted from International Risk Governance Council (2020).

Figure 7: Level and type of stakeholder involvement based on risk characteristics

There are numerous formats through which the public could be consulted across the assessment, management and communication phases; the creation of stakeholder committees, public forums or the expanded use of public consultations should all be considered as possible components of strategies designed to foster public understanding of risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome. Arvai (2003) claims that, on the assumption that public participation in decision making becomes par for the course during 'policy making efforts', 'risk communication efforts that routinely discuss them may work, over the long term, to enhance public trust and perceptions of legitimacy as they relate to industry and government'. The author is not the first to posit that public participation in processes can have positive outcomes; it has been argued for years that 'participatory decision-making approaches legitimise policy decisions because they foster the inclusion of differently formulated values, objectives, claims and arguments in the decision-making process' (NRC, 1996; Renn, 1999; Chess and Purcell, 1999; Gregory, 2000, cited in Arvai, 2003, p. 286).

As the communication with interested parties is intended as two-way flow of information and dialogue-based participation, more innovative techniques of engagement such as citizen science, can also contribute to the quality of regulatory science by widening the pool of available data and expertise. Work carried out by EFSA in response to question 5a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, point 2.i; EFSA, 2021b) provided an 'Engagement Toolkit - Methods, tips and best practices to design effective participatory processes', including a catalogue of target identification methodologies and engagement formats.

The Transparency Regulation (Article 32c) refers to particular formats, e.g. the use of consultations in the risk assessment process for authorisation or renewal of regulated products. If we define consultation as the conveying of information from the audience to the engaging organisation following a process initiated by the organisation (Dendler and Böl, 2020), the following aspects will need to hold for this process to be 'appropriate', particularly in case of risk assessment of regulated products with arguably high ambiguity:

- Consultations provide most value in terms of exploring different positions and receiving input on specific questions (Dendler and Böl, 2020), therefore comments can be used to attempt to increase the scientific robustness of the assessment or to inform risk management options.
- Regulatory bodies must provide a clear picture of how comments were used, either through information sessions or dedicated publications; comments should also be shared throughout risk analysis and if assessors do not use comments, they should be available to risk managers for their use.

- For complex risks, involvement of social scientists is recommended to understand risk perceptions and anticipate social concerns (Fischhoff, 1998; Renn, 2015) to inform communication of risk assessment outputs and corresponding risk management decisions.

The inclusion of different opinions, values and claims is the core of the 'participatory discourse' around systemic risks: established legal procedures for decision-making, supported by mediation and citizen participation are appropriate to find solutions compatible with the interests and values of affected parties (Renn and Klinke, 2004). This can reflect positively on any decision arrived at and communicated upon, as the public are more likely to feel that a variety of perspectives were included during the process, and thus, the quality of the decision is higher.

Further, transparency and openness should have a clear and consistent purpose. Not all documentation may be intuitively understood by everyone (Renn, 2009a), however, 'communicating transparently is not merely normative but can mitigate potentially serious reputational risks' such as damaging press coverage. It is important to acknowledge limitations and not downplay ambiguities in the evidence base, recognising uncertainties (Cairns et al., 2013). Ultimately, if the object and the mechanism of transparency initiatives are clear and explicit, these can achieve many specific objectives, not least of which the highly desired goal of building trust (Bouder et al., 2015). Objects may include data used in scientific opinions, declarations of interest of experts and calls for citizen science data. Mechanisms, as previously noted, include amongst others public consultations, round tables, and public hearings.

However, when transparency is merely conceived as 'opening up data' (i.e. fishbowl transparency) without being integrated within risk communication, regulators are unlikely to come across as trustworthy sources. Research suggest that regulators should avoid quick gains such as internet-mediated transparency that do not take into account findings and lessons from communication science; otherwise transparency measures can have limited or even negative effects on trust. Well-thought-through risk communication strategies are key to achieving successful transparency initiatives (Bouder et al., 2015).

As mentioned in Section 3.1.3, communicating through 'open data' should meet the standards of 'intelligent openness' (The Royal Society, 2012), meaning that information provided needs to be i) accessible and easily located; ii) comprehensible and usable to those that wish to analyse it; and iii) assessable so that judgements can be made accordingly. Other aspects to be considered when employing transparency in risk communication include data protection and intellectual property rights.

The principles of open dialogue represent a shift towards 'co-production' of knowledge by science and society (see Section 3.1.1 Risk analysis: assessment, management, communication). Evidence shows that bringing together different views about complex problems, often characterised by uncertainty, can improve the legitimacy of decisions and help to overcome decision stalemates (Scolobig et al., 2016). Yet, varying views, interests and expectations of interested parties may also lead to conflicts in the co-production process and need to be acknowledged. Five key issues to consider are: i) understanding divergent and convergent stakeholder views; ii) identifying power dynamics in problem and solution framing; iii) translating different views into options for co-evaluation; iv) reaching compromise solutions in contested policy terrains; and v) discussing jointly the effectiveness of the co-production process itself (Scolobig and Gallagher, 2021). As time is required to build trust among interested parties, eliminating conflicts may not always be possible; however, understanding and clarifying the root causes of conflicts is an important step towards a collaborative decision-making process (De Marchi, 2003).

Mapping controversies and the varying positions on science and technology issues is a potentially rich source of data to assist in understanding audience perceptions, their understanding of these issues and associated information seeking and processing needs and behaviours. An example of tools for this purpose is the EU-funded MACOSPOL project (2009) which created a platform for broad-based audiences to consider different views on controversies and articulate their own positions.

Conclusions

- Communicators can help develop 'social capacities' such as knowledge, attitudes or even trustful relationships among interested parties through development of appropriate communication content.
- The way communication objectives are set, and subsequent communication content developed, varies across different target groups, across different areas of work as well as during different

phases of the risk analysis process. Regulatory bodies must consider all three of these factors when developing appropriate content.

- When discussing what to communicate, facts need to be presented in a way that interests targeted audiences, with the right balance of risk characteristics communicated in a clear and understandable manner. Framing needs to be part of the content design process – positive or 'gain' frames may attract more attention and trigger motivation to act. However, frames should not be limited to provision of selective information only, which can overgeneralise risk perceptions.
- In cases where risk analysis is characterised by high uncertainty, this may reduce confidence in the risk assessment results. Nevertheless, most authors suggest that recognising the uncertainty and communicating how uncertainty is taken into account is the appropriate communication strategy in such cases.
- Presentation of content influences understanding therefore the careful use of framing, risk comparisons, storytelling, clear, concise and jargon-free language and, where appropriate, educational content, can increase the effectiveness of risk communication.
- Open dialogue with interested parties throughout the risk analysis process is appropriate for delivering the desired two-way communication. Different combinations of risk characteristics such as complexity, uncertainty or ambiguity can help define the 'appropriate' level of stakeholder involvement in the risk analysis process.
- Different proven formats for open dialogue may be adequate, including creation of stakeholder committees, public forums or the use of public consultations.
- Public consultations need to be used in an attempt to increase scientific robustness and there should be a clear indication on how comments were used. If relevant, comments can be shared throughout risk analysis and if assessors do not use comments, they should be available to risk managers for their use.
- Transparency must be deployed cautiously and not as a quick gain, and challenges regarding opening up data, data protection and intellectual property rights must be considered across transparency initiatives. Regulators should avoid quick gains through internet-mediated transparency that do not take into account evidence-based communication science.
- Conflicts may arise during the open dialogue with multiple interested parties. In an attempt to manage these, key issues to consider are: i) understanding divergent and convergent stakeholder views; ii) identifying power dynamics in problem and solution framing; iii) translating different views into options for co-evaluation; iv) reaching compromise solutions in contested policy terrains; and v) discussing jointly the effectiveness of the co-production process itself.

3.2.5. Communication tools and channels

In this section, we provide guidance on how to take account of the identified 'key factors' in defining the 'types and levels of risk communication activities' and 'appropriate main tools and channels'. We interpreted 'communication tools' to include: i) communication products and services used to deliver information and/or support dialogue and engagement, e.g. press releases, websites, videos, publications; and ii) methods and approaches for understanding the communication preferences of audiences, e.g. interviews, polls, questionnaires. Channels refers to the means for delivering and receiving those products and services.

Tools. Renn (2009b) lists three categories of communication tools, i.e. information-based, dialogue-based and participation-based.

- Information-based tools refer to any form of communication aimed at informing target audiences, e.g. written material, newspapers, press releases, websites, events, etc. This is useful when communicating to a large number of individuals and it can be a solid foundation for the use of subsequent tools.
- Dialogue-based tools are intended as a two-way communication in which the audience can be involved in questions and answers, discussions of opinions and judgements and shared information. For example, chat rooms, opinion polls, open days for visitors, leaflets with return coupon and panel discussions.
- Participation-based tools integrate the concerns of the audience into the decision-making process. They can be subdivided in three categories of sub-tools: orientation, self-governing and decision-making.

- Orientation tools are designed to support and facilitate discussion on topics of concern for decision makers; however, the audience does not influence the final decision. Examples include focus groups, citizen assemblies and hearings.
- Self-governing tools enable coordination between the decision makers and stakeholders to facilitate the discourse. These tools include working groups and round tables.
- Decision-making tools refer to the actual preparation of a political decision which can be facilitated through citizens' fora and consensus conferences.

Tool selection is dependent on the particular risk issue and the intended function of the communication. Information on the types of tools and their current uses in the EU food safety system by risk assessors and risk managers, are included in two complementary reports developed by EFSA in response to question 5a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, points 2.i and 2.ii):

- An Engagement Toolkit (EFSA, 2021b) provides a thorough mapping of all the different types and levels of engagement activities and the appropriate tools depending on the different target audiences. The toolkit identifies six objectives of stakeholder engagement and the respective tools that can help in achieving those goals: i) generate new ideas, e.g. brainstorming and stakeholder forum; ii) learn from and consult experts and stakeholders, e.g. expert knowledge elicitation and focus group; iii) gather data, e.g. crowdsourcing and gamification; iv) inform, e.g. information session and science café; v) learn and share lessons within groups, e.g. academic social networking sites and communities of practice; vi) co-design, e.g. participatory workshop and roundtable.
- A Catalogue of Communication Tools and Dissemination Guidelines (EFSA, 2021c) describes the current communication tools and practices of risk assessment and risk management bodies in the EU food safety system. A comprehensive benchmarking exercise on current best practices on communication tools and dissemination processes of EU Member State organisations plus Iceland and Norway, selected ENVI EU agencies (EFSA, EMA, ECHA, ECDC) and EU bodies (DG SANTE, JRC, EU COUN) was carried out via an online survey, remote qualitative interviews and a desk analysis of documents and web content. The catalogue highlights that multimedia tools show relatively high impact scores and high mention rates by respondents participating in the online survey. Editorial tools are still very important, especially to reach the media. Both physical meetings and events and educational tools have very high impact scores but limited mention rates. All communication tools can be effective if properly designed (i.e. 'right content and tone of voice for the intended target audience(s) disseminated through the right channels').

The risk perception literature describes three main tools for investigating audience opinions and points of view:

- Quantitative methods like self-report measures, e.g. surveys and questionnaires could be used to gather information coming from large samples of individuals regarding their knowledge, attitudes, beliefs and behaviour concerning the risk. In addition to self-reports and direct measures, instantaneous (emotional) reaction to a risk could be measured via indirect tests, such as physiological measures to compensate for the methodological drawbacks of questionnaires (Visschers and Siegrist, 2008).
- Nowadays, quantitative analysis can also leverage on online data (e.g. social media) and neuro-linguistic programming techniques. Such techniques have been recognised in the area of public health, e.g. social media monitoring has been defined by ECDC as 'a new area of research methodology that can help (national) health authorities understand how information about vaccination is shared and spread online' (ECDC, 2020a,b).
- Qualitative methods such as in-depth rolling opinion polling (Pidgeon, 1998) and focus groups with smaller groups help to understand how members of the public speak about risks and what messages most effectively address their concerns. It also provides an opportunity to involve the audience in risk evaluation and control. Furthermore, by acknowledging consumers' concerns, experts foster public trust and enhance their credibility (Bruhn, 2005).
- Experimental studies, think-aloud studies (Siegrist, 2019) or studies in which participants explain and discuss with other participants how they evaluate perceived risks might represent an informative source. This type of research could offer insights into people's decision-making processes when they evaluate the acceptance of a technology and the knowledge on which they rely in these situations.

Some authors underline the challenges that surveys pose to the field of risk perception research. For instance, Covello (1983) states that risk perception literature suffers from shortcomings of survey research. First, the authors argue that people tend to answer survey questions with the first thing that comes to their mind, and afterwards become committed to their answer. Second, people tend to respond to all the questions within a survey, even when they have no opinion or when they have difficulties in understanding the question. Third, survey responses can be affected by the order in which the questions are presented, by the type of question (closed or open) and by how the question is framed. According to the authors, risk perception surveys are especially exposed to these types of biases, because people are often unfamiliar with the activity or substance being assessed and because they may not understand the technical and methodological issues under discussion (see also Okrent, 1998).

Further, Gaskell et al. (2017) showed that the methodology used for the estimation of risk perception, i.e. survey questions including an array of risks with fixed response alternatives measuring the size of worry or concern, might overestimate food risk perception. Their analysis of data from the Special Eurobarometer 345 on Food-related risks consisting of both closed and open-ended questions revealed a significant difference between mentioning a risk in the open-ended question (unprompted awareness) and the expression of worry about risks in the closed questions (prompted awareness). Among those respondents who did not report a specific risk in the open question, between 60% and 83% (depending on the risk) expressed concern in the closed questions. This is in line with findings from research on cognitive aspects of survey methodology, indicating that survey questions may frame the respondent's thinking about an issue. The authors recommend the use of branched questions involving a two-step process in which respondents are first asked if they have thought about a specific risk during (a specified target window or since a particular date) and, in a second step, ask those who respond affirmatively the degree to which they have worried.

To overcome these issues, it is advisable to adopt mixed methods and assess risk perception through a plurality of quantitative and qualitative methods.

Channels. A recent report from the Food Standards Agency (FSA, 2019) distinguishes between traditional media channels and social media.

Traditional media channels include news delivered through TV and radio news or published in newspapers, either on paper or online. While traditional media are usually a one-way form of communication, social media channels are more participatory and enable interaction between users, facilitating two-way communication.

According to the Special Eurobarometer on Food safety in the EU (2019), television is the most common source of information about food risks in the EU. Specifically, more than two thirds of Europeans (69%) report that television is among their main sources of information about food risks, followed by the Internet (excluding social media) (46%), newspapers and magazines (38%). On this topic, Nan et al. (2017) state that TV and radio campaigns are effective due to their broad coverage, as research shows that nearly 70% of US consumers receive food safety information from these two channels combined.

Age is a determining factor in preferred sources of food-related information in the EU: younger respondents are more likely than older respondents to mention social media (45% of 15–24 years old, falling to 10% of those aged 55 or over) and other information from the internet (63% vs. 28%). However, older people are more likely to mention television (78% vs. 55%), newspapers and magazines (46% vs. 22%) and radio (30% vs. 13%) (EFSA and European Commission, 2019). To reach younger generations, new media and interpersonal information sources would be suitable, while traditional media are appropriate for reaching older generations (Nan et al., 2017). Importantly, the same social media platforms have different audiences in terms of age and these differences may vary across EU countries, therefore this aspect should be taken into account for tailoring messages.

Communication efforts can be combined to maximise the message reach, as pointed out by Wolkin et al. (2019). People prefer traditional media as a news sources which then shapes social media content and ensuing discussions (Overbey et al., 2017). A challenge faced by mass media is that people could perceive risk information delivered through this channel as relevant to others but not to themselves (McComas, 2006). Even if traditional media alert individuals to health risks and help form 'societal level judgements', individuals have a tendency to assess their own personal risk via interpersonal networks (McComas, 2006). To overcome this challenge, other channels of communication can be considered when reaching the target audiences.

Using multiple ways to deliver information, including TV, social media and word of mouth, increases the opportunity to reach and engage the whole community and takes advantage of the different

strengths of each of these methods. People often look for message confirmation before taking action, so it can be beneficial to share messages through multiple communication routes (Wolkin et al., 2019). People are more likely to seek information when they perceive greater risks leading to higher self-efficacy (Rimal, 2001; in McComas, 2006). Another benefit of combining 'efficacy information' from news sources and 'peer feedback' on social platforms is that it encourages individuals' 'self-protective behaviour and levels of involvement' more than using any single channel (Verroen et al., 2013).

Although social media and word of mouth messaging are harder to control, these methods are popular and can quickly reach a large audience. An advantage of social media and word of mouth messaging is the lack of reliance on the original source to spread the message. Messaging via TV is determined by the number of times the news media decides to provide the message. In contrast, social media and word of mouth messaging is constantly being recirculated through sharing, reposting and retweeting, with social media enabling rapid amplification of messaging (Wolkin et al., 2019).

The FSA report (2019) notes several considerations for the use of social media:

- The interactive nature of social media makes it difficult to control messages once information is published. Public interaction in the forms of comments, shares and retweets can cause the messages to increase in popularity and become widespread.
- Often there is an audience preference for communications from traditional media, due to low trust in social media content.
- Engaging successfully with audiences through social media entails a significant time effort if the intention is to address queries in real-time to maintain control of the message. This real time response ensures that a two-way communication takes place; in case this is not met, the communication becomes a one-way information delivery system, similar to traditional media channels.

In addition to traditional and social media channels, people can act as sources of information when communicating to the public. In the case of risk communication, the source of the information should be credible, informed and trusted. Tonkin et al. (2019), generally recommends that information should be provided by trusted independent bodies, providing examples like chief medical officers or hospitals. This supports Van Kleef et al.'s (2007) findings that independent actors are perceived to offer unbiased opinions regarding food safety matters, and so are trustworthy channels of information. Often experts, such as scientists or medical professionals, are cited when talking about risks. Frewer (2003) refer to this as 'source credibility', as it relates to the public's perceptions of the motivations of institutions or individuals in providing information to them.

According to the Special Eurobarometer on Food safety in the EU (2019), despite differences between countries, scientists and consumer organisations are the most trusted sources of information on food risks overall, with 82% of respondents trusting scientists and 79% trusting consumer organisations, (see also Section 3.2.1 Factors influencing risk perceptions). Van Kleef et al.'s cross European study (2007) observes that consumer representative organisations and scientists working for universities are two of the most trusted actors. Additionally, Frewer and Miles (2003) found that physicians, such as medical doctors, are trusted sources of risk information. On the other hand, the food industry and scientists working for industry are ranked as considerably less trustworthy (Van Kleef et al., 2007). This is also the case for celebrities, bloggers and influencers who are deemed trustworthy by a minority of individuals (19%) (Special Eurobarometer, 2019). However, influencers on social media can help in increasing the reach of a message, explaining why they are frequently used in marketing campaigns. As an extension of social media, influencers can 'have a wide reach, knowledge, ability, motivation and social capital to influence public opinion', therefore co-opting strategies to work with influencers and help them to develop 'more persuasive and scientifically accurate materials' protects the public from incorrect information that poses a risk to public health (Overbey et al., 2017).

This overview is complemented by a Catalogue of Communication Tools and Dissemination Guidelines (EFSA, 2021c), which describes current practices of risk assessment and risk management bodies in the EU food safety system developed in response to question 5a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, point 2.ii). The report notes that social media and websites are the most used dissemination channels. The reliance on campaigns is widespread as they help achieve a stronger impact on the target audience. Moreover, communication tools supported by best practices in dissemination perform much better and are used by a wider audience than tools that are merely published on an organisation's website. A systematic phased approach to dissemination (1. planning, 2. preparation, 3. publication and distribution and 4. post-publication and distribution) is, therefore, crucial for a successful communication strategy.

Effective leverage of amplifiers (planned and prepared in the first two phases) substantially increases communication tools' outreach in the publication and distribution phase.

Conclusions

- Communication tools can be divided in three categories, i.e. information-based, dialogue-based and participation-based.
- In the area of risk perception, quantitative methods, qualitative methods, mixed methods and experimental studies can be used to gather audiences' opinions and perspectives.
- Channels can be divided into traditional media channels and social media.
- While traditional media are usually a one-way form of communication, social media channels are more engaging and enable interaction between users, therefore they could be used as amplifiers of risk information, facilitating two-way communication.
- Scientists and consumer organisations are the most trusted sources of information on food risks overall.
- There is great variety in the tools and channels used by food chain risk assessment and risk management bodies in the EU. All communication tools can be effective if properly designed, i.e. appropriate content and tone of voice for the target audience(s), and disseminated through the most appropriate selection of channels.
- Based on a review conducted by EFSA among EU actors, multimedia products demonstrate highest impact score, while social media and websites are the most frequently used dissemination channels. Communication tools supported by best practices in dissemination (e.g. use of amplifiers) perform much better and are used by a wider audience than tools that are merely published on an organisation's website.

3.3. Risk profiling, communication models and coordination

In this section, we describe options for combining the key factors described in Sections 3.1 and 3.2 in structured approaches to risk communication. First, we explore the possibilities of developing generic risk profiles summarising the literature on this subject and propose our own framework as a starting point for the future development of such a tool. We then analyse theoretical risk communications models, highlighting their applicability for certain types of communication purposes and audience segments. We also summarise here the literature on existing models for coordinated communication among risk managers and assessors at international and supranational levels.

3.3.1. Generic risk profiles

In this section, we describe the available literature on risk profiling approaches and we explore the possibility to create 'generic risk profiles' corresponding to the different workflows of risk analysis procedures, and especially for regulated products[14] based on the factors identified in the previous sections.

The review of the grey literature and the input received from the targeted consultation helped to retrieve general guidelines on which kind of information to include in a risk profile and evidence on existing risk profiles.

Guidelines on risk profiles. A joint report by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) (1997) describes risk profiles as follows:

> 'Risk profiling is the process of describing a food safety problem and its context, in order to identify those elements of the hazard or risk relevant to various risk management decisions. The risk profile would include identifying aspects of hazards relevant to prioritising and setting the risk assessment policy and aspects of the risk relevant to the choice of safety standards and management options.

[14] As described in the terms of reference (section 1.1): . . .these 'generic risk profiles' should aim at a) providing a generic mapping of the elements that would need to be assessed and/or considered both at risk assessment and risk management level, on the basis of the above-mentioned factors, according to available knowledge and past experiences; b) provide preliminary assessments - based on existing knowledge, if any - of any associated benefits associated with the relevant risks, e.g. actual or expected benefits, their magnitude and importance, who benefits and how, who may be in disadvantage and how, potential trade-offs etc.; and c) identify overall sensitivity of the subject matter, taking into account concerns, expectations and most importantly risk perceptions.

'A typical risk profile might include the following:

- A brief description of the situation, product or commodity involved.
- The values expected to be placed at risk, (e.g. human health, economic concerns).
- Potential consequences.
- Consumer perception of the risks.
- Distribution of risks and benefits.'

A more recent joint report by FAO/WHO (2006) provides an example of information to include in a risk profile:

- 'Initial statement of the food safety issue.
- Description of the hazard and food(s) involved.
- How and where the hazard enters the food supply.
- Which foods expose consumers to the hazard and how much of those foods are consumed by various populations.
- Frequency, distribution and levels of occurrence of the hazard in foods.
- Identification of possible risks from the available scientific literature.
- Nature of values at risk (human health, economic, cultural, etc.).
- Distribution of the risk (who produces, benefits from and/or bears the risk).
- Characteristics of the commodity/hazard that might affect the availability and feasibility of risk management options.
- Current risk management practices relevant to the issue, including any regulatory standards in place.
- Public perceptions of the possible risks.
- Information about possible risk management (control) measures.
- Preliminary indication of questions that a risk assessment could (and could not) be expected to answer.
- Preliminary identification of important scientific data gaps that may prevent or limit a risk assessment.
- Implications of risk management in terms of international agreements (e.g. SPS Agreement).'

According to the report, the aim of the risk profile is to support risk managers in taking further action. Usually a risk profile would be developed mainly by risk assessors and other experts on the issue under examination.

Existing risk profiles. Two examples related to risk profiles in food safety have been retrieved, i.e. those developed by the New Zealand Food Safety Authority (NZFSA, 2020) and the German Federal Institute for Risk Assessment (BfR, online).

The New Zealand Food Safety Authority (NZFSA, 2020) risk profiles are specific and intended primarily for risk managers. As stated on NZFSA website:

'The documents are analytical and concise and offer more specific information than a hazard data sheet. They are structured in seven parts.

1) Executive summary – gives a statement of the scientific evidence about the risk to human health of the combination of food and the hazard that are the subject of the risk profile, including a critical evaluation of current data.
2) Statement of purpose – describes the food/hazard combination, the context and reasons for preparing the risk profile.
3) Hazard and food – outlines the food and the hazard that are the subject of the risk profile. Also included is information that has a bearing on controlling the risk, such as sources of the food, contamination pathways, exposure and other factors.
4) Evaluation of adverse health effects – offers an evaluation of the risks to human health by drawing on human health surveillance data from New Zealand and other countries.
5) Evaluation of risk – brings together critical scientific information about the risk, a commentary on the burden of food-borne illness in New Zealand and the food source attribution and concludes with a summary of the food-borne human health risk.
6) Availability of control measures – includes information about current control measures, their effectiveness and additional options for controlling the risk.
7) Appendices – offer relevant background or generic information to support the information in the risk profile.'

The risk profiles developed by the German Federal Institute for Risk Assessment (BfR, online) are specific and intended for the general public to make the information accessible to the wider audience.

As stated on the BfR website:

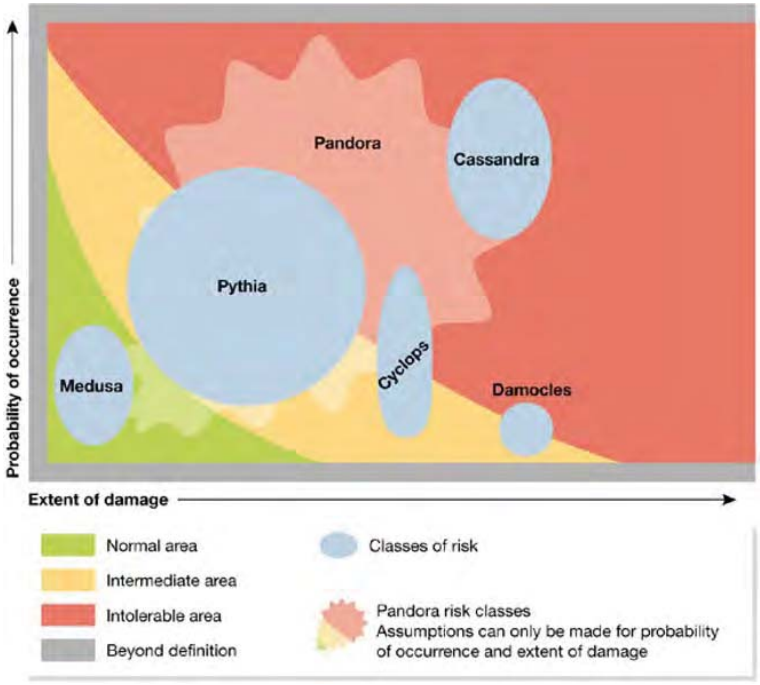
'The chart is structured as a table containing five characteristics:

1) Affected groups of persons
2) The probability of impaired health in the event of exposure
3) The severity of impaired health in the event of exposure
4) The validity of the available data
5) The possibilities for consumers to control the risk through such measures as avoidance or caution.'

Drawing from the documents retrieved in the grey literature, it appears that risk profiles in food safety are meant as a tool for risk managers and the examples found relate to specific hazards rather than generic risks.

In the past EFSA has developed scientific opinions in the form of risk profiles, for instance on the topic of production and consumption of insects as food and feed (EFSA Scientific Committee, 2015); however, the public perceptions of the risk were not included.

One classification of risks worth mentioning adopts a 'traffic light system' dividing the risks in three areas, namely normal, intermediate and intolerable (Renn and Klinke, 2004). The normal area includes risks with small statistical uncertainty, low catastrophic potential and low complexity, whereas the intermediate and intolerable areas pertain to risks characterised by low reliability of assessment, high statistical uncertainty and catastrophic potential. Building on these areas, the authors identify six different clusters of risk that they illustrate through Greek Mythology. First, *Damocles* refer to risks with low probability but high damage potentials, such as technological risks (e.g. nuclear energy). Second, *Cyclops* concern highly uncertain risks with high well-known disaster potential like natural hazards (e.g. earthquakes). Third, *Pythia* relate to risks with uncertain probability of occurrence and uncertain extent of damage, e.g. risks due to climate change. Fourth, *Pandora* risks refer to wide-spread, persistent and irreversible changes caused by human intervention on the environment (e.g. endocrine disruptors). Fifth, *Cassandra* includes risks with high probability of occurrence and extent of damage, which are well-known but, due to their delayed consequences, are ignored or underestimated (e.g. loss of biodiversity). Sixth, *Medusa* risks refer to some innovations that are scientifically assessed as safe but rejected by citizens who consider them frightening or unwelcome (e.g. electromagnetic fields). Figure 8 illustrates how the six clusters are distributed in the three areas of risk.



Source: Renn and Klinke (2004).

Figure 8: Risk clusters as identified in Renn and Klinke (2004)

The objective of this classification is to draw strategies for risk management on which measures to adopt for each risk cluster. As shown in Table 8, Renn and Klinke (2004) recognise three strategies, i.e. science-based, precautionary and discursive. *Damocles* and *Cyclopes* need mainly a science-based approach, *Pythia* and *Pandora* require applying the precautionary principle and *Cassandra* and *Medusa* demand discursive strategy for building awareness and trust (see table below for further details).

Table 8: Risk management strategies for dealing with risk clusters (adapted from Renn and Klinke, 2004)

Management	Risk class	Extent of damage	Probability of occurrence	Strategies for action
Science-based	*Damocles* *Cyclops*	High High	Low Uncertain	• Reducing disaster potential • Ascertaining probability • Increasing resilience • Preventing surprises • Emergency management
Precautionary	*Pythia* *Pandora*	Uncertain Uncertain	Uncertain Uncertain	• Implementing precautionary principle • Developing substitutes • Improving knowledge • Reduction and containment • Emergency management
Discursive	*Cassandra* *Medusa*	High Low	High Low	• Consciousness building • Confidence building • Public participation • Risk communication • Contingency management

Creation of generic risk profiles. Based on the literature reviewed in the various sections of the report, we outline a general list of factors to take into account for risk communication. It is worth noting that the aim is to be descriptive and not prescriptive, offering a high-level categorisation that

can be adapted to different contexts of risk assessment and risk communication. As shown in Table 9, the risk profile is divided in four levels, i.e. i) hazard, ii) individual, iii) socio-cultural and iv) information. For each level, we illustrate the factors to consider, and, drawing from the literature reviewed, we provide an indication of how these factors influence risk perception. To make the risk profile a useful tool for risk communication planning, we also provide science-based advice for risk communication.

Table 9: Levels and corresponding factors to take into account when developing risk profiles. Green arrows indicate lower risk perception, while red arrows indicate higher risk perception

Level	Factors	Direction of influence on risk perception	Advice for risk communication
Hazard	Dread	Controllable Short-term Voluntary Easy to reduce/mitigate Equal distribution of risk Fatal Potentially catastrophic	Identifying **public knowledge schemes** can help in tailoring the content of the risk communication to this knowledge ('Mental Model Approach')
	Familiarity	Known Observable Delayed consequence Immediate consequence	Knowledge schemes could be used to **identify the differences** between experts and the members of the public
	Severity	Non-severe Severe	Listening to the target audience can help in **gaining insights** on perceptions, knowledge and the preferred information method and means
	Naturalness	Natural Non-natural/man-made	Highlighting **tangible benefits** of foods that are perceived as 'less natural' can increase public's acceptance
	Exposure	Low number of people High number of people	The mental model analysis can help in **bridging the gap** between the mental models held by the public and expert models with the aim of adding missing concepts, correcting mistakes and strengthening correct beliefs
	Magnitude of risk	Low probability High probability	Annual risks of one in a million chance are not considered with serious concern ('**small level of risk**'), whereas annual risks of death in the order of one in a thousand or one in a hundred are deemed unacceptable by most people ('**high level of risk**')
	Level of uncertainty	Certainty Uncertainty	Uncertainty needs to be **acknowledged**, clarifying what is unknown and controversial within the scientific community

Level	Factors	Direction of influence on risk perception	Advice for risk communication
Individual	Personality traits	Risk-seeking Emotional stability Risk-aversion Food tech. neophobia Disgust sensitivity Anxiety	**Social research methods** can represent an informative source of knowledge on the psychological dispositions of the audience
	Cognition	Overconfidence Optimistic bias Positive framing Cognitive dissonance Negative framing	As people base their judgements on their experiential system, which is more driven by affect, **concrete images**, **metaphors** and **narratives**, these can be used in communication to help individuals to better understand the risk, prepare for and prevent potential risks and boosting resilience
	Emotions	Positive emotions Negative emotions	Instantaneous (emotional) reaction to a risk could be measured via **indirect tests**, such as physiological measures
	Direct experience	Positive experience Negative experience	Rolling **opinion polling** and **focus groups** can help in understanding public's experiences and adapt the content of the message
	Perceived benefit	High benefit Low benefit	Provide **information on the benefits** to decrease the perceived risks
	Demographics	Males Younger individuals Higher education Higher income Females Older individuals Lower education Ethnic minority Lower income	**Surveys** and **questionnaires** should always gather information on the sociodemographic characteristics of the audience to adapt the communication accordingly

Level	Factors	Direction of influence on risk perception	Advice for risk communication
Socio-cultural	Social Amplification of Risk	Large volume of info Dispute Dramatisation Stigmatisation	Enable **coordination** between the decision makers and stakeholders to facilitate the discourse
	Social norms	No conflict Conflict	Communication messages that are tuned to the social norms of a group, e.g. referring to the '**members of your community'**), are the most effective
	Level of public concern	Low concern/outrage High concern/outrage	Social media allow for a **more in-depth understanding** of consumers' response to risk communication and aid the communicator to achieve an understanding of the general public feeling towards the issue
	Social trust	High trust Low trust	Having **similar values** determines social trust, therefore social trust can be increased if a risk is framed in a way that reflects public's salient values
	Worldviews	Individualistic Hierarchical Fatalistic Egalitarian	It is crucial to **know the audience** to whom the communication is directed - a reference to cost-benefit ratios would be appropriate for an audience with Individualistic worldview, but it would trigger outrage when being referred to in a group of Egalitarians
Information	Transparency	High transparency Low transparency	Dialogue-based tools are needed to enable a **two-way communication** in which the audience can be involved in questions and answers, discussions of opinions and judgements and shared information
	Consistency	Consistent Conflicting	Establish appropriate mechanisms of **coordination** and **cooperation** to strengthen coherence
	Costs and benefits	More benefit More costs	As the general public might refrain from acquiring more information if the cost of information processing is too high, communication should be delivered with **simple language** to help individuals perceiving the benefits coming from information
	Characteristic of the media/information source/channel	Trustful source Untrustful source	Qualitative methods and **public engagement** represent useful tools to acknowledge the consumers concerns that would result in fostering public trust and enhance credibility
	Cognitive costs	Low cognitive effort High cognitive effort	As information processing demands high effort in terms of mental capacity and motivation needs, communication should be delivered with **simple language** adapted to the audience to which it is addressed
	Information overload	No overload Overload	Establish appropriate mechanisms of **coordination** and **cooperation** to avoid overload

Conclusions

- Guidelines on risk profiling define it as the process of describing a food safety problem and its context, in order to identify those elements of the hazard or risk relevant to various risk management decisions.
- A typical risk profile is advised to include i) a brief description of the situation, product or commodity involved, ii) the values expected to be placed at risk, iii) potential consequences, iv) consumer perception of the risks and v) distribution of risks and benefits.
- A potential classification of risks adopts a 'traffic light system' dividing the risks in three clusters, namely normal (risks with small statistical uncertainty, low catastrophic potential and low complexity), intermediate and intolerable (risks characterised by low reliability of assessment, high statistical uncertainty and catastrophic potential).
- Based on the literature reviewed and the key factors identified, we provide a framework for developing generic risk profiles divided in four levels, i.e. i) hazard, ii) individual, iii) socio-cultural and iv) information, which can serve as basis for communication planning and development of specific risk profiles.

3.3.2. Risk communication models

Conceptual models for risk communication are tools which the risk communication actors in the EU food safety system can use 'to take account of the relevant factors' in risk communication. Such models can give indications how to adapt existing organisational structures or to develop new ones to facilitate 'coordinated communication among risk assessors and risk managers at Union and national levels'. The literature describes a variety of risk communication models which have emerged and evolved over recent decades to adjust to new developments and prevailing trends in risk communication theory and practice. Few if any of these models were conceived specifically for the food safety area, yet their conception for sectors ranging from public health to climate change, natural disasters and industrial incidents allows us to evaluate their application to the EU food safety system.

Analytical framework

We sought to assess the models in the literature according to their scope and their inclusion of or reference to the 'key factors in risk communication'. Since such conceptual models vary in purpose this influences the inclusion or exclusion of input variables, i.e. the key factors. For practical purposes we used an analytical framework which describes both the drivers ('imperatives') for risk communication and the purpose ('functions') of different approaches. In addition, we sought to understand if this analytical framework can help to devise approaches suited to risk communication that targets any of the audience segments identified in Section 3.2.3 above.

Imperatives. Wardman states that traditional analyses of risk communication theories and practices are too 'atheoretical' in that they lack a common framework that allows comparison and describes how they may be interconnected (Wardman, 2008). However, a framework first developed by Fiorino depicts the interplay of legal, socio-political and institutional obligations and circumstances within which the risk analysis paradigm is situated in democratic societies (Fiorino, 1990, cited by Wardman, 2008, p. 1621). This approach identifies three broad drivers or 'imperatives' of risk communication:

- *normative* – fulfils the rights of citizens to information and involvement in risk analysis (Fiorino, 1989, 1990; Stirling, 2005; Pidgeon and Rogers-Hayden, 2007; cited in Wardman, 2008, p. 1621);
- *instrumental* – serves individuals and organisations to achieve a particular 'self-serving' end, e.g. protecting commercial interests, amplifying public concerns, raising public awareness;
- *substantive* – leads to engagement (or not) that improves understanding of and the quality of available knowledge, i.e. outcomes favouring the 'general interest' over 'self-serving ends' (Stirling, 2005, cited in Wardman, 2008, p. 1622).

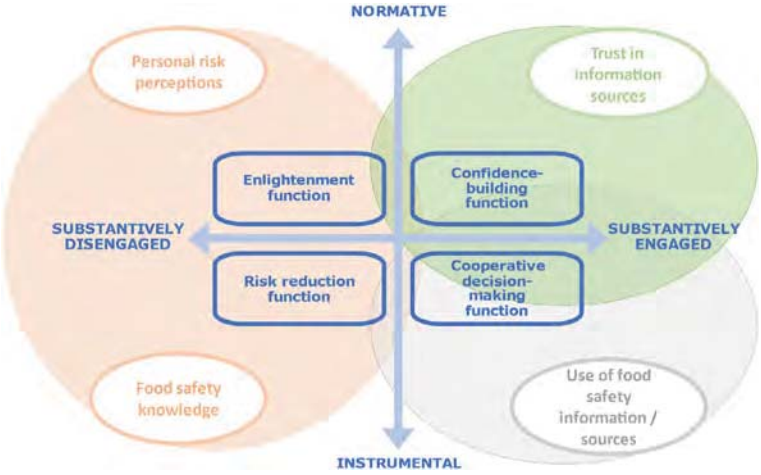
Function. According to classical communication theory, all communication has a purpose (i.e. 'function') which is achieved through the transmission of messages to a target audience through 'a system of meaningful symbols' devised to have different possible impacts on the receiver (Jaeger et al., 2001, cited in Renn, 2009a, p. 124). Renn describes a framework for organising and characterising the objectives of different risk communication in the food safety area–most frequently

executed by a risk management agency with 'the public as target audience'–according to four main 'functions' (Renn, 2009a):

- *enlightenment* – enhances the individual's understanding and knowledge of risks;
- *confidence-building* – establishes or rebuilds trustful relationships between sender and receiver;
- *risk-reduction* – changes attitudes/behaviours to causes or types of risk through persuasion;
- *cooperative decision-making* – involves stakeholders in resolving existing or potential conflicts related to potential and perceived risks.

Target audience. As mentioned above, an appropriately defined target audience is an intrinsic element in any communication activity. Therefore, in addition to the imperatives and functions of various risk communication models, we examined the models below also in terms of their possible application in targeting audiences, specifically with reference to the factors to consider in segmentation described in Section 3.2.3 above, i.e. by i) food safety knowledge; ii) personal risk perception; iii) use of food safety information and information sources; iv) trust in information from different sources.

Figure 9 illustrates how risk communication functions can be mapped according to their fulfilment of the imperatives underlying the risk analysis process, providing a two-dimensional construct for analysing various risk communication models. Further, the diagram highlights a potential correlation between the proposed segmentation strategies for the public and the purpose of the conceptual models.



Source: Adapted from Wardman (2008).

Figure 9: Mapping of imperatives and functions of risk communication and audience segments

Enlightenment > personal risk perception. Many traditional risk communication models aim primarily to take account of the psychometric paradigm in relation to categories of hazards (Section 3.2.1). Such models propose approaches for designing impact-oriented risk messages that redress disparities in personal understandings of and perception between real risks and perceived risks, in an 'interactive exchange with stakeholders about emergent issues' (Cairns et al., 2013). While enlightenment fulfils the normative obligation to inform audiences and help them understand risks, substantive engagement is not a prerequisite for this type of risk communication.

Risk-reduction > food safety knowledge. People seek and process information about risks according to their risk perceptions, but also such individual characteristics as their cultural identity, socio-economic context, social and personal pressures, and preferred information channels, amongst other factors (Otto et al., 2018). Such 'mental noise' may limit the individual's ability to process risk information efficiently. It is heightened when an individual is under stress, when the negative information bias elevates the importance of potential losses or negative outcomes (see Section 3.1.4), therefore positive and proactive information is needed to counterbalance (Cairns et al., 2013). Communication needs to transmit the 'availability' of actions to prevent or avoid risks and should appear 'personalised' to affected populations.

Confidence-building > trust in information and sources. Building confidence underlies the risk analysis framework of the EU food safety system. Establishing trustful relationships before

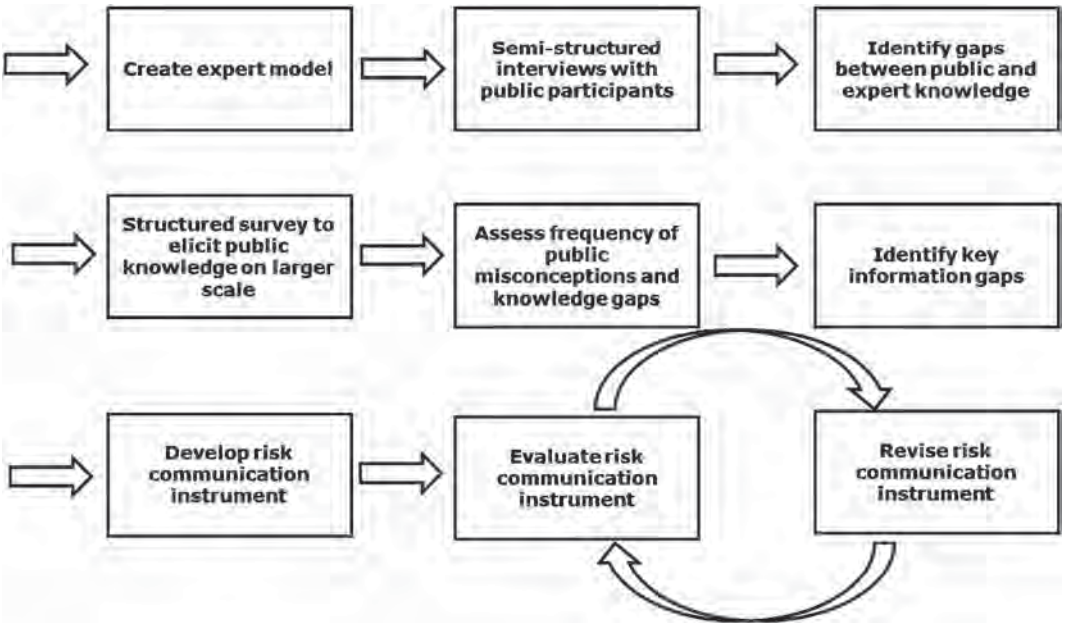
controversies arise is a core requirement of effective risk communication message development and strategies (Cairns et al., 2013). However, risk communication may falter in situations of public distrust caused by 'lack of credibility, past history or social alienation' (Löfstedt, 2010). It refers to both the confidence of the wider public and therefore society as a whole, as well as that of individuals, organisations and structures that constitute technical and civil society interests, frequently characterised as 'stakeholders'.

Cooperative decision-making > use of food safety information. Risk communication involving 'stakeholder' configurations comprises both conventional communication (e.g. public information delivered via channels such as websites, social platforms and publications) and other mechanisms that enable two-way interaction, which we can also characterise as dialogue or engagement, constituting 'the flow of information between subsystems of society' (Renn, 2010), as discussed in Section 3.2.4 above.

While the above combination of perspectives offers a three-dimensional solution for analysing the inputs, objectives and targets of the risk communication described below, we stress that this framework was not derived directly from the literature and we would therefore welcome research designed to test the veracity and robustness of the interconnections described in Figure 6. With this caveat, our analytical framework helps to evaluate the risk communication models below and reach some conclusions as to whether they could be adapted to serve as practical tools for 'taking account of the factors in risk communication,' that could contribute also to developing 'generic risk profile' frameworks as explored in Section 3.3.1 above.

Assessment of risk communication models

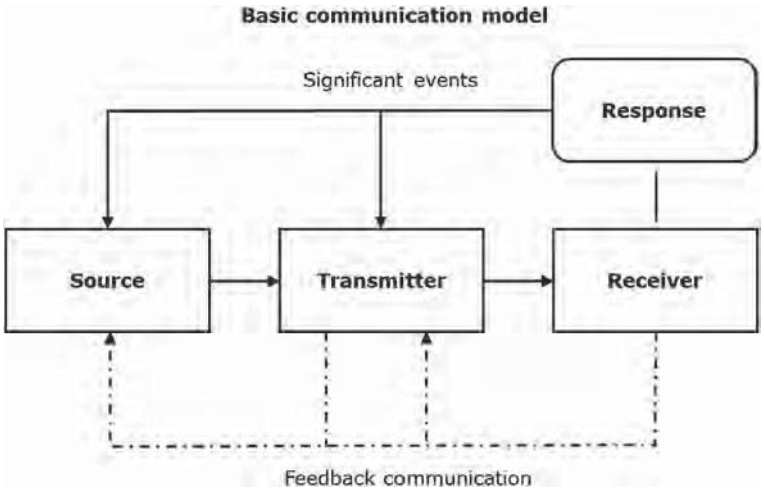
Mental models approach to risk communication (MMARC). Developed by Morgan, Fischhoff and others (Morgan et al., 2002; as described in Wardman, 2008; Otto et al., 2018) the MMARC is considered a milestone in the field of risk communication frameworks. It expressly responds to the normative requirement to enlighten information receivers about risks. The MMARC provides an iterative framework for studying how technical experts and lay audiences perceive risks differently, and to then use these findings about the information gaps to formulate and test messaging (see Figure 10). This includes 'actionable information' e.g. in the form of colour coding of weather impacts (Otto et al., 2018) that allows individuals to reduce the information deficit and correct misunderstandings, implying a more realistic understanding of the real risks associated with a given hazard. This includes use of 'risk comparisons' to help individuals understand risk-taking is relative and shaped by social conditions.



Source: Adapted from Morgan et al. (2002), Gurian (2007).

Figure 10: The mental models risk communication framework

Social amplification of risk framework (SARF). Described in Section 3.2.1 above, a SARF approach to risk information transmission resembles the MMARC inasmuch that it is driven mainly by normative considerations and it involves similar research methods (quantitative surveys, focus groups, interviews). However, SARF focuses on understanding better 'the complex dynamic social phenomena that influence amplification and attenuation processes' in addition to the focus mainly on psychological factors influencing the individual's risk perceptions at the heart of the MMARC. A core principle of SARF for developing risk communication messaging is to analyse the social and institutional context of single risk events, including the roles of interest groups, political cultures, mismanagement and blame (Kasperson et al., 1988, cited in Pidgeon et al., 2003; Löfstedt, 2010; Renn, 2010). Amplification in the communication context involves removing unnecessary 'noise' in the main communication channels, e.g. news media so that 'authoritative information' is delivered unblemished (Murdock et al., 2003 in Pidgeon et al., 2003). Figure 11 illustrates this concept by adding a feedback loop to the basic Shannon-Weaver linear communication model in which information is generated by a source and then amplified by a transmitter before reaching the receiver. A SARF approach appears to support the risk-reduction function and is primarily focused on the audiences requiring food safety knowledge. It includes limited substantive engagement in the form of responses by the receiver act as feedback, potentially further amplifying risk perceptions and triggering additional communication.



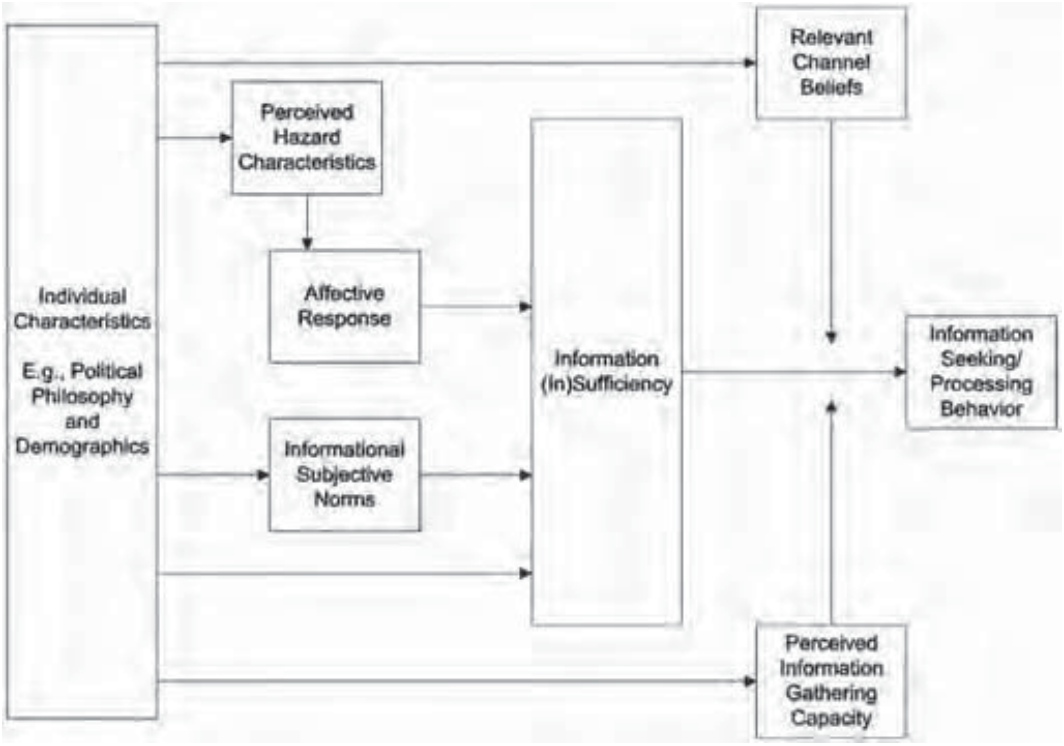
Source: Adapted from Renn (1991).

Figure 11: 'Shannon-Weaver' communication model within a social amplification of risk framework

Risk messaging models (RMMs). RMMs are based on the notion of a 'free market' for risk messages that the intended audience will consume if they are well coded and delivered transparently. Any interruption of the delivery or noise that obscures the encoding may lead to a communication failure. Wardman classifies both MMARC and SARF partially as RMMs. Communication is a top-down push process from sender to receiver. The latter may respond or reply with feedback but does not participate in the development of risk messages (Wardman, 2008).

Overall, risk messaging models include affirmative characteristics such as: tools to understand the psychological and social determinants of risk perceptions to craft impactful messages; the endorsement of transparency as a prerequisite for providing public information; and reducing the information deficit, therefore, addressing normative expectations for individuals and groups in society to understand the specificities of hazards and act according to their interests. More critically, RMMs can result in information overload, which puts at risk the reduction of the information deficit, or worse may exacerbate it. Also, a one-way sender/receiver framework is reliant on (the receiver's) trust in the source (the sender) yet this trust is easily eroded if the receiver fails to correctly de-codify the message or considers the message to be managed or compromised. Crucially, these approaches do not include mechanisms to sufficiently take into account competing sources of risk messages. These include societal 'noise' such as hearsay or stigma (Löfstedt, 2010), that can greatly influence the creation of meaning beyond risk messages, e.g. people are unconvinced by risk comparisons (Renn, 2009a) although they can be effective if used cautiously (Wardman and Lofstedt, 2009).

Risk information seeking and processing model (RISP). The RISP attempts to provide a framework to draw upon subconscious motivations in devising risk communication strategies and content that meet people's information preferences and expectations (Griffin et al., 1999, cited in Otto et al., 2018). The shortfall between people's knowledge and what they perceive they need to know – their information sufficiency (see Figure 12) – influences their information processing (i.e. heuristic or systematic – see Section 3.2.1 Factors influencing risk perceptions) and their information seeking behaviours (i.e. avoidance, routine) (McComas, 2006). Therefore, communication needs to transmit the 'availability' of actions to prevent or avoid risks and should appear 'personalised' to affected populations. This model addresses both normative and instrumental imperatives for risk communication, while also providing the means to target audiences segmented according to their food safety knowledge. Information format is important, e.g. risk comparisons (notwithstanding doubts about their effectiveness) and visualisation can contribute to greater understanding among the public, e.g. weather forecasts and impacts are commonly communicated visually. The RISP model is versatile in being applicable to different contexts and evolving behaviours (Balog-Way et al., 2020), however, it may also be more likely to work with respect to 'familiar risks' (Otto et al., 2018), implying that for new and emerging risks supplementary strategies may be needed.



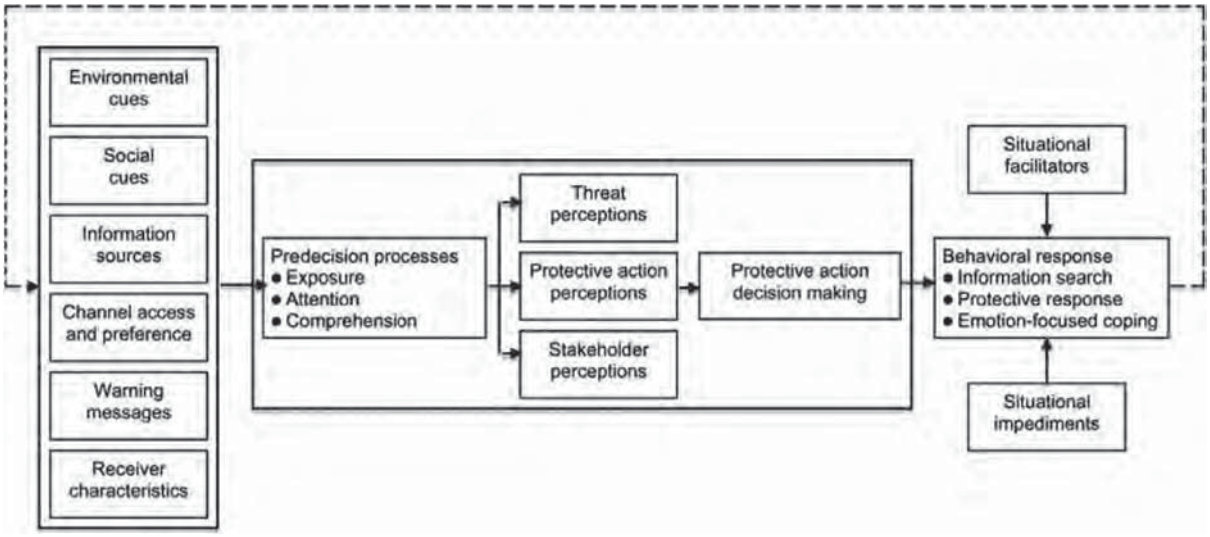
Source: Griffin et al. (1999); adapted from Kahlor (2007).

Figure 12: The risk information seeking and processing model

Risk government model (RGM). This philosophical approach attempts to explain how risk-reduction communication aims to 'responsibilise citizens' to risks and impose a social construct of risk. Risk communication is a political instrument used by public authorities to define the 'truth' about risks and consequently submit audiences to the control of 'governmental technologies', i.e. bureaucracies. Communication is instrumental as it individualises the risk among the population and facilitates freedom of choice for citizens to enhance their economic, social and physical well-being, but there is limited or no substantive engagement. Communicating uncertainty may increase public trust in authorities and help individuals make informed choices, although there is no consensus in the literature on this (Löfstedt, 2010). Criticisms of this model focus on the 'privileging of risk knowledge and expertise' whereby technical knowledge and skills about risks are seen to somehow delegitimise lay opinions and characterise them as irrational or subjective perspectives. More extremely, risk communication is seen as a form 'behavioural determinism' used to manage and govern society at

large and individual citizens (Wardman, 2008). (N.B. No visual illustration of the RGM was available in the selected literature.)

Protective action decision model (PADM). The PADM is a framework for 'managing societal response' to natural disasters, environmental hazards and more recently infectious diseases, that targets audience's willingness to take protective action and seek risk information by integrating processing of information from social and environmental indicators with messages communicated by other 'social sources' (Lindell and Perry, 2011; Balog-Way et al., 2020). It specifies 'pre-decision processes' of reception, attention, and comprehension of risk messages, as triggers of individual processing of risk information, as shown in Figure 13. The individual's decisions about actions to remedy risks are then shaped by three core perceptions: threat perceptions, protective action perceptions and stakeholder perceptions. Taken together with contextual factors which can amplify or dampen perceptions these profiles help to elicit confirmation of likely behavioural responses in sequential steps (Otto et al., 2018). The timing of communication may reduce the number of steps needed, but equivocal information prolongs information processing.



Source: Lindell and Perry (2011).

Figure 13: Information flow in the Protective Action Model (PADM)

In facilitating a mechanism to take account of a variety of individual and contextual inputs and also elicit insights on behavioural responses, the PADM appears to take a step beyond the RISP, with risk communication assisting in delivering cooperative decision-making about the content of risk messaging. However, there are indications that persuasion may work at convincing people about the consequences of their behaviour, e.g. smoking, when the impact of risks is high and personal, but less so for 'environmental and technological issues' which are more likely to impact society as a whole (Renn, 2010).

Risk field model (RFM). The RFM pitches risk communication within an interactive 'field of activity' that takes account of actors' opportunities to 'influence risk outcomes' if they wield sufficient social influence, expressed as capital such as knowledge, wealth, networks and standing. The field of activity is a constantly evolving 'complex interacting systems of beliefs' as the actors interact and reconfigure their relative power relationships. Risk communication's value is rhetorical, its expression moral, ideological or rational. Therefore, it is dependent on the audience's sense of legitimacy and trust in the source. (N.B. No visual illustration of a risk field model was available in the selected literature.)

The drivers for risk communication in the RFM are both normative and substantive engagement, while the function of communication is confidence among audiences segmented by their trust in information and its sources. Criticism of the risk field model focuses on how stakeholders do not construct objective conceptions of risks and their consequences because of the over-riding goals of their own interests. Consequently, official risk communication by public bodies must legitimise

institutional arrangements and procedures for dealing with potential adverse outcomes associated with the risks (Wardman, 2008).

Risk dialogue model (RDM). Risk communication in the RDM is a 'historically situated discursive engagement' between equal partners involved in risk issues where all perspectives and interests are considered in advance (Wardman, 2008). Risk communication is collaborative and two-way with mutual recognition of the legitimacy of different views of risk, rather than expert to lay, thus moderating disagreements and helping to build consensus and contribute to the development of balanced and informed decisions (Renn, 2010). This kind of rational dialogue requires a transparent framework in which information is 'intelligible, truthful, trustworthy and legitimate' (Wardman, 2008). Disagreements are resolved through dialogue where issues can be 'weighed and compared' in a clear framework. Risk dialogue is essential on issues that are socially divisive, the science is highly uncertain and/or have major economic or political consequences. (N.B. No visual illustration of a risk dialogue model was available in the selected literature.)

Both the instrumental imperative and substantive engagement drive the cooperative communication function of the RDM. Wardman argues however that risk dialogue approaches 'failed to live up to expectations' due to the cost and over-complicated procedures for participants and lack of representativeness allowing some stakeholders 'undue influence of over proceedings and substantive outcomes' (Wardman, 2008). Yet, practical European and national examples in the food safety and public health areas indicate that such lessons have been learnt and risk dialogue mechanisms improved as a result (Smith et al., 2019). More recently, the risk dialogue model evolved into a model of co-design or co-production which developed to address problems 'where consensus is low, uncertainty high and collaboration, co-decision and joint action is needed' (Scolobig and Gallagher, 2021). This is an emerging area of theory, which considers how to use risk communication strategies to develop risk management solutions, i.e. in addition to gathering scientific contributions to risk assessment. We explore elements of the approaches involved in co-production frameworks above, i.e. knowledge co-production (Section 3.1.1), co-design of solutions and stakeholder engagement (Section 3.2.5), public participation (Sections 3.2.4, 3.4.2 and 3.4.3), and citizen science (Sections 3.1.1 and 3.2.4). These improved structures will, however, always face greater challenges during 'risk controversies' when positions are too intractable regardless of the procedures in place. Also, they may be too inwardly institutional and limited to take into account the real-life 'processes of democratic social change [. . .] and the instrumental dynamics that shape them' (Wardman, 2008) once social amplification of risks reaches beyond the narrower stakeholder framework.

Overall, we agree that 'no one model is more helpful than the other in the quest to effectively convey risk, as they all consider different aspects of people's underlying attitudes and responses to warning messages' (e.g. Otto et al., 2018), and their judicious application depends on context and the data used from the dynamics of real-life situations. There is a consensus in the literature that 'risk communication surpassed limits of public relations advice to extend to 'the flow of information between subsystems of society" (Renn, 2010). Therefore, although the top-down (expert to lay public) approach is still prevalent in practice, 'constructive dialogue between all those involved' in a risk debate (Löfstedt, 2010) is desirable, however challenging this may be even within narrower audience segments, e.g. 'stakeholder' categories. Critically, most of the models do not account for the impact of social media on dissemination (e.g. the digital divide), audience targeting and heuristic processing by individuals (Rasmussen and Ihlen, 2017), which could impel the research community to update them or develop alternative models in the near future.

Conclusions

- Risk messaging and information transmission models including the mental models and social amplification of risk approaches provide useful tools for generating the necessary inputs (understanding psychological and social/cultural factors influencing risk perceptions) to build risk communication narratives that address personal risk perceptions.
- However, there are limitations in ensuring these narratives are decodified effectively in relation to other sources of information or 'noise'.
- Also, there are inherent contradictions in any sender-to-receiver relationship – need for trust vs. loss of trust – which expose the models' limitations as frameworks for the downstream information delivery phase of risk communication.
- Solutions to these problems include increased consideration of noise and the 'social process of meaning creation and interpretation' and developing content that includes 'steps individuals can take during risk events' to cope with potential adversity.

- A risk information-seeking and processing approach helps to develop and deliver impactful messages about 'familiar risks' and behaviours in a variety of contexts to audiences segmented by their food safety knowledge needs. Increased attention is needed on the choice of formats and channels which need to be accessible to the broader public and/or specific target groups.
- Such approaches must transmit the 'availability' of actions to prevent or avoid risks and appear 'personalised' to affected populations, i.e. it should address their 'information sufficiency', the gap between people's knowledge and what they perceive they need to know to influence their information processing and information seeking.
- A protective action decision making approach may help deliver cooperative decision-making about the content of risk messaging with risks that are personal and high impact, but is limited for broader societal risks or those considered to be 'low risk'.
- The risk government model and risk field models are tools for understanding risk communication as an instrument of power in modern societies.
- The risk dialogue model captures the key elements of many current engagement approaches, highlighting both the advantages and challenges of implementing effective dialogue mechanisms with representatives of competing interests in risk issues.
- Risk dialogue is essential on issues that are socially divisive, where the outcome of the scientific risk assessment is highly uncertain or have major economic or political consequences. Further, it becomes particularly challenging during 'risk controversies' when interested parties have opposing intractable positions. Approaches oriented to co-design or co-production can help to address these problems, particularly in how to use risk communication strategies to develop risk management solutions.
- Most existing risk communication models do not account for the impact of social media on dissemination, audience targeting and heuristic processing by individuals.

3.3.3. Mechanisms for coordinated communication

Few sources in the scientific literature identify 'existing models for coordinated risk communication' involving supranational, European and national risk communication bodies, to evaluate. While many studies recognise the separate risk communication tasks of risk assessors and risk managers, respectively, there are few organisational design models for such arrangements. Hence, there are no comprehensive evaluations of existing structures and procedures to explain how to coordinate these overlapping roles and tasks. However, some sources partially cover some aspects, which could potentially help to shape a future model for coordinated communication. Critically, the literature tends to amalgamate 'pure communication,' e.g. message development and content dissemination with engagement/ participation activities such as dialogue or consultations, whereas we concentrate here solely on the former (see Section 3.1.1 on intersection of communication and engagement, and Section 3.2.4 Appropriate information in risk communication).

We gathered additional insights from structures used in other organisations and summarised existing structures at EFSA used for limited risk communication coordination with the European Commission and EU Member States. Finally, we summarised the main conclusions and recommendations of the report on 'Mapping the Coordination and Cooperation Mechanisms of Risk Communication in the EU' (FCEC, 2021) commissioned by EFSA in response to question 6a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, point 2.iii)).

General Framework. The book 'Food Safety Governance: Integrating Science, Precaution and Public Involvement' (Eds. Dreyer and Renn, 2009) proposes a pan-European 'General Framework' for risk analysis of EU food safety emphasising both greater transparency on and stakeholder participation in the framing of risk questions, the assessment and evaluation stages and implementation of risk management actions. Chapters on 'Legal and Institutional Aspects of the General Framework' (Vos and Wendler, 2009) and 'Communication about Food Safety' (Renn, 2009a) taken together present elements aimed at increased engagement (more frequently referred to as 'participation' in the book) and dialogue, which could feasibly be adapted to core communication tasks, e.g. strategy, message and content development, dissemination and evaluation. The General Framework concepts and structures follow closely the International Risk Governance Council's 'IRGC risk governance framework', a comprehensive yet flexible blueprint for risk governance tailorable to different risk contexts and organisational settings (IRGC, 2017).

The 'General Framework' advocates establishment of 'food safety interface institutions' to facilitate and increase transparency of the interaction between risk assessors and risk managers, while also enabling stakeholder involvement at various stages. The authors describe two main institutional mechanisms: a web-based 'Internet Forum' to facilitate involvement and debate, and an 'Interface Committee' for more structured 'direct, face-to-face discussion between assessors, managers and stakeholders' (Vos and Wendler, 2009).

Internet Forum. An online environment in which the various contributors to risk analysis can, according to their respective roles, publish, comment and collect inputs at the various stages of risk analysis. Involvement is both 'top-down' whereby assessors and/or managers seek stakeholder views or inputs on specific questions, but also 'bottom-up' allowing stakeholders to shape agendas for prioritising threats (i.e. those risks to assess/manage), the choice of risk management measures and monitoring of results. The Internet Forum would be a completely transparent and open environment with minimal mediation but specific rules of participation. Table 10 summarises its functions within three scenarios involving more or less oversight and control by the second body, the Interface Committee (with lesser or greater stakeholder involvement in either 'Advisory' or 'Steering' configurations).

Table 10: Three options for the institutional design of the food safety interface (Vos and Wendler, 2009)

Internet Forum only 'Minimum option'	**Internet Forum and Interface Advisory Committee (IAC) 'Intermediate option'**	**Internet Forum and Interface Steering Committee (ISC) 'Maximum option'**
Tasks:		
	– Gives advice on the terms of reference and evaluation to the Commission	– Adopts terms of reference – Gives advice on evaluation to the Commission
Working procedures		
	– Deals with a selection of cases – IAC is convened by the Commission for particular cases, especially when screening has found uncertainty and/or ambiguity	– Deals with all cases of food safety governance
Internet Forum:		
Framing: – Publication of terms of reference – Exchange of views about referral and review **Assessment:** – Exchange of views on application of terms of reference in assessment procedures **Evaluation:** – Exchange of views on evaluation of food safety threats **Management:** – Exchange of views on management options	(in addition to the tasks of the Internet Forum listed for the 'minimum option'): – Discusses proposals for the appointment of stakeholder representatives in the IAC/ISC – Makes suggestions for cases to be discussed by the IAC/ISC – Discusses evaluation results and the advice on terms of reference by the IAC/ISC	

Source: 'Legal and Institutional Aspects of the General Framework' (Vos and Wendler, 2009) in 'Food Safety Governance: Integrating Science, Precaution and Public Involvement' (Eds. Dreyer and Renn, 2009), p. 91–92.

Interface Committee. This institution is responsible for governance and decision-making within the General Framework. Core membership comprises permanent representatives (6–12 in total) of EU risk managers (European Commission), risk assessors (EFSA) and stakeholders representing 'general interests of consumers, industry, farmers or other interests of the food chain'. The core is complemented with a flexible membership of 'case-specific committee members' (6–12 in total) who would provide expertise in different scientific areas. To cover sufficiently the broad spectrum of issues in EU food safety (e.g. pesticides, GMOs, animal health) the authors propose the need for six to nine

groups of these 'experts'. As mentioned above, the authors describe two variants of the Interface Committee: an 'Interface Advisory Committee,' which would be a forum for discussion on sensitive topics only, e.g. when there is a societal concern or the screening of mandates reveals important 'sources of uncertainty or ambiguity'. The second more encompassing option would be the 'Interface Steering Committee' which would review all food safety issues and adopt the terms of reference of mandates. Table 11 summarises the size and composition of the Committee and indicates appointing rules for the 'case-specific' members.

Table 11: Size and composition of the Interface Advisory/Steering Committee

	Managers	**Assessors**	**Stakeholder representatives**
Core committee members	2–4 persons representing 'horizontal' units of DG SANCO (e.g. on science and stakeholder relations, food law, food chain and labelling)	2–4 persons representing 'horizontal' EFSA bodies (e.g. Scientific Committee, units on science and risk/concern assessment)	2–4 persons having their background in the representation of general interests of consumers, industry, farmers or other interests of the food chain
Case-specific committee members	2–4 persons representing case-specific units of DG SANCO (e.g. on pesticides, GMOs or animal health)	2–4 persons representing case-specific bodies of EFSA (e.g. members of the scientific panels or of the scientific services)	2–4 persons with a background in the representation of case-specific stakeholder interests
	Case-specific members to be appointed by the core committee members for all major fields of food safety governance (i.e. 6–9 different constellations of case-specific committee members)		
	Plus: may invite ad hoc members for particular cases when considered necessary		

Source: 'Legal and Institutional Aspects of the General Framework' (Vos and Wendler, 2009) in 'Food Safety Governance: Integrating Science, Precaution and Public Involvement' (Eds. Dreyer and Renn, 2009), p. 97.

The General Framework institutions and the examples described above make clear the main direction of this organisational structure: stakeholder participation in risk assessment and risk management. Looking at core communications functions, the Internet Forum would serve as a two-way participatory communications platform, both increasing the transparency and accessibility of information and acting as an enabler for stakeholder involvement. This communications function of the Internet Platform is described in Table 9 above. In this system, Renn assigns the role of communicator to 'the food safety agency or the Interface Committee,' implying that the latter could fulfil at least some operational communications functions (e.g. communications strategy, content development and dissemination) without describing the required structures and processes. Instead, the author stresses what decisions need to be explained in public information, i.e. judgements about the tolerability/acceptability of risks, justification of trade-offs made during this process. Communication should take into account the socio-political context and the risk perceptions and information needs of affected populations while the Internet Forum can ensure stakeholders and the public are able to challenge the outcomes openly and transparently if they wish. Greater detail on the communications required at each step of risk analysis is reproduced in Table 6 in Section 3.2.4 above.

Bearing in mind that the General Framework was designed to meet broader organisational objectives, the mechanisms of coordination it describes are nonetheless worthy of consideration given the concepts were purposefully designed for the EU food safety system, albeit over a decade ago. It is the sole model in the selected literature that provides an example of 'appropriate mechanisms of coordination and cooperation' between managers and assessors, as well as with stakeholders. The Interface Committee could possibly be adapted to coordinated communications planning and execution as envisaged under the Transparency Regulation. The existing model's composition and decision-making processes and functions are limited to the EU level with national input from managers, assessors and stakeholders to be channelled through the respective EU-level body, therefore, the basic structure needs to be re-shaped to include direct representation of national public bodies and to consider an appropriate form of stakeholder involvement, if any, in risk communication planning and decision-making given the applicability of this report (see Section 1.3 Interpretation of the Terms of Reference). The Interface Committee's described operational tasks focus heavily on key steps in the overall risk analysis process such as the framing of risk questions, while contiguous to risk

communication this does not offer solutions on the questions of 'the type and level of communications activities and the appropriate tools and channels to be used'. Therefore, as well as the composition, the purpose and mandate of the Interface Committee would also require redesigning with a focus on core communications functions. Finally, given the current plethora of public information sources on food safety, a single coordinated platform involving the participation of EU and national risk managers, risk assessors and stakeholders along the lines of the proposed Internet Forum is an idea worthy of further exploration. Table 12 provides an example of these possible adaptations of the General Framework institutions to consider in support of GPRC implementation.

Table 12: Example of possible adaptations of the General Framework institutions needed to support GPRC implementation

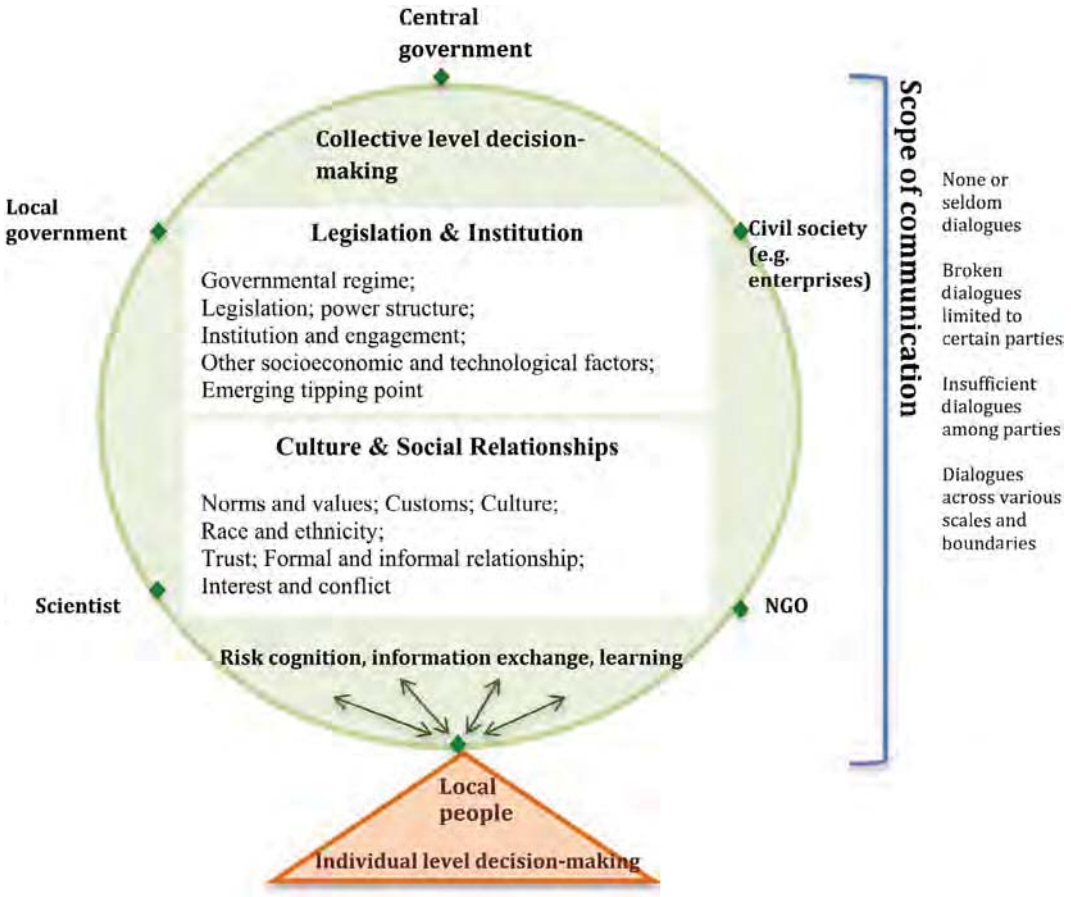
	'Internet Forum'	**'Interface Committee'**
Composition	Rotating Co-chair Communications officers of: • Risk managers – DG SANTE and national managers • Risk assessors – EFSA and national assessors	Rotating Co-chair Communications managers of: • Risk managers – DG SANTE and national managers • Risk assessors – EFSA and national assessors
Stakeholders	Users	Sounding board
Decision-making	Workflows – content production and dissemination	Communication strategy Long-term planning
Operational tasks	Short-term planning Content co-creation Dissemination	Oversight of sensitive outputs, e.g. risk controversies
Frequency	Regular interaction, e.g. weekly/fortnightly	Periodic contact, e.g. quarterly/twice-yearly

Other sources. Several organisation studies theories exist for understanding complex systems such as networks of organisations. These can help to provide a framework both to analyse existing institutional structures and mechanisms and propose new configurations based on revised or refined objectives and guiding principles. Complex Adaptive Systems (CAS) theory focuses on 'complexity, patterns and interrelationships' rather than on cause and effect, which allows a better understanding of underlying causes and interactions within systems (Sapir, 2019). It allows the search for commonalities in complex phenomena including 'superorganisms' such as the collaborative regulatory partnerships between and among European and national partners. For a superorganism, the relationships between the 'collective' and its constituent parts need defining, in particular to ensure a common understanding of rights and responsibilities. The shift from a hierarchical to a network structure becomes evident when the behaviour of the parts in the system becomes interdependent and the system's behaviour overall is 'dependent on its parts' (Bar-Yam, 1997). 'Sensemaking' approaches provide insights 'for shaping and building systemic resilience' through the analysis of how individuals, leaders, institutions and society understand and respond to unpredictable situations. Weick defined seven properties of sensemaking: *identity* shapes how people act and interpret events; *retrospection* affects how people make sense of past experiences; *enacting* evolves during dialogues and narratives; *social* interaction and discourse as lens through which people experience reality; the *ongoing* nature of reality as a continuous form of feedback; *extraction of cues* from context influences the relevance of information and explanations; and people's inclination towards *plausibility over accuracy* (Weick, 1995; in Cuevas Shaw, 2021).

More specifically, Lin et al. (2020) developed a 'conceptual framework for risk communication' that attempts to integrate and take into account research, communication decision-making and community dialogue. While the study is based on case studies of post-disaster communication in five Asian countries, it includes potentially useful concepts to consider in developing mechanisms for coordinated communication.

The framework includes two distinct but interconnected research fields: a broader macro-area focused on political structures, institutional design, law and power relations, and a second area focused on 'intangible and micro-level [...] social, cultural and personal factors that underpin the trajectory of risk perception and interpretation at individual level.' More pertinently, the paper describes a 'multi-level interaction' system (see Figure 14). This characterises how official engagement and

communication mechanisms are influenced by the different legislative and institutional contexts, and particularly by the prevailing political ideology of governments, together with social and cultural mechanisms that influence 'framing of the individual cognition and behaviour in the face of the risk'.



Source: Lin et al. (2020).

Figure 14: Integrated framework of risk communication

Particularly, a 'cross country synthesis of the legislative and institutional mechanisms to influence the scope of communication' describes in a schematic form how successive levels – national, regional, NGO (i.e. international), local community and individual – interface and how the distinctive characteristics of the macro/micro mechanisms in each country influence and shape the form of communication on post-disaster situations.

Two EFSA-funded projects looked at different organisational aspects of EU food safety, focusing, respectively, on the risk manager–risk assessor dialogue, and best practices in risk communication including the role of NGOs. The first 'Communication inside Risk Assessment and Risk Management' (COMRISK) used qualitative results to characterise the risk manager–risk assessor dialogue, with a focus on improving efficacy through enhanced communication between the two parties. The final report (Andersson et al., 2020) contains some suggestions and tips in line with the literature quoted above in Sections 3.1 and 3.2, including an open and transparent 'two-way dialogue', building and maintaining trust, closer cooperation on framing of risk questions, explaining the impact of uncertainties and regular feedback. However, it does not propose specific structures or mechanisms for these activities. SafeConsume[15] is an ongoing project that conducted two extensive surveys: one on the functions, responsibilities, resources, cooperation networks and communication practices of EU food safety authorities; and a second on stakeholders, in particular cooperation between NGOs and official bodies. The results were not publicly available during preparation of this report, however, preliminary findings shared with EFSA indicate that it will help to map the types of approaches and

[15] For more details see https://safeconsume.eu.

tools/channels used by different EU, national and regional authorities and also describe the types of existing relationships and connections between EU and national bodies, including cooperation between the national authorities of different countries.

Existing structures. The mechanisms coordinated by EFSA for joint risk communication activities provide a foundation on which to base a future framework. Wardman and Lofstedt (2009) described the basic elements comprising EFSA and its national partners a decade ago. These were expanded upon and upgraded in the years following that review, therefore, the following overview also includes contemporary information from EFSA's website, interviews with EFSA staff and the report on 'Mapping the Coordination and Cooperation Mechanisms of Risk Communication in the EU' (FCEC, 2021), which was developed in response to question 6a of the TR (see Section 1.2 Terms of reference and Section 1.3 Interpretation of the Terms of reference, point 2.iii)).

EFSA and the national competent authorities (NCA) operate a network of communications specialists and focal points under the umbrella of the EFSA Advisory Forum (AF). The AF comprises representatives of the NCAs of the 27 EU Member States, Iceland and Norway with observer status for the European Commission and seven candidate countries and Kosovo under the EU's Instrument for Pre-Accession Assistance (IPA). Some of the NCAs are risk assessment bodies, others are in risk management and some exercise both assessment and management tasks. The AF provides oversight and cooperates with EFSA on scientific strategy (e.g. prioritisation of risk assessments), data gathering and standardisation and the provision of experts. The EFSA Communications Expert Network (CEN), formerly an AF working group, boasts a membership of national communications specialists who exchange best practices, coordinate some communications activities, e.g. on sensitive topics in particular countries, and play a key crisis communications role during multi-country outbreaks or emergencies. The EFSA Focal Points provide operational support to EFSA and the AF in implementing an array of scientific cooperation and also communications activities, e.g. dissemination of EFSA materials, their translation into local languages. Further, the communications services of EFSA and the European Commission's Directorate-General for Health and Food Safety (SANTE) hold regular encounters to inform and if necessary, coordinate their respective communications. The two bodies exchange forward planners and discuss strategy at twice-yearly horizon scanning meetings and share key messages, audience insights and communications outputs during weekly operational updates. Last but not least, EFSA created together with international (FAO, IARC, OIE, WHO), EU Member States (Croatia, France, Germany, Portugal) and partners in third non-EU partner countries (Australia, Canada, Chile, China, Japan, New Zealand, UK, USA) an International Risk Communication Liaison Group (IRCLG). The IRCLG has fewer formal mechanisms of cooperation, yet still meets twice yearly to share best practices and coordinate regional or global activities, e.g. in support of World Food Safety Day which takes place every 7 June.

These organisational structures and mechanisms of cooperation are detailed in the report on 'Mapping the Coordination and Cooperation Mechanisms of Risk Communication in the EU' (FCEC, 2021). The project had three tasks to detail food and feed safety risk communication bodies, both risk assessment and risk management, specifically: list national and regional bodies; map domestic mechanisms in the Member States; map mechanisms at EU level (EFSA, European Commission, other relevant EU Agencies) and with relevant international bodies (FAO, WHO). The report is a comprehensive overview of organisations and their interrelationships at different levels (regional/state, national, European). It also provides conclusions and recommendations to add to the evidence base, as follows:

- For those interviewed, the lines between communication in general and non-crisis risk communication are blurred.
- The structure across the EU27/EEA region includes considerable diversity and complexity of administrative structures at national level and a multitude of competent authorities.
- The most widely used source of risk communication material on feed and food safety by national organisations is EFSA, followed by WHO, FAO and ECDC, and where relevant JRC, ECHA and EMA, plus OIE (for animal health) and EPPO and IPPC (for plant health).
- Existing networks, foremost of which those managed by EFSA (FP network, CEN and AF) and primarily comprising risk assessment bodies, ensure the sharing of communications, but other EU and international networks are also relevant.
- There are no parallel risk management networks at EU level liaising with national authorities on food and feed safety risk communication, however, coordination at EU level results in strong coherence among Member States in international meetings.

The authors also identify a series of problems and challenges to the coordination of risk communication, currently and in the future, at the EU level:

- The complexity of scientific assessments vs. the need to communicate with clarity, especially to non-expert audiences.
- The need to address issues of public perception, including how different organisations are involved in risk assessment and risk management, the understanding of risk vs. hazard and wide differences among individual citizens in perception and trust to the information provided by the various institutions involved.
- An inherent challenge for each authority is communicating risks within a specific mandate (as defined by government and/or legislation) while current coordination among organisations at national level is generally considered insufficient. This can result in issues of timing and differing (albeit justifiable) viewpoints, which confuse the message, particularly for non-expert audiences.
- Lack of public interest in positive messages (i.e. negativity bias, see Section 3.1.4 Public awareness and understanding) may hinder communications aimed at reinforcing public trust in authorities and the EU risk analysis process.
- The growing impact of NGOs on communication to the broader public, and of social media in delivering messages to non-expert audiences.
- Challenges in tracking the uptake of messages by target audiences and their impact, e.g. in improving awareness/understanding of risks, improving confidence in the food safety system.

Since the main gaps and bottlenecks in risk communication were identified at national level, the authors propose several recommendations to help meet these challenges:

- Increased national budgets for communication, to improve the capacity of resources to undertake this task, in particular to increase human resources; set up dedicated communication departments; provide training on risk communication skills including specialisation in science communication; and investment in additional tools and channels for communication and engagement.
- To improve cooperation and coordination between authorities clearly define the remit, mandate and tasks of all national, regional and local organisations involved (building on the mapping in the report), develop a protocol specifying roles of organisations, the 'chain of command' and sharing of responsibilities, e.g. target audience definition, content development; establish regular meetings and contact among these organisations and systematic content dissemination; concentrate on enhancing existing networks (already in place, avoid increased confusion).

The authors concluded also that coordination of risk communication at EU level needs to follow a partnership approach that can facilitate the improvements at national level, as follows:

- Each Member State should develop a comprehensive national risk communication strategy on feed/food safety to serve as a blueprint for implementing risk communication at national level; to ensure coordination, each Member State could appoint a communication coordinator to work with EFSA towards the development of the national strategy.
- EFSA's support consists of use of existing networks for coordination and development of materials on risk communication capacity building.
- Developing clusters of common communication activities amongst Member States at regional level on themes of common interest, e.g. Belgium, France, Germany, Luxembourg and Netherlands communication on animal health issues affecting livestock sectors.
- Further collaboration between EFSA and other EU Agencies on feed/food safety topics of joint interest have the potential to create synergies, by allowing collective communication while maximising outreach, i.e. communicating towards broader audiences.

Conclusions

- Complex Adaptive Systems theory allows a better understanding of underlying causes and interactions within systems, facilitating the search for commonalities in complex phenomena such as 'superorganisms' like the EU food safety system, and require clear definition of the relationships between the 'collective' and its constituent parts to ensure a common understanding of rights and responsibilities.

- Multi-level interaction for engagement and communication is shaped both by different legislative and institutional contexts, and social and cultural mechanisms that influence individual cognition and behaviour with regard to risks.
- Existing networks managed by EFSA and primarily comprising risk assessment bodies aid communication, with other EU and international networks also relevant. There are no parallel risk management networks at EU level liaising with national authorities on risk communication, however, there is strong coherence among Member States in international fora.
- A protocol specifying roles of organisations, the 'chain of command' and sharing of responsibilities would improve cooperation and coordination between authorities with clearly defined remits, mandates and tasks of all national, regional and local organisations involved. Any such mechanism must follow a partnership approach and take account of the considerable diversity and complexity of administrative structures, responsibilities and resources at national level and a multitude of competent authorities.
- The mechanisms of coordination described in the General Framework (Eds. Dreyer and Renn, 2009) are worthy of consideration since they were designed specifically for the EU food safety system.
- The Interface Committee model could suit EU-wide coordinated communications planning and execution if the basic structure is re-shaped to include representation of national risk assessors and managers.
- The purpose and mandate of such a committee would also require redesigning beyond the 'participatory-oriented' model proposed to capture additional core components of public information functions, e.g. communication strategy, audience segmentation, message and content development, dissemination and evaluation.

3.4. Contributions to communication strategies

Below we provide information for use in developing communication strategies on key issues highlighted in the terms of reference: 'foster public understanding of the risk analysis, including of the respective tasks and responsibilities of risk assessors and risk managers to enhance confidence in its outcome,' 'take into account risk perceptions of all interested parties,' 'the ambiguity in the public perception of the difference between hazard and risk' and 'contribute to the fight against the dissemination of false information and the sources thereof'.

3.4.1. Foster public understanding of risk analysis

The concept of understanding plays a role in fostering public[16] comprehension of the risk analysis process, particularly concerning the element of the mandate which focuses on public willingness to understand both the nature of science and the value of evidence-based regulatory science. The basic concept underlying understanding is described in Section 3.1.4, and it categorises understanding in two ways: subjective or objective.

An issue that hinders public understanding of the risk analysis process is lay knowledge and understanding of the roles and remits of risk assessors and risk managers. While some articles within the literature review discuss how the practices of the assessors and managers could be improved, there is overall little evidence to support the thesis that there is a high degree of public knowledge and understanding regarding the roles and remits of either risk body.

According to the Special Eurobarometer on Food safety in the EU (2019), citizens have limited awareness of how the EU food safety system works. Just 43% say that 'there are regulations in place to make sure that the food you eat is safe'. And less than one in five (19%) know that 'the EU has a separate institution that provides scientific advice on the safety of food'. Additionally, less than three in ten (28%) EU citizens know that 'to decide how risky something could be for you to eat, the EU relies on scientists to give expert advice'. This data indicates that on a citizen level, there is limited knowledge of the existence of the food safety system, and the role assessors and managers play in it.

Roles and Remits. With limited knowledge of the roles of the assessors and managers, it stands to reason that there is limited knowledge and understanding of the risk analysis process as a whole. This likely acts as a hindrance to enhancing confidence in risk analysis outcomes, and so could be rectified through strategies such as providing education about and improving transparency in the risk

[16] In the context of this report, we interpreted 'public' to mean "those most affected by a particular risk, or most interested/ concerned about food safety issues'.

analysis process, whilst recognising that this approach would only reach those sufficiently engaged to invest time in such education. Another possible strategy to overcome this lack of knowledge is to expand on the terminology used when discussing the roles and remits of these risk bodies. Using terms based on non-technical language (e.g. 'scientific advisers' instead of risk assessor, 'decision-makers' or 'public administrators' as an alternative for risk manager), citizens may better infer from context the role of these actors.

In the European Union, the roles laid out for performing risk analysis are clearly assigned to specific bodies, so at least superficially it is simple to describe. The risk assessor is EFSA, the risk manager is the European Commission and both institutes have responsibility for risk communication. Additionally, national authorities within member states play a role in risk assessment and risk management at national level. The level of assessment and management responsibilities undertaken at national level varies between states.

Regarding the role and remits of the risk bodies, Visschers and Siegrist (2008) assert that 'risk managers should investigate people's instantaneous reaction to a risk, e.g. by means of an indirect test, in addition to people's deliberate response'. This will provide insights into the public's perception of risk, but in itself also highlights an issue that is found among the risk bodies: at times there is public confusion or misunderstanding around how the risk analysis process is organised, and what bodies are concerned with which tasks. This recommendation borders closely on 'assessment', with the suggestion that managers 'investigate' the public's reaction to risk, supporting the recommendation that by broadening risk assessments beyond scientific assessments for human and animal health to include other areas, such as social, environmental and economic impacts, public confidence in the risk analysis process would be enhanced. This recommendation is explored more robustly in the strategies to enhance confidence section below.

This recommendation highlights the perceived overlap between the three strands of risk analysis; risk managers investigating the human response to risks is likely something that should be done in the assessment process.

As indicated in the Eurobarometer (2019) above, there is some evidence that public knowledge of the risk analysis process – specifically the remits of particular risk bodies – is not as high as it could be; this is supported by the varied recommendations of improvements that should be applied to the assessment, management and communication functions. For example, Papadopoulos et al. (2012) asserts that 'the public is not comfortable leaving the safety of their food supply wholly in the hands of the food producers and would like a strong government presence, although they acknowledge that producers do play a significant role in food safety'. This indicates a lack of knowledge about the analysis process, and perhaps also a misunderstanding of the difference between food safety and food security.

Nature of Science. Fostering understanding in the risk analysis process can also be made difficult by the very nature of science. For lay people, scientific information can appear inconsistent, confusing or difficult to understand. This is generally caused by the changes of opinion that emerge when new information is brought to the attention of experts. Van Kleef et al. (2006) describes the impact of information overload on consumers, when they perceive inconsistency in science as a result of expert disagreements or changes in opinion. Conversely, there is also anecdotal evidence from EFSA which finds that the opposite can also be true; should scientists fail to adjust their opinions based on new evidence, there is a risk that the public may perceive the scientific opinion to be uninformed or out of date. Recency bias may play a role in how the lay public understand and value science. Additionally, a time lag may exist between new scientific evidence and its incorporation into relevant regulations, which again may inspire distrust among the public, with the time delay between new evidence and updated opinions or regulations appearing to the public as inconsistent.

Despite this, it is important to note that scientists are often regarded as a trustworthy source of information. According to the Special Eurobarometer on Food safety in the EU (2019), scientists are the most trusted sources of information on food risks, with 82% of respondents trusting scientists. This indicates that the value of evidence-based science is not overlooked by the public, but that the nature of science (e.g. the presence of uncertainty) can result in public confusion or discontent.

Verbeke et al. (2007) details a point of difficulty for the public in terms of understanding the complexities of the nature of science. The measurement of uncertainty contains terminology which may be misleading to lay people. There are aspects of the analytical measurement of uncertainty, such as the accuracy, trueness and precision of an analysis, that have different meaning in analytical (expert) terms vs. in lay language. For example, the measurement term 'precision' means the reproducibility of an analysis, while in conventional language 'precision' is synonymous with accuracy or correctness. Many citizens also have trouble with the term 'measurement uncertainty' because they

understand measurement to always be certain (Verbeke et al., 2007). These differences in terminology and understanding are a factor of the pubic-science relationship that should be addressed in strategies aimed at fostering knowledge as they inform the public's value in evidence-based science and their understanding of the nature of science. EFSA overcomes these issues by following such approaches through its guidance documents, which, among other recommendations, calls for quantifying uncertainty (EFSA Scientific Committee, 2018b) to reduce ambiguity and for communicating the uncertainty to explain the relative likelihood of the possible outcomes in assessment conclusions (EFSA, 2019b).

Engdahl and Lidskog (2014) provide further insights into the nature of the relationship between the public and science by acknowledging that there is a degree of public distrust in regulation related science. This distrust is thought to emerge for a variety of reasons: prior regulatory failures (Löfstedt, 2005; Power, 2007, cited in Engdahl and Lidskog, 2014, p. 703), the increased ability of members of the public to evaluate some scientific evidence independently (Nowotny et al., 2001, cited in Engdahl and Lidskog, 2014, p. 703), the perceived inability of science to solve real-life problems (Lidskog, 1996; De Marchi and Ravetz, 1999, cited in Engdahl and Lidskog, 2014, p. 703), science's exclusion of local knowledge and citizen competence (Irwin and Michael, 2003; Fischer, 2005, cited in Engdahl and Lidskog, 2014, p. 703), and the technical framing of public issues (Wynne, 2001; Jasanoff, 2003; Gustafsson and Lidskog, 2012, cited in Engdahl and Lidskog, 2014, p. 703).

Lay-expert gap. The disparity between lay and expert opinions about risks is attributed to the existence of a so-called perception filter causing bias between reality (scientific evidence) and consumer perception of this reality (Verbeke et al., 2007).

In examining distrust in science, Engdahl and Lidskog (2014) highlight the disparity between public and expert understanding, and the false narrative of ignorance that at times permeates the citizen-science relationship. Van Kleef et al. (2006) agree that there exists a gap between the public and the experts in regard to risk perception. Engdahl and Lidskog (2014), however, note that the style of interaction between scientists and the public lends itself to creating a false narrative in which the public are deemed to be ignorant or disinterested – 'experts often exert hegemonic control over the meaning of an issue, resulting in the experts' mistaken belief that the public's viewpoints are framed by ignorance'.

The power dynamic between scientists and citizens is indeed unequal. Risk issues are presented to the public as 'pre-defined packages', where terms and meanings are pre-set and presented to the public as fully formed concepts that are not open for debate. This limits the citizens' ability to actively engage with and discuss the meaning of the risks involved, and reduces their role to either accepting or rejecting the issues presented. The citizens' reaction to the limitations are at times misconstrued and scientists can construct a perception that the public is 'defensive, uninformed, risk averse and unreflexive' which can lead to conflicts arising between scientists and citizens (Engdahl and Lidskog, 2014). This is an important factor to consider when contemplating the public's willingness to understand the nature of science and value of evidence based regulatory science. This erroneous perception prevents the scientists from understanding the citizen's perspectives and a false narrative of ignorance or disinterest is created. In reality, the problem is not that the public misunderstands science, but rather that scientists incorrectly understand the public's views (Engdahl and Lidskog, 2014).

Expert contributions, usually expressed quantitatively, are not easily accepted as objective facts, rather, they are carefully scrutinised, starting from the criteria which were considered in the framing of the problem (health, economy, ecology, ethics, etc.) and the weights which were assigned to them (De Marchi, 2015). In other words, scientists aim to evaluate issues objectively while the public relate issues back to their social impact and the extent to which it threatens or supports their social identities. In clearer terms, scientists endeavour to evaluate risks objectively while the public often evaluate them subjectively (Verbeke et al., 2007). Lay persons weigh risks and benefits differently than experts, and so may have other implicit definitions of risks and thus arrive at conclusions through another mechanism of risk estimation as compared to experts (Verbeke et al., 2007). As Wynne (2008, cited in Engdahl and Lidskog, 2014) explains, the public are not responding to science as scientists understand it, but instead they are working with their own (collective) meanings.

As a result of the difference in evaluation and understanding, the public concerns that emerge are legitimate and should not be seen as being caused by a limited public understanding of an issue. Simply put, it is erroneous to claim that the public lacks the capacity, interest or inclination to understand the perspective provided by scientists and regulators. Instead, the problem is that scientists and regulators do not always leave space for other perspectives than their own. This results

in an institutional-scientific denial of the legitimacy of the public evaluation of an issue (Wynne, 1992; Wickson and Wynne, 2012, cited in Engdahl and Lidskog, 2014, p. 707).

Additionally, communication is also key to fostering understanding of risk analysis; as described extensively in Section 3.2, and concisely summarised in Section 3.4.2, appropriate communication is required for the successful transference of information and for the facilitation of understanding. It is therefore an important factor that should not be overlooked when planning strategies intended to promote understanding.

To foster understanding throughout the risk analysis process, and to foster a greater willingness to understand the nature of science and value of evidence based regulatory science, this gap between scientists and the public must be bridged. To close this lay-expert gap, early stakeholder engagement should be utilised. Demonstrating the inclusion of the public's concerns and their values from the beginning of the scientific process can establish a degree of goodwill which may extend to fostering understanding in the analysis process as well as fostering a greater willingness to comprehend the nature of science and the value of evidence based regulatory science.

Conclusions

- There is limited knowledge among the public of the role and remit of risk assessors and managers.
- Scientists endeavour to evaluate risks objectively while the public often evaluate them subjectively, leading to a disparity between opinions of lay people and experts.
- To reduce the lay-expert gap, early stakeholder engagement in the process should be utilised.
- Scientific information can appear inconsistent to the public when experts update or change their opinion based on newly emerged information. The reverse may also hold.

3.4.2. Enhance confidence in risk analysis outcomes

In this subsection of the report, we focus on factors that can enhance confidence in the outcomes of the risk analysis process. These factors include:

- Transparency
- Honesty and openness
- Stakeholder engagement
- Accountability
- Expanding assessments
- Independence of risk analysis
- Appropriate communication

Transparency. A common theme among papers within the literature review is the recommendation to increase openness and transparency – this includes increasing accountability and increasing the transparency of risk governing processes (Devaney, 2016). Overall, there is a consensus that as (perceived) transparency, openness, honesty and accountability increase, then an improvement in confidence could follow.

There are many actions that could be taken to increase transparency more generally. This involves simple changes like including and communicating the clear procedures behind public decision making, opening up channels for communication between risk bodies and the public, and providing wider access to the information used to inform decisions. This information, like raw data, must be more widely available (Schreider et al., 2010) for those interested in accessing it and providing context and summaries of the data would increase accessibility (in a broad sense) to a wider audience. Making data difficult to access, especially data concerning uncertainty, can reduce public trust as it makes risk bodies appear unforthcoming or secretive (Frewer, 2004; Van Kleef et al., 2007). Van Kleef et al. (2007) found that one driver of distrust is the concern behind the motives of particular information sources in providing the public with information. Transparency could alleviate this type of concern and thus minimise the establishment of distrust.

Overall, the decision-making process in risk management must be better documented, and establishing a guidance framework for both the management process and its communication to the public would be beneficial (Schreider et al., 2010). This is in line with the principles of risk management laid out by the FAO/WHO (1997) indicating that risk management decisions should be transparent to ensure that the rationale is clear to all interested parties. Communication objectives for risk managers are multiple; as an example, for businesses they need to relay the message of complying with safety measures, while for

consumers they need to provide sufficient information about the risk, the evaluation process and uncertainties to make decisions for themselves and society (Renn, 2015).

In terms of increasing transparency through risk communication, these elements all must be effectively demonstrated: what information was (and was not) taken into consideration during the risk assessment or management process, what underlying scientific data was used during the assessment or management process, and details of the methodology used to arrive at a particular decision.

Despite the benefits of increasing transparency, however, it is important to note that there are possible trade-offs for risk communicators who demonstrate total transparency and participate in full disclosure of risk related information with the public (see also Section 3.2.2). In situations where the actual risk is very low, but public concern is high, the trade-off for the risk communicator might be between the goal of avoiding overreaction to a small risk (see Slovic et al., 2016 for examples) and the need to build public trust by providing information about it (Hooker et al., 2017). Also, according to Löfstedt (2006), communicating uncertainty transparently encourages trust and enables informed choice, but communicating uncertainty unnecessarily can result in public distrust, confusion and the amplification of risk perception. Therefore, a balance must be struck between demonstrating transparency and not overloading the public with unnecessary details that may promote confusion or fear.

Communicative transparency is one of two types of transparency Auger (2014) describes – it highlights the importance of public participation in the risk analysis process, displaying accountability and provision of substantive information. These factors are discussed below, independently of transparency.

Honesty and openness. To enhance confidence in the risk analysis process, it is important to understand the factors that influence confidence – such as trust, as discussed in Section 3.1.2. To increase confidence (by building or rebuilding trust), honesty and openness are terms that have emerged as determining factors.

Irrespective of the variance in definitions, openness and honesty are integral to trust, 'trust and credibility are based on three determinants: knowledge and expertise, openness and honesty and concern and care' (Frewer and Miles, 2003). Charlebois and Summan's (2015) core risk communication strategy supports the inclusion of openness (and transparency, independence and timeliness) as key factors that inform the strategy. These findings, as cited by Tonkin et al. (2019), indicate that strategies designed to enhance confidence in the risk analysis process should incorporate these factors. These strategies may include taking action to communicate openly about the purpose, intent and limits of public engagement approaches, e.g. communicating how the engagement process impacts the decision-making process.

Stakeholder engagement. An important emerging factor in designing frameworks to enhance confidence in the risk analysis process is the involvement of the public (non-expert lay people) in the risk analysis process (see also Section 3.2.4). The risk analysis process is overseen and enacted by experts, with the resulting decisions being communicated to the public after the process is complete. Adapting stakeholder engagement by incorporating the public into the risk analysis process earlier, and within each of the three branches of the analysis process, would have many benefits. For example, involving stakeholders in identifying risk analysis issues and framing risk assessment questions could help foster public understanding of the process and enhance confidence in its outcomes. Engagement of citizens into the whole policy cycle is beyond the scope of this document, but may be exemplified by activities such as the Second Citizen Engagement Festival organised by the European Commission in 2019.

According to Arvai (2003), public participation in risk-related decision making can lead to a higher acceptance of risk policies. Arvai (2003) also argues that including the public in the risk analysis process will lead to 'democratising the process of decision making and improving the quality of resulting decisions'.

Arvai's (2003) experimental study supports the findings outlined in relation to public participation in the risk analysis process. The experiment tested the hypothesis that risk communication outputs that cast risk policy decisions as the product of public participation in the decision-making process would result in a higher degree of support for the decision-making process and its resulting decisions among non-participants. The experiment results indicate that, after receiving information during risk communication that implied the risk policies about space exploration were informed by the public, experiment participants felt more supportive of the resulting decisions than the control participants. Therefore, the results and findings that emerged from this experiment support the hypothesis being tested (Arvai, 2003). Thus, this experimental paper acts as a concrete example of quantitative data that supports the provision of public participation in decision-making processes, including at the assessment, management and communication stages.

Ultimately, it is important to keep in mind that it is not just the decision arrived at that is important to those the decision effects, but also the manner at which the decision was arrived at. Similarly to how procedural justice literature is concerned with the fairness of the procedure rather than the correctness of the outcome, Arvai (2003) highlights that it is not just the results of public participation in the process that is important to the public, but rather the process employed in reaching these decisions may be equally, if not more, important.

An additional benefit of involving the public in the risk analysis process is the effect it can have on public trust in the process. According to Papadopoulos et al. (2012) 'to regain the public's trust [...] policy solutions should include transparency and public participation in the process'; this, combined with Arnot's (2016) claim that 'building trust requires an increase in early stakeholder engagement', indicates that public inclusion in the risk analysis process could positively impact trust – and thus confidence – in that same process and its outcomes.

Petts (2008) notes that public engagement alone may not be sufficient to encourage public trust in policy makers (such as risk managers); however, there are three general components of any engagement activity which could lead to greater trust: 'who is engaged and which interests are represented; an open and collaborative framing of the discussion, and a direct and clear relationship between engagement and the risk decision" (Petts, 2008, cited in Hobbs and Goddard, 2015, p. 72).

This provides insight into how to design strategies: to enhance confidence in risk analysis outcomes, the public (consisting of a balanced representation of all actors) must be not only engaged in the process but feel represented. The discussion between the public and managers or assessors should be collaborative in nature, rather than one sided. That is, a 'pre-packaged definition' of an issue should not be provided to the public as it is detrimental to the public's ability to actively engage with the issue and discuss the real meaning of the risk (Engdahl and Lidskog, 2014).

Engdahl and Lidskog (2014) summarise this section concisely when they state that trust (which is integral to confidence, as previously discussed) is created when 'citizens are emotionally involved, take part, have a say and in some sense are able to recognise themselves in the recipient of their trust.' Trust cannot be established by 'passively being fed knowledge, or by standing alone outside of social life' (Engdahl and Lidskog, 2014). Therefore, it is essential that stakeholders, specifically the public, be incorporated into the risk analysis process.

Despite the consensus in the literature regarding the necessity of stakeholder engagement in the process, there are some challenges to incorporating and enacting an effective engagement process. According to Dendler and Böl (2020) there are, at times, significant resources (time, human and financial) required to participate in engagement processes, especially in highly specialised ones, and the ability to mobilise such resource requirements may be unequally distributed among stakeholder groups. Another challenge that emerges is the struggle between including external participation in a process while also maintaining independence. Further, conflicts between parties may arise and need to be accounted for in the co-production process. These conflicts can emerge as a result of the inclusion of the varying views, interests and expectations of interested parties, (the co-production process is discussed in more detail in Section 3.2.4.) (Scolobig and Gallagher, 2021). These challenges are realistic and legitimate and should therefore be accounted for when designing strategies to enhance confidence in risk analysis outcomes.

Accountability. The term accountability is frequently associated with transparency and described as a determinant of communicative transparency (Auger, 2014). Auger (2014) claims that Menon and Goh alluded to accountability when they defined transparency as 'providing the evidence behind decisions and actions' (Menon and Goh, 2005, as cited by Auger, 2014). No matter the origin of the term in this field of research, accountability has emerged as a factor to consider when designing strategies to enhance confidence in the outcomes of the risk analysis process. Why is this?

Accountability was defined by Rawlins (2009) as a trait that is measurable; to become accountable and to be perceived as accountable, strategies could incorporate the following components as described by Rawlin's measurement and determinants of Communicative Transparency (Rawlins, 2009, cited in Auger, 2014):

Accountability:

- Presents more than one side of controversial issues
- Is forthcoming with information that might be damaging to the organisation
- Is open to criticism
- Freely admits when it has made mistakes
- Provides information that can be compared to industry standards

Overall, Wilson et al.'s proposed model for (re)building consumer trust in the food system, supports the need for accountability structures when dealing with issues of trust (Abelson, 2009, cited in Wilson et al., 2017, p. 997). This is supported by Devaney (2016) who encourages the increase of accountability and transparency in risk governing processes and Finucane and Holup (2005) who argue that expertise, as often used within the risk analysis process (e.g. scientists) does not lead to trust without the addition of characteristics such as accountability. Finucane and Holup (2005) also maintain that information sources with a moderate degree of accountability tend to be more trusted that those with total freedom or little oversight, reinforcing the value of including accountability in any proposed strategies to boost confidence in the risk analysis process.

Ultimately it appears that the system as a whole must be perceived to be accountable, especially to the public – a self-regulated industry is not trusted by the public, and so improving the system's accountability could enhance confidence in the analysis process as a whole: 'A self-regulated industry does not enjoy the trust of the public, as the public's general perception is that industry will not be forthcoming with important information that may impact its short- or long-term viability' (Papadopoulos et al., 2012).

Expanding the types of assessments included in risk analysis. An important strategy for increasing confidence in risk analysis outcomes involves expanding the assessments included within the process to better represent the public's concerns. Engdahl and Lidskog's research (2014) indicates that science in general often fails to adequately consider public concerns. As such, a broader, more well-rounded approach to understanding and assessing risk must be established. As risk is 'socially embedded', it is necessary that risk is no longer discussed or presented in the abstract, but instead must be assessed, managed and communicated in the social context (Engdahl and Lidskog, 2014). As the public often understands and evaluates issues based on their social meaning, integrating a wider range of scientific assessments into the risk analysis process would improve the quality and durability of management decisions (Van Kleef et al., 2006; Knudsen, 2010).

Risk analysis – in particular, risk assessment and risk management – should evaluate the risks and benefits not just to human health but should also involve the environmental impacts, economical assessments and social and ethical assessments (Knudsen, 2010). Public trust in risk analysis, and in science more generally, is dependent on the extent to which their concerns and their understanding of the issue is addressed. By expanding the types of assessments included in the risk analysis process, the public will be better represented in the process and so more likely to have confidence that the outcomes arrived at were well informed and include appropriate consideration for social and individual concerns.

The need for the inclusion of a variety of assessment types emerges at least partly due to the large lay-expert risk perception discrepancy – public perceptions of food risks differ from experts (Van Kleef et al., 2006. See also Section 3.2.1). Ideally, risk communication would help bridge this gap (Engdahl and Lidskog, 2014); however, one criticism of risk analysis is that the gulf between the scientific understanding of risk and the public understanding of risk is too large to be acceptable (Funtowicz and Ravetz, 1993; Amendola, 2001; Lidskog, 2008; Renn, 2008, cited in Engdahl and Lidskog, 2014). Risk communication cannot wholly bridge/fill this gap, so expanding the assessments included within the process to better represent the public's concerns is a viable solution to this problem.

Ultimately, research indicates that failure to integrate societal concerns and values into the risk analysis process is one of the causative factors associated with the decline in public confidence in risk assessment and risk management (Frewer et al., 2005, p. 23). Therefore, the broadening of the assessments completed is a worthy strategy for enhancing confidence in the analysis process.

Independence of risk analysis. Van Kleef et al. (2007) found that one driver of distrust in general is the concern behind the motives of particular information sources in providing the public with information. Frewer (2003) refers to this as 'source credibility', and it relates to the public's perceptions of the motivations of institutions or individuals in providing information to the public. It is therefore imperative that the bodies related to risk analysis (such as risk assessors or risk managers) be independent from undue influence (such as other public institutions, civil society or private industry) and remain unbiased. This independence must be clear, perceived and unquestionable in order to diminish the risk of distrust emerging and to maintain credibility among the recipients of the risk analysis process. Increased transparency could alleviate this type of concern by clearly highlighting the separation from undue influence, and thus, this could minimise the establishment of distrust.

Frewer (2003) stresses that there appears to be a link between institutions or individuals that express concern about public welfare and have a good track record of providing information with higher levels of trust in the information source. It would benefit the branches of the risk analysis process to utilise this finding and to incorporate not just independence into future strategies, but also

endeavour to highlight the motivation behind the risk analysis process – to ensure food safety for the benefit of the public. At the heart of the process is the desire to protect public health by mitigating food risk (Van Kleef et al., 2006), and this should be clearly communicated. It is not in the nature of risk analysis to be self-serving, and so it is important that no negative perceptions (specifically for risk communicators) arise as a result of distrust in motives.

Frewer (2003) claims that reducing distrust may be linked to the halting of activities where it is perceived that a vested interest is being promoted by the risk communication activity, or that the communicator is only providing accurate information to protect themselves. As previously discussed in the transparency section above, actions like these can result in risk bodies appearing unforthcoming or secretive, which would negatively impact trust and confidence levels (Frewer, 2004; Van Kleef et al., 2007).

Appropriate communication. To enhance confidence in the risk analysis process, communication is key. While risk communication is an integral component of risk analysis, communication in general spans all three branches of the process. Numerous recommendations regarding communication have emerged from the literature.

There must be an emphasis on communicating in clear, unambiguous and understandable ways. Health literacy research (e.g. Sørensen et al., 2012) shows that people have difficulty relating to information that is too complex or uses too much jargon. Easy-to-understand language, visual supports and the use of aids, such as allegories, facilitate understanding and promotes the desired behaviour, especially when limited knowledge of the subject is present. Communication messages should contain three key components:

1) the risk warning;
2) the risk prevention method or behaviour (with a clear rationale);
3) suggestions on how to integrate the new behaviour into existing habits.

Messages containing these components have proved to be more effective and better received by the public, as they appeal to social norms (e.g. 'we are all in this together').

Additionally, Visschers and Siegrist (2008) recommend that risk managers should take care to 'communicate the values that are compatible between themselves and the public, since value similarity determines social trust'. Demonstrating value similarity can help build trust and confidence between the public and risk bodies. It is recommended that risk managers highlight the values and concerns of their target audience and respond to these. Additionally, they should demonstrate empathy to the public and be open and honest about their own values (Visschers and Siegrist, 2008). This trust can be useful for enhancing confidence in risk analysis outcomes, and so risk bodies should ensure their communications convey their values, especially values that are consistent with the values the public hold.

Furthermore, risk communicators should aim to ensure the 'credibility' of risk messages in order to guarantee public acceptance. This can be achieved by adopting a multidisciplinary approach in which various expert groups like academia and consumer organisations, combined with non-expert groups collaborate (Cho et al., 2017).

Frewer and Miles (2003) claim that the lay public's reaction to risk communication can be influenced by trust in the source of the information. Regular communication with the public during the analysis process could demystify the whole risk process while simultaneously establishing a trustful relationship between the public and the risk bodies. Frewer et al. (1996) find that the reasons for trust and distrust in information (communications) are often closely linked to specific information sources. To overcome this issue, Tonkin et al. (2019) generally recommend that information should be provided by trusted independent bodies, providing examples like chief medical officers or hospitals. Independent actors are perceived to offer unbiased opinions regarding food safety matters (Van Kleef et al., 2007), and so they are trustworthy channels of information. According to Fiske and Dupree (2014), the credibility of a communicator is predicated not just on their expertise or status in a given field, but also on their trustworthiness or 'warmth'. The warmth/trustworthiness judgement assesses the communicator's perceived intent for conveying the message. To enhance confidence in risk analysis outcomes, it is necessary for the credibility of the communicator that the communicator's trustworthiness, in addition to their competence and expertise, is conveyed.

In terms of addressing declining levels of trust and wishing to rebuild it, especially if this is a long-term issue, the literature suggests that a simple one-size-fits-all solution does not exist (Tuler and Kasperson, 2014). Empirical research recommends using varying approaches, depending on the nature of the situation. That is, advice differs depending on whether the decline is based on a crisis/acute event e.g. product recall or disease outbreak, or if the change in trust is caused by some other reason

(Rickard et al., 2013). The advice, therefore, is to regularly test baseline trust levels (Löfstedt and Bouder, 2017; Balog-Way et al., 2019). To overcome long-term decline of trust in risk analysis, and in other fields, structural and procedural approaches should be implemented. These approaches could include: 1) developing long-term relationships with trusted sources of information, like journalists, local leaders and other influential people, groups or organisations who engage in risk communication (these sources of information are sometimes referred to as 'messengers' in the literature); 2) designing clearly structured risk communication mechanisms to coordinate activities, messages and interactions with the public; 3) building both baseline and surge capacities through actions such as hiring trained 'messengers', and involving them at the strategic level of decision making and 4) engaging audiences in meaningful multiway dialog (see also Section 3.2.5 Communication tools and channels) (Löfstedt, 2013; Rickard et al., 2013; Tuler and Kasperson, 2014; Bouder et al., 2015; National Academy of Sciences, 2016; Löfstedt, 2019; Balog-Way and McComas, 2020).

Further to this, Van Kleef et al. (2007) recommends communicating regularly rather than on an ad hoc basis with a short-term goal. Communication about risk management procedures should be firmly entrenched in the risk analysis process (Van Kleef et al., 2007), and regular communication with messages designed to enhance confidence or foster knowledge could facilitate this.

According to De Jonge et al. (2010), confidence is based on familiarity and often arises from the accumulation of positive experiences. It could be argued therefore that regular, if not continuous, communication with the public during the risk analysis process could provide a consistency that will establish and maintain trust and confidence (Knudsen, 2010); the benefit of this is two-fold: first, it is easier to enhance confidence when there exists already prior knowledge and trust in the risk analysis process, and two, in the event of a negative food risk incident, as seen with the BSE outbreak in the early two thousands, or the horse meat scandal of 2013, having a longstanding relationship built upon strong communication and a foundation of trust and confidence, could reduce the negative impact on trust or reputation of the risk bodies.

Wilson et al.'s (2017) model for (re)building consumer trust in the food system finds that a useful strategy would incorporate consistency and building reputation. When applied to risk bodies, this could be a viable contributory method for building and later enhancing confidence in risk analysis outcomes – regular, consistent communication throughout the risk process provides a degree of transparency and openness that could instil public trust and confidence in risk analysis; According to Walls et al. (2004), invisibility in terms of reputation or public knowledge can be a 'double-edged sword'. Relative invisibility might be considered desirable at times due to its ability to reduce potentially negative associations forming and impacting upon an existing trust profile. However, invisibility may also serve to obscure actions which could potentially enhance trust or confidence. Therefore, it is ultimately recommended to build a positive reputation through consistent, proactive and informed communication as it would be beneficial to improving confidence in outcomes (Wilson et al., 2017).

Proactively communicating about risks to the public can have a positive mitigating effect on public concern (Van Kleef et al., 2006; Wilson et al., 2017). Frewer et al. (1996) claim that risk regulators that proactively engage with the media see a positive improvement with how risk information is reported upon. Therefore, this should be considered for future strategies on enhancing confidence in the outcomes of risk analysis.

Table 13: Summary of factors that contribute to enhancing confidence in risk analysis outcomes

Factor	Enhancing Confidence

Transparency (Schreider et al., 2010)	• Procedures behind decision making
	• Information
	  ○ Make data available
	  ○ Make processes/procedures accessible
	  ○ Establish two-way methods of communication
	• Communicate
	  ○ Scientific data used
	  ○ Methodology used
	  ○ The information used/not used during the analysis process

Honesty/Openness (Frewer and Miles, 2003)	• Driver of trust

Factor	Enhancing Confidence
Stakeholder engagement (Arvai, 2003; Engdahl and Lidskog, 2014)	• Legitimises policy decisions • Builds trust • Higher quality decisions (as perceived by public) • Higher acceptance of decisions • Engagement leads to perception of being better 'represented' in the process
Accountability (Auger, 2014)	• Communicate ○ all information (incl. damaging information) ○ information that can be compared to industry standards • Accept criticism • Admit mistakes
Expanding Assessments (Van Kleef et al., 2006; Knudsen, 2010; Engdahl and Lidskog, 2014)	• Public understands issues based on their social meaning • Expanding assessments makes public feel 'represented' • Expanding assessments improves the quality and durability of management decisions
Independence (Frewer, 2003; Van Kleef et al., 2007)	• Demonstrate independence to maintain credibility
Appropriate Communication (Frewer et al., 1996; Van Kleef et al., 2006; Van Kleef et al., 2007; Knudsen, 2010; Fiske and Dupree, 2014; Cho et al., 2017; Wilson et al., 2017; Tonkin et al., 2019)	• Proactive or Reactive? ○ Proactively communicating about risks can mitigate public concern • Source of information ○ Should be credible, informed and trusted e.g. doctor, scientist • Message ○ Clear, concise and informed by research into public perceptions ○ Free from jargon ○ Contain visual aids/visualisations ○ Explain the risk, how to prevent the risk and suggest how to integrate the new behaviour into existing habits • Frequency ○ Communicate regularly, even during non-crisis times

Conclusions

- To enhance confidence in risk analysis outcomes, the public must be not only engaged in process but feel represented. Public participation in risk-related decision making democratises the process of decision making and improves the quality of resulting decisions.
- Scientific risk assessments should be complemented by environmental, economic, social and ethical assessments, in order to better reflect public concerns.
- Risk analysis must be independent of undue influence of any interested party, be it public institution, civil society or private sector.
- Communications should be clear, channelled through trusted sources (e.g. doctors, scientists) and conveyed regularly.
- Communications should clearly convey three things: the risk, how to prevent the risk, and how to integrate the risk-prevention behaviour into existing habits.
- There are challenges to incorporating and enacting an effective engagement process, such as the significant resources required to participate in engagement processes.
- To improve trust, it is recommended to build a positive reputation through consistent, proactive and informed communication.
- To overcome distrust, structural and procedural approaches should be implemented, such as engaging audiences and designing risk communication mechanisms.

3.4.3. Take account of risk perceptions of all interested parties

In this section, we provide guidance for risk communication on how to 'take into account risk perceptions of all interested parties'.

The literature we reviewed highlights the need to consider both the technical elements of the risk characteristics and the public perceptions (e.g. low risk, high concern) (Cope et al., 2010; Frewer et al., 2016). Risk perception research, and in particular the psychometric approach, has been criticised by some authors (see McDaniels, 1998) who argue that risk perception studies have no direct prescriptive weight and they have no direct relevance for setting management priorities. In McDaniels's view, descriptive risk perception findings are of indirect prescriptive value in several aspects of risk management where learning about perceptions held by the members of the general public is important. Direct prescriptive insight for setting risk management priorities requires more thoughtful, informed judgements, within more specifically structured frameworks.

As stated also by Slovic et al. (1982), 'Psychometric knowledge may not ensure wise or effective decisions, but lack of such knowledge certainly increases the probability that well-intentioned policies will fail to meet their goals'. As also highlighted in Renn (2009b), 'Any successful risk communication program needs to address the problems faced by risk perception. Risk perception studies can help to anticipate public reaction to new risk sources'.

The majority of scientific literature on the topic of risk perception insist on the concept of Two-way Communication intended as a mutual learning and deliberation process, public participation, dialogue and involvement in the decision-making (Slovic, 1993; Hansen et al., 2003; Frewer, 2004; European Commission, 2014). The need for dialogue and involvement of the public is also highlighted in the developmental stages of risk communication (Fischhoff, 1995). Each stage is characterised by a risk communication strategy that builds upon the previous one. First, the risk assessment or technical work needs to be carefully performed. Second, the outcome of the risk assessment needs to be communicated. However, it is not enough to 'tell them the numbers', but third, there needs to be an explanation of the meaning of the numbers (including uncertainty about them). Fourth, risk communication can make use of risk comparisons (see Sections 3.2.4 and 3.3.2). The fifth stage focuses on the need to inform about both risks and benefits. Sixth, the communication needs to build trust. Seventh, members of the public have the desire to be more active and play a more constructive role, therefore more direct contact and engagement are needed. In Fischhoff's view, risk communication is effective when it is built on all these seven stages.

Renn (2009b) identifies four different risk categories that require different forms of participation. First, simple risk problems need an instrumental discourse between agency staff, directly affected groups and enforcement personnel. It is also important to monitor these risks closely as they might evolve into more complex, uncertain or ambiguous risks. Second, for complex risk problems it is advised to adopt an epistemological discourse with experts from academia, industry or civil society. Methods like Delphi, Group Delphi and consensus workshops would help in facilitating such discourse. Third, risk problems due to high unresolved uncertainty call for a reflective discourse in which policy makers, representatives of main stakeholders' groups and scientists should take part. Round tables, open space forums, negotiated rule-making exercises, mediation or mixed advisory committees including scientists and stakeholders would be valuable methods for this kind of exercise. Fourth, risk problems due to high ambiguity demand the most inclusive strategy for participation, i.e. a participative discourse, a platform where competing arguments, beliefs and values are openly discussed. To find agreement, there needs to be put in place a 'process of identifying common values, defining options that allow people to live their own vision of a 'good life' without compromising the vision of others, to find equitable and just distribution rules when it comes to common resources and to activate institutional means for reaching common welfare so all can reap the collective benefits' (Renn, 2009b, p. 94). Citizen panels, citizen juries, consensus conferences, ombudspersons, citizen advisory commissions and similar participatory instruments can serve this purpose. The aim of such fora is twofold: first, empower participants in the processes of decision-making about the risks, which affect them or their communities and, second, provide useful intelligence back to scientists to shape technologies and their trajectories (Pidgeon, 2020). The categorisation of risks should be conducted through a design discourse aimed at choosing the most relevant risk assessment policy, defining priorities and organising the most suitable involvement procedure. This view resonates with Dendler and Böl (2020) according to whom the exact form of engagement should be adapted to the stakeholder and the topic under assessment.

While risk perception studies are essentially inspired by psychology and focus on individual representations, Science and Technology Studies (STS) sociologically analyse broader interactions between techno-scientific actors (such as experts) and lay publics (Jasanoff et al., 1995; Irwin and Wynne, 1996; Wynne, 1996). Instead of separating objective (expert-based) risk from perceived risk, STS studies do not consider science as being the reference source of knowledge, but address on the same level the different knowledge claims, including those of scientists, of policy-makers and of different (local or general) publics concerned by a risk. According to this literature, the different perception of risk in lay publics is due not as much to psychological characteristics, individual life experiences or lack of sufficient scientific knowledge, but to contestation of socio-political relations that the use of risk science indirectly promotes in particular decisional contexts. Expert risk calculations can embody particular power relationships and particular views about social relations, and for this reason can be a source of rejection by certain publics.

Methodologically, STS studies essentially build on qualitative analyses instead of quantitative studies privileged by psychometric studies, and look in particular at controversial situations, that reveal mechanisms of interaction and political legitimation of knowledge claims. Controversies are not viewed as dysfunctional situations, in which the public and the experts are in contradiction, but as learning processes that favour the production of new knowledge and socio-political relations (Rip, 1986). Therefore, involving publics with different perspectives, sometimes contradictory, in participatory situations can lead to enlarging expert-only understandings and to accounting for those publics' needs and interpretations.

For the STS literature, the role of local knowledge is thus important for informing experts about the specificities of the risk situation being studied. STS studies propose essentially a dialogue between expert and lay publics including various stakeholders ('extended peer community') in order to improve the relevancy and quality of science for policy (Funtowicz and Ravetz, 1990, 1993). Furthermore, addressing controversial situations necessitates both exploration of the public interpretations of calculated risks and opens the 'black box' of scientific expertise for submitting its built-in assumptions to discussion.

As indicated above, the literature on psychometric approaches identifies a series of practical suggestions for taking into account risk perception in risk communication.

First, some authors maintain that identifying public knowledge schemes that are related to the risk can help in tailoring the content of the risk communication to this knowledge (Visschers et al., 2007). This so-called 'Mental Model Approach' posits that knowledge schemes could be used to identify the differences between experts and the members of the public concerning a specific risk. According to Fischhoff et al. (1993) the mental model analysis would help to bridge the gap between the mental models held by the public and expert models with the aim of adding missing concepts, correcting mistakes and strengthening correct beliefs.

Second, listening to the target audience might help in gaining insights on how the different audiences perceive the risk, their knowledge and the preferred information method and means (Bruhn, 2005). On this topic, the use of digital tools such as social media might be valuable. Social media represent a channel to gather consumers' perceptions of food issues and the way these can impact on their search for, reaction to and understanding of information (Rutsaert et al., 2013). As pointed out in Rutsaert and colleagues' view-point paper, social media enable taking stock of consumer feedback, allowing for a more in-depth understanding of consumers' responses to risk communication and aiding the communicator to achieve an understanding of the general public feeling towards an issue.

Third, there is a need to ensure that the members of the public from whom judgements of risk and acceptability are elicited are well-informed (Pidgeon, 1998). Some authors, such as Slovic et al. (1982) and Lobb et al. (2007), refer to the need to 'educate', i.e. provide information to the public to 'correct people's misunderstandings', however they also recognise that 'strong initial views are resistant to change because they influence the way that subsequent information is interpreted' (Slovic, 1987).

Fourth, according to the authors, two-way communication is meant as effective dialogue with society and between societal groups, a public participation in which people express directly their 'perceptions' (Renn, 1998). Prior consumer knowledge/habits (Frewer et al., 2016) needs to be considered and it is crucial to engage stakeholders to assess risk perceptions and the standards by which they are judged as acceptable (Brunk, 2014), also identifying communication barrier (Johnson, 2014). The dialogue should also consider the existence of psychological factors that might represent barriers to risk communication: i) the resistance to attitude change derived from optimistic bias; ii) the effort that information processing demands to consumers in terms of mental capacity and motivation;

and iii) the observation that information processing rests upon an 'experiential and affect-driven solving strategy rather than one of formal logic' (Frewer et al., 2005).

Fifth, many studies we reviewed consider building and maintaining trust and confidence as a prerequisite for risk communication. Research showed that having similar values determines social trust (Visschers and Siegrist, 2008), therefore social trust might increase if a risk is framed in a way that reflects public's salient values (Siegrist et al., 2000).

Sixth, despite the paucity of research on the influence of cross-cultural differences in risk perception, the literature recommends considering cultural differences (Finucane and Holup, 2005). This is crucial to account for similarities and differences in risk perception across European countries. As found in Hohl and Gaskell (2008) analysing the data from the 2005 Eurobarometer survey on Risk Issues (European Commission, 2006), there are substantial differences in the worry expressed by respondents towards food risks. Specifically, there is evidence of a North-South split, with Southern countries being more concerned than Northern countries. On this topic, a recent paper by Meagher (2019) which analyses the results of the Eurobarometer 73.5 survey on food-related risks conducted in June 2010 (European Commission, 2010, cited in Meagher, 2019), suggests that current theories about risk perception may be better suited to societies in Northern and Western Europe than to newer EU Member States in Eastern Europe.

Conclusions

- Risk communication should embrace a two-way inclusive communication involving all relevant stakeholders, including the members of the public, characterised by participation in the risk analysis process that would facilitate identification of the public's knowledge and perceptions of risks and would support the building and maintenance of trust.
- To make two-way communication effective, a mix of quantitative and qualitative research methods is recommended for studying risk perception; subsequently adapted forms of participation need to be considered according to the type of risk and the audience.
- The need for dialogue between expert and lay publics including various stakeholders ('extended peer community') to improve the relevancy and quality of science for policy is also supported by Science and Technology Studies.

3.4.4. Reduce ambiguity of the perceived difference between hazard and risk

In this section, we identify social, cultural and psychological factors to explain the ambiguity in the public perception of the difference between hazard and risk. This review aims at supporting risk communication that can clarify and improve public understanding of the difference between these two terms.

The literature on the public perception of the difference between hazard and risk is still quite scarce. A first experimental study (Young et al., 1990) on a small sample of undergraduate students revealed that there is misunderstanding of the terms hazardous, risky, dangerous and hazardous-to-use which were considered as synonyms. To overcome this issue, the authors suggest expressing probabilities placing them within 'a context of a person's lifespan' that would make them seem more significant and concrete.

These results found confirmation in a later online experiment conducted on a wider sample of the population (Wiedemann et al., 2010). More than 80% of the respondents did not distinguish between hazard and risk, however if information was supplied people were able to understand the difference. Therefore, it seems more an issue of lack of knowledge instead of lack of understanding. Wiedemann et al. (2010) advise to provide information about the risk and not only the hazard and make use of risk comparisons to ease the comprehension.

Vandermoere (2008) illustrated the public perception of hazard and risk through a case study of individuals living in an area affected by soil pollution. The article adopts an 'ecological-symbolic approach (ESA)' that posits that risk perception is related to the interpretation of the hazard made by the individual within the social context. This model can explain why the study found a weak correlation between hazard and risk perception, suggesting that risk perception formed regardless of assessed dangers. More than an alarming risk perception, experts' risk assessment of the soil pollution produced a hazard awareness and a 'collective risk-disbelief' as residents believed that knowledge was insufficient to support a health risk. The author suggests that the knowledge deficit model (i.e. the supposed lay-expert gap, see Section 3.4.1) in environmental decision making should be substituted

by more deliberative methods that can deal with the principles of sustainability and the limits of expert knowledge.

The approach of analysis of case studies was also adopted by Löfstedt (2011) who focused on the phase-out of certain brominated flame retardants and the partial ban of bisphenol A. Importantly, the author highlights that most of the research conducted in the field of risk analysis is primarily of American origin. Therefore, the language around risk assessment is grounded in English, where the linguistic distinction between risk and hazard is clear. This is not the same in other languages, such as Dutch, German or Swedish, e.g. which leads to great ambiguity. Recommendations provided by the author includes the importance of education, for instance introducing risk assessment as part of the science curriculum in the last years of school as well as in universities. Additionally, scientific peer review of risk assessments used for regulations is highly advised. For risk communication, there is a need to develop media guidelines and to improve capacity and competences.

Support for the effectiveness of education in improving the understanding of hazard and risk can be found in Oyarzabal and Rowe (2017) who designed training to teach the concepts of hazard and risk to participants of Hazard Analysis and Critical Control Points (HACCP) classes. All the participants were professionals who worked in different food industries. While less than one third of the participants answered correctly to the definitions of hazard and risk at baseline, post-training self-assessment data showed an improvement in the understanding of these terms.

The framing of the communication message reporting either a hazard identification or a complete risk assessment can strongly impact risk perception (Freudenstein et al., 2020). In this study short text modules were presented framed as either hazard identification or risk assessment to investigate their influence on the risk perception of mobile phones. Findings show that the majority of people understood the text as being a risk assessment, regardless of the framing. This could be due to three reasons. First, the word 'risk' was often presented in the excerpt that was framed as hazard identification, therefore creating ambiguity between the terms. Second, it might be that risk judgement relies on a hazard = risk heuristic, i.e. reading about mobile phones usage as possibly carcinogenic leads the reader to think that this is true, regardless of the exposure. Third, the framing might not have been effective because the distinction between these terms requires a basic knowledge in risk assessment which is generally not available to the public. Among those people who read the text and understood it as a risk assessment, results indicated a significantly higher risk perception concerning heavy mobile phone usage compared to those who understood the text as a hazard identification. Although findings revealed that understanding a press release as hazard identification was associated with decreased risk perception, it also showed that it is rather difficult to change prevailing strong beliefs about the risk. According to the authors, an effort in differentiating between hazard and risk would be beneficial for future risk communication, to avoid unnecessarily increasing risk perception. Another study on the distinction between hazard and risk in the field of chemicals shows divergent results (Jansen et al., 2019). Findings revealed that the public is able to understand the difference between hazard and risk appraisal, as a large majority of the respondents agreed that exposure determines whether a chemical represents a risk. Nevertheless, a significant proportion of respondents agreed that all chemical substances are equally harmful. Although the public is able to understand the difference between 'hazard' and 'risk, in some cases the mere existence of a substance ('hazard') in food is disturbing for people, regardless of the exposure. Recommendations stress the need to distinguish between the use of hazard and risk in risk communication to prevent misinterpretation of scientific evidence. In addition, risk communication should try to address the existing negative attitude towards chemicals which could positively affect public appraisal.

More recent research (Jansen et al., 2020) stressed that people often do not use scientific, quantitative methods to assess risk but instead rest upon their senses, affect and associated cognitions to judge risks from chemical substances. This is also described as 'intuitive toxicology' (Kraus et al., 1992). The interview study investigated people's appraisal of uncertain risks of chemical substances in food. Findings showed that people tend to judge chemicals as either safe or dangerous and think that even low doses can cause harm. Only a few participants expressed the view that chemicals could vary in toxicity. Participants also held beliefs that are consistent with the scientific understanding of chemical risk. For instance, many participants distinguished the levels of exposure, based on frequency, amount and duration. In line with an EU Insights study on chemical mixtures (ICF, 2019), participants mostly expressed negative attitudes toward chemical substances in food and considered them unwanted, unnatural and harmful to health. Overall, these findings support the view that, when risks are still unknown, the public assesses hazards and risks differently (as found by Vandermoere,

2008) and that a trade-off between judgements of the hazard and the risk may guide consumer responses.

One study focused on expert understanding of the difference between hazard and risk (Scheer et al., 2014). Interviews and focus groups addressed to a total of 53 experts representing different institutions in Germany, e.g. business and industry organisations, environmental and consumer organisations and public authority organisations were conducted. The analysis of the discourse revealed an association between perceived low knowledge of the audience and ambiguity created around the use of the two terms hazard and risk. In other words, both terms seem to be used for strategic reasons even if experts are well aware of their semantic differences.

The paper highlights the need to distinguish between semantic, conceptual, strategic and control-specific dimensions of hazard and risk terminology. The semantic dimension refers to the interchangeable usage of different words like hazard, risk, damage, damage potential, disasters and danger. The conceptual dimension is described as the difference between public authorities that focus on the damage alone and business and industry that have the tendency to weigh the trade-offs between damage and benefits. On the other hand, environmental and consumer organisations consider aspects of subjective risk perception to a greater degree in their risk assessment. The strategic dimension relates to the objective that certain terms fulfil in order to change attitudes, solve conflicts or influence decisions. Lastly, the control dimension explains the reason why stakeholders might use the terms differently on the basis of the specific implications they can have for risk management. The authors call for a correct usage of the two terms by experts working in the field of food safety to help the public to understand the difference in this context.

As few articles dealing with the topic of public perception of the difference between hazard and risk were identified, future work should investigate this aspect. As suggested by Löfstedt (2011), efforts should be made to address the language barrier through the development of more targeted information to increase the knowledge within specific cultural contexts.

Conclusions

- The literature on the public perception of the difference between hazard and risk is scarce.
- The few studies identified show that the two terms are ambiguous or used interchangeably by both the general public and sometimes even by experts.
- Education in schools and universities and through continuous and ad-hoc trainings of workers who deal with risk analysis could help in increasing the knowledge, keeping in mind that short text modules have proved to result in only limited success.
- Cultural differences need to be taken into account, as the terminology is grounded in English and might differ in other languages.

3.4.5. Fight dissemination of 'false information' and its sources

In this section, we 'provide guidance for risk communication (including types and levels of communication activities) that can 'contribute to the fight against the dissemination of false information and the sources thereof' in relation to risk analysis of food and feed safety'.

A deep understanding of this phenomenon cannot disregard the factors behind information consumption and processing. In this regard, the literature is rich and offers copious evidence of the crucial role of socio-cognitive factors in the way people select and process information, either reliable or not. Individual differences might be important in the evaluation of disinformation and peoples' attitudes serve an essential function in the evaluation of online disinformation (Marie et al., 2020; Schaewitz et al., 2020).

Moreover, a fundamental role in information consumption is played by confirmation bias, which is the human tendency to look for information that is coherent to one's system of beliefs. Empirical results show that online users tend to fragment into bubbles, the so-called echo chambers (Del Vicario et al., 2016). Immersed in these polarised communities of like-minded people, users select information consistent with their worldview, even when false, and tend to ignore information dissenting from their beliefs. Also, it is important to point out that discussing with many like-minded others makes one's pre-existing views become even more extreme (Sunstein, 2005). While an increase of ideological segregation can be observed on social networks and through search engines, these same channels are also associated with greater exposure to people's less preferred side of the political spectrum (Flaxman et al., 2016). Nonetheless, users' news consumption patterns on social media reveal a strong

polarisation, with users tending to confine their attention to a limited set of information sources (selective exposure), especially on controversial issues (Schmidt et al., 2017).

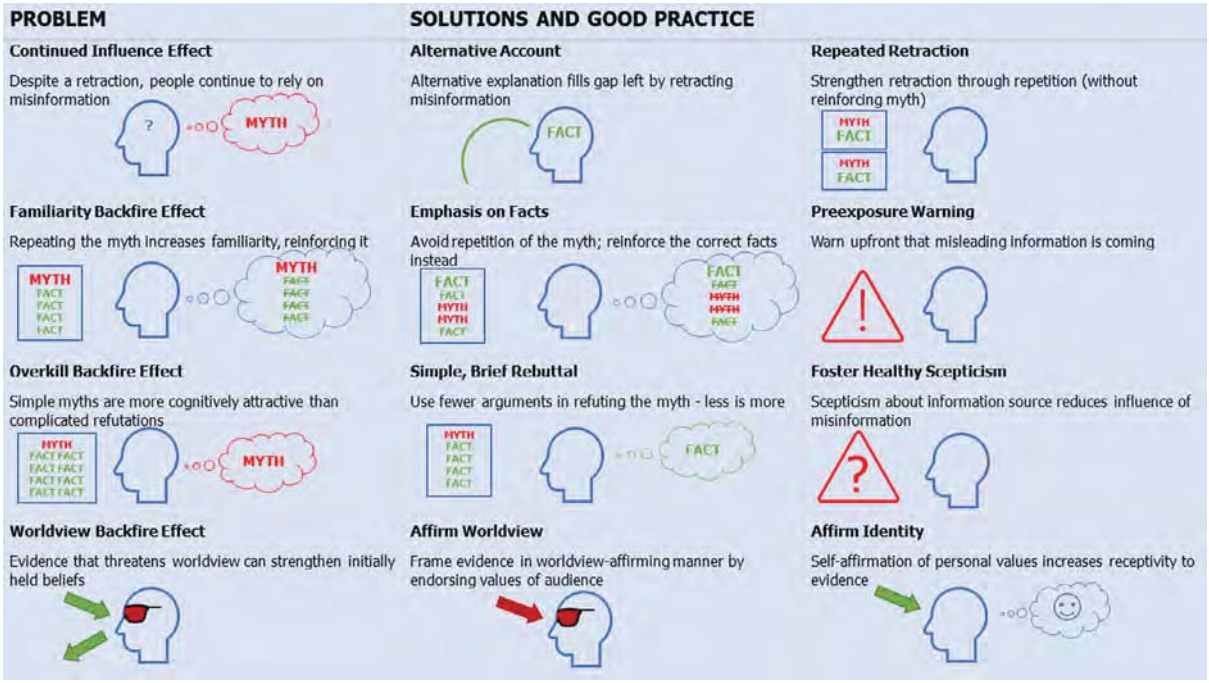
Users from different and contrasting communities rarely interact and, when that happens, the debate degenerates, especially during longer discussions (Zollo et al., 2015). Response to debunking attempts is not that dissimilar, and results in the well-known backfire effect (Nyhan and Reifler, 2010). Correction can be perceived as a further attempt to manipulate information, thus reinforcing users' original viewpoint (Zollo et al., 2017).

Cognitive variables within each person might indeed make it difficult to correct widespread belief in misinformation, e.g. people's inability to update their memories in light of corrective information (Lewandowsky et al., 2012). As an example, the commonly employed technique of reiterating myths and then discrediting them with a number of facts ('myths vs. facts' format) is ineffective on its own (Pluviano et al., 2019). This strategy may indeed cause a familiarity backfire effect, because of people's tendency to 'mistake repetition for truth and judge something that sounds familiar as correct, regardless of whether it is factually true or false' (Peter and Koch, 2016; Pluviano et al., 2019). As mentioned in Section 3.2.2, beliefs are resistant to change and research shows that individuals with pre-existing distrust show less trust following both positive and negative news events (Slovic, 1987; Cvetkovich et al., 2002).

Furthermore, message characteristics such as the source of an article, its consistency, image manipulation, subjectivity and sensationalism, despite being recommended by experts as cues for verifying information, do not seem to affect readers' attitude to believe and/or spread the information (Schaewitz et al., 2020).

Moreover, the form and content of many conspiracy theories recall those found in the beliefs of institutionalised religions (Franks et al., 2013), helping to explain how they are able to appeal to believers and to spread. Thus, these factors cannot be disregarded in the design of appropriate counternarratives.

We provide a summary of findings from Lewandowsky et al. (2012) in Figure 15. Following these recommendations, an empirical study on 700 US participants investigated the effect of two types of corrective information – simple rebuttal and factual elaboration – showing that the latter is able to alter one's intention to take preventive actions during a public health crisis (Van der Meer and Jin, 2019). The experimental results indicate that a detailed counter-message is fundamental to help individuals develop a new narrative, however 'more elaborated collective information resulted in increased feelings of fear and anxiety, the effective coping which needs to be facilitated properly by health organisations.' Moreover, corrective information coming from government and news media sources are likely to be more successful in altering people's perception of crisis severity than their peers on social media, although 'individuals tend to experience more anxiety in response to a public health crisis'. Therefore, both the information source and type appear to have an effect in the correction of misinformation through debunking activities.



Source: Adapted from Lewandowsky et al. (2012).

Figure 15: Graphical summary of findings from misinformation literature relevant for communication practitioners

While in specific settings false information appears to spread faster and farther than true information (Vosoughi et al., 2018), it was recently shown that there is no significant difference in the spreading patterns of information deriving from sources marked either as reliable or questionable (Cinelli et al., 2020). For this reason, policies aimed to contain misinformation spreading should emphasise behavioural actions. Alongside the crucial promotion of information literacy, the scientific literature provides many insights on possible strategies and interventions, which largely depend on the characteristics of the target population and how deeply rooted a certain misbelief is.

Debiasing – the process of reduction of biases– can be hampered by people's ideology and worldview and comes with ethical implications, because from a cognitive point of view the correction of misinformation cannot be distinguished from misinforming people (Lewandowsky et al., 2012). In particular, debiasing is not advisable when people hold strong beliefs concerning the misinformation. In such cases, an alternative solution is to ignore the misinformation and implement more direct interventions. An example is nudging, a concept developed by behavioural economists, which proposes to apply indirect suggestions or support to influence the decisions of groups or individuals without openly forbidding any options (Thaler and Sunstein, 2008). To limit the risk of a backfire effect, avoiding emphasising the myth, focusing on the facts and using simple and clear language is advised (Lewandowsky et al., 2012). It is crucial to take into account the worldview and values of the target audience, as to present content 'in a worldview-affirming manner (e.g. by focusing on opportunities and potential benefits rather than risks and threats) and/or by encouraging self-affirmation' (Lewandowsky et al., 2012). A proactive measure to counter misinformation is prebunking, which is based on the psychological theory of inoculation (Lewandowsky and van der Linden, 2021). Following the analogy with vaccines, prebunking consists in exposing people to a weakened version of the information to trigger the production of 'mental antibodies' and make the individual more resistant to persuasion in the future. More specifically: 'A threat is introduced by forewarning people that they may be exposed to information that challenges their existing beliefs or behaviours. Then, one or more (weakened) examples of that information are presented and directly refuted in a process called 'refutational pre-emption' or 'prebunking'. In short, attitudinal resistance is 'conferred by pre-emptively highlighting false claims and refuting potential counterarguments' (van der Linden et al., 2017). In terms of efficacy, inoculation theory has had promising results for a variety of scientific topics, from health (Maibach and Parrott, 1995) to climate change (Van der Linden et al., 2017). When myths concern health issues, such as vaccination, another effective strategy is to 'state that vaccinations are

safe and to emphasise the scientific consensus around their need and effectiveness' (Schwarz et al., 2016; Pluviano et al., 2019). Any action against health misinformation should take into account the social, political and cultural background where it is applied, preparing different messages for different portions of the population (Pluviano et al., 2019). Given how fast health misinformation can influence people's behaviour (Donovan, 2020), it is of crucial importance to better understand the context and adopt appropriate counterstrategies. For example, empirical results showed that negative information bias (see Section 3.1.4) occurs for variations in risk communication, i.e. stronger risk negations lead to higher risk perceptions, while weaker negations lead to lower risk perceptions (Betsch and Sachse, 2013). Moreover, strong negations have been proved to lead to greater risk perceptions than weak negations when communicated by noncredible sources (Betsch and Sachse, 2013). In cases such as vaccine hesitancy, where there can be a problem of public mistrust of experts and institutions, investing in a 'dialogical rather than didactic' communication approach for effective outreach is advised, instead of charging the public as 'ignorant' whose irrational fear makes them susceptible to misinformation (Goldenberg, 2016).

Social responses to different types of news framing have also been investigated (Schmidt et al., 2020), showing that visual pieces and factual reports generate the highest level of trust in the information source, while opinion pieces and editorials are more likely to be criticised and data-driven articles elicit an extremely low level of trust in the news source. These insights may be useful to smooth polarisation and facilitate a civil debate when dealing with controversial issues. We provide a summary of the techniques and content types and their impact on users' responses in Table 14.

Table 14: Overview of techniques and content types and their impact on users' response

Journalistic Technique/Content Type	Associated impact on users' response
o Impartial, accurate reporting with context **o Multimedia format (text with photos, videos)**	○ Low criticism of the information source (more trust)
Human interest stories	(Especially on groups of people rather than individuals) ○ Strong negative comments from readers ○ High levels of criticism of the source
o Infographics **o Fact-checking** **o Data-driven approaches**	○ Strong pushback from audiences who do not agree with the data ○ Strong criticism of the source
o Strong opinions **o Policy prescriptions** **o 'Constructive news' (i.e. news stories that include proposals for policy solutions)**	○ Pushback from audiences ○ Provoke toxic debates (less for constructive news)

Source: (Schmidt et al., 2020).

Guidelines to achieve effective risk communication in the context of food are available (Smillie and Blissett, 2010) and propose a communication model that encourages risk communicators to take into account the environment of the target audience when interpreting the perceived risk. More precisely, the model is built on the assumption that risk communication requires some level of understanding from all involved parties and consists of three main phases: i) risk appraisal, where an objective overview of the scientific facts is provided; ii) situational analysis, i.e. an analysis of how the risk is perceived; and iii), source analysis, i.e. an analysis of how the risk is perceived in the different environments (Smillie and Blissett, 2010).

Moreover, the COVID-19 pandemic offers an unprecedented opportunity to derive insights on how to communicate properly and effectively in a context of high uncertainty and polarisation. The World Health Organization released interim guidance in March 2020 to provide checklists for risk communication and community engagement readiness (RCCE) and initial responses to the outbreak (WHO, 2020). The guidance built on the lessons learnt during past public health events such as severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), influenza A(H1N1) and Ebola virus disease. It highlights the importance of proactive communication in preventing 'infodemics'. Infodemic was defined by the WHO as the circulation of an excessive amount of information, often

unverified or unreliable, that can destabilise the public and make it difficult to form a clear opinion. The European Centre for Disease Prevention and Control (ECDC) framework to monitor responses to the COVID-19 pandemic includes specific indicators for monitoring communication and community engagement activities aiming to increase trust in and adherence to public health measures, with a specific section on the mechanisms to put in place to address rumours, misinformation and disinformation (ECDC, 2020a,b). Along the same lines, the European Commission presented the Communication 'Tackling online disinformation: a European approach', outlining the key principles and goals to pursue in developing actions to deal with the phenomenon of disinformation and to limit its spread (European Commission, 2020a,b).

Conclusions

- Socio-cognitive factors are crucial to how people select and process information, either reliable or not and have to be taken into account to properly tackle disinformation phenomena.
- Echo chambers and strong polarisation are commonly observed on social media, and influence the way in which online users select and interact with online content and react to corrective attempts (i.e. debunking, fact-checking).
- Cognitive variables make it difficult to correct widespread belief in misinformation, causing a familiarity backfire effect.
- Both the information source and type seem to have an effect on the correction of misinformation; the type of news framing and technique used may impact differently on user responses.
- Strategies and interventions to promote information literacy depend on the characteristics of the target population and how deeply rooted misbeliefs are.

4. Conclusions

Below we summarised the most important findings from our assessment in Section 3.

Risk analysis: assessment, management, communication

- Risk analysis is an umbrella term that describes the whole risk process, from risk assessing hazards to managing the risks identified and finally communicating any sensitive risk-related findings and risk management measures.
- Risk analysis is a process that produces knowledge that informs how to understand, assess, characterise, communicate, manage and govern risk.
- A risk assessment is a scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation.
- The assessment branch of the analysis process aims at providing food safety regulators with the food safety related information necessary for effective decision-making, thus contributing to improved food safety and public health.
- In food safety terms, the demarcation between the two terms is clear: 'risk analysis' is a process consisting of three interconnected components: risk assessment, risk management and risk communication; 'risk assessment' is a component of risk analysis, and it is the scientifically based process consisting of four steps: hazard identification, hazard characterisation, exposure assessment and risk characterisation.
- Risk management is the process, distinct from the scientific risk assessment, of weighing policy alternatives in consultation with interested parties, considering risk assessment and other legitimate factors in order to select appropriate prevention and control options. Risk Management often includes completing a cost/benefit analysis.
- Risk communication is 'the interactive exchange of information and opinions throughout the risk analysis process as regards hazards and risks, risk-related factors and risk perceptions, among risk assessors, risk managers, consumers, feed and food businesses, the academic community and other interested parties, including the explanation of risk assessment findings and the basis of risk management decisions.'
- Risk communication involves different levels of interactive exchange: 1) the dissemination of public information about risks to consumers or other affected groups; 2) the dialogue within and between risk assessment and risk management; 3) engagement with interested parties affected by risk analysis outcomes.
- Whereas risk communication is mainly a discourse of ongoing communication intended to prevent and prepare for possible future risks, crisis communication deals with immediate

hazards and takes place within pre-crisis, emergency or post-crisis situations, such as food-borne incidents or outbreaks, which pose a risk to public health, consumer perception or may be politically sensitive.
- Generally, a crisis is an unprecedented or extraordinary event or situation that threatens a population, organisation or system, and requires a strategic, adaptive and timely response to preserve safety, viability and integrity.
- An incident is an adverse event that might be, or could lead to, a disruption, loss, emergency or crisis.
- In the context of risk communication, engagement ensures the involvement of interested parties and the exchange of information among them within a framework of open dialogue.
- The demand for participatory approaches requires not only that interaction takes into account societal concerns and perspectives but that the open dialogue adds value to the scientific process. This concept is in line with that of knowledge co-production, and must be characterised by representativeness of all interested parties, in order to generate a shared and trusted knowledge pool.

Trust and confidence

- Definitions of trust are varied and inconsistent, but overall it is clear that levels of public trust and confidence can be increased through certain acts, such as increasing transparency and tailoring risk communications.
- The distinction between trust and confidence may not operationalise across all languages as it does in English; e.g. the terms trust and confidence can both be translated as 'vertrouwen' in Dutch or 'Vertrauen' in German.
- Beliefs can be resistant to change; once trust or distrust is established, people accept information that confirm their beliefs, and discard information that contradict them.
- Trust and confidence are distinct concepts; trust is frequently based on social relationships, but one can have confidence in anything: a person, an institution or a concept. Confidence is often based on prior knowledge, experience, performance or other accumulated evidence that suggests that future events would occur as expected.
- Regulators use trust and social trust as well as trust and confidence interchangeably. This is to be avoided as studies show that the relationship between risk perceptions and trust differs depending on which of the three types of trust is being measured.
- Trust, when applied to the food system, is driven by three elements: competence, confidence and influential people.

Transparency, openness and responsiveness

- Transparency is about providing evidence behind decisions and actions taken. It calls for clear information that can contribute to increased understanding of the risk analysis process.
- Openness is reflected in the opportunity of interested parties to participate in the risk analysis process and, together with honesty and transparency, acts as an important determinant of the trustworthiness of regulatory bodies. When openness is translated into the concept of open data, it requires information provided to be accessible, comprehensible, useful to and assessable by interested parties.
- Responsiveness should be seen as organised delivery of communication in a timely manner, meeting the target audience needs through collaboration in the network of institutions and interested parties.
- In the context of ensuring transparent and open communication described in the Transparency Regulation, these principles must apply along the entire risk analysis process. This therefore includes access to information about internal processes, access to and understanding of specific risk assessment findings or management actions, engagement of interested parties along these processes through appropriate consultative fora as well as communication of risk assessment findings and risk management decisions.

Public awareness and understanding

- Becoming aware of and understanding information regarding food, food risks and food safety is an active, and often unconscious, cognitive process that mobilises information processing strategies and is influenced by motivational and emotional factors.

- The biases that are operational in risk information processing add to the fact that different groups of people refer to different mental or conceptual frameworks to understand and evaluate risk, which makes perceived risk inherently subjective. Since risk cannot be measured independently of our minds and cultures, the notion of 'real' or 'objective' risk is not useful.
- Understanding the cognitive and decision-making processes that underlie behaviour related to risks is critical for developing risk communications that are appropriately targeted and formulated.
- Population-based studies on emergency preparedness and risk responses in general are rarely supported by theoretical models of behaviour change.

Risk perception

- Risk perception refers to beliefs, attitudes, judgements and feelings; it is about opinions and it is influenced by multiple factors other than statistical calculation of risk.
- Even if the terms 'risk perception' and 'perceived risk' are used interchangeably in the literature, risk perception refers to the psychological process, while perceived risk is the outcome of that process.

The concepts of 'hazard' and 'risk'

- Hazard is a 'biological, chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect', while 'risk' is 'a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard'.
- The definitions of risk vary across the literature, some of them referring to statistical likelihood or probability (objective risk) and others adopting the term as synonym of danger or threat (subjective risk).
- While the concepts of 'hazard' and 'risk' are separate and have different meanings in risk analysis, there is ambiguity about hazard–risk judgements made by members of the general public and even experts sometimes use these terms interchangeably.

'False information': misinformation, disinformation

- The terms 'fake news' and 'false information' bring under a single umbrella at least two different notions, i.e. misinformation and disinformation which need to be differentiated in order to tackle them.
- Misinformation refers to inadvertently spreading inaccurate or misleading information, while disinformation is 'the deliberate creation and dissemination of false and/or manipulated information that is intended to deceive and mislead audiences.
- In practice, a co-occurrence of the two forms can be observed and therefore distinguishing one from the other is not straightforward.

Factors influencing risk perceptions

- Many of the papers reviewed adopted the psychometric approach, which focuses on three qualitative characteristics of the hazards which influence risk perception, namely dread, knowledge and exposure.
- A similar theory is the concept of risk as a function of hazard and outrage, this latter composed of 12 characteristics plus an additional eight features.
- Factors that have been studied as variables influencing risk perception are the characteristics of the recipients, social factors and cultural factors.
- The characteristics of the recipients include demographics, personality dispositions and traits, direct experience, perceived benefit, heuristics and biases.
- The main heuristics and biases considered are anchoring, availability, representativeness, overconfidence, optimistic bias, affect and trust (or credibility).
- Social factors are explained in the Social Amplification of Risk Framework and cultural factors have been considered by the Cultural Theory of Risk Perception.
- All these factors are included in validated models of risk perception, such as the Nested Influence Diagram for Risk Perception and the Climate Change Risk Perception Model.

Trade-offs in risk decisions

- People face a variety of trade-offs in their decision-making processes, and the ultimate effects of risk communication may be heavily influenced by those trade-offs, as discussed in examples listed below.
- Benefits of information vs. costs (e.g. costs of processing information; hedonic costs, etc.): people tend to ignore risk communication when the information is complex or it affects hedonic experiences negatively, and the perceived benefits of information are limited.
- Existing personal beliefs and social norms vs. new information: people undervalue risk communication on new risks when it goes against pre-existing beliefs or it conflicts with social norms, especially when it concerns habitual behaviours.
- Another category of trade-offs is faced by risk communicators when countervailing risks exists; how these trade-offs are dealt with depends on the remit of the risk communicator (i.e. whether risk assessors or risk managers).
- Communication of low risk when public concern is high implies a trade-off between the objective of building trust and the need to avoid unnecessary alarm, especially in conditions of high uncertainty: strong commitment to rigorous research and evidence-base communication helps to address this type of trade-off.

Approaches to audience segmentation

- Segmentation is key to understanding the characteristics of different target audiences and to then tailor communication messages to them.
- Limited literature is available on the segmentation of stakeholders in the regulatory environment. Lessons from health promotion suggest that salience and position in an organisational network can be used to map target stakeholders. Further, distinction can be made based on the proximity of different stakeholders to a specific risk and their organisation structure.
- A mapping model, developed by EFSA, which clusters audience categories into 'entry', 'informed' and 'technical' may also serve to categorise stakeholders for development of appropriate communication material. Regarding degrees of engagement, a recent report from EFSA proposes that entities in the food safety ecosystem be classified as: i) customers, ii) partners, iii) stakeholders; and iv) the (general) public.
- For the general public, depending on the specific type of risks in question, one or more of the following factors should be considered in segmentation: i) food safety knowledge; ii) personal risk perception; iii) use of food safety information and information sources and iv) trust in information coming from different actors from farm to fork.
- Consideration of sociodemographic and cultural factors is important in providing insights into identified segments but is not recommended as a segmentation criterion per se.

Appropriate information in risk communication

- The way communication objectives are set, and subsequent communication content developed, varies across different target groups, across different areas of work as well as during different phases of the risk analysis process. Regulatory bodies must consider all three of these factors when developing appropriate content.
- When discussing what to communicate, facts need to be presented in a way that interests targeted audiences, with the right balance of risk characteristics communicated in a clear and understandable manner. Framing needs to be part of the content design process – positive or 'gain' frames may attract more attention and trigger motivation to act. However, frames should not be limited to provision of selective information only, which can overgeneralise risk perceptions.
- In cases where risk analysis is characterised by high uncertainty, this may reduce confidence in the risk assessment results. Nevertheless, most authors suggest that recognising the uncertainty and communicating how uncertainty is taken into account is the appropriate communication strategy in such cases.
- Presentation of content influences understanding therefore the careful use of framing, risk comparisons, storytelling, clear, concise and jargon-free language and, where appropriate, educational content, can increase the effectiveness of risk communication.

- Open dialogue with interested parties throughout the risk analysis process is appropriate for delivering the desired two-way communication. Different combinations of risk characteristics such as complexity, uncertainty or ambiguity can help define the 'appropriate' level of stakeholder involvement in the risk analysis process.
- Different proven formats for open dialogue may be adequate, including creation of stakeholder committees, public forums or the use of public consultations.
- Public consultations need to be used in an attempt to increase scientific robustness and there should be a clear indication on how comments were used. If relevant, comments can be shared throughout risk analysis and if assessors do not use comments, they should be available to risk managers for their use.
- Transparency must be deployed cautiously and not as a quick gain, and challenges regarding opening up data, data protection and intellectual property rights must be considered across transparency initiatives. Regulators should avoid quick gains through internet-mediated transparency that do not take into account evidence-based communication science.
- Conflicts may arise during the open dialogue with multiple interested parties. In an attempt to manage these, key issues to consider are: i) understanding divergent and convergent stakeholder views; ii) identifying power dynamics in problem and solution framing; iii) translating different views into options for co-evaluation; iv) reaching compromise solutions in contested policy terrains; and v) discussing jointly the effectiveness of the co-production process itself.

Communication tools and channels

- Communication tools can be divided in three categories, i.e. information-based, dialogue-based and participation-based.
- In the area of risk perception, quantitative methods, qualitative methods, mixed methods and experimental studies can be used to gather audiences' opinions and perspectives.
- Channels can be divided into traditional media channels and social media.
- While traditional media are usually a one-way form of communication, social media channels are more engaging and enable interaction between users, therefore they could be used as amplifiers of risk information, facilitating two-way communication.
- Scientists and consumer organisations are the most trusted sources of information on food risks overall.
- There is great variety in the tools and channels used by food chain risk assessment and risk management bodies in the EU. All communication tools can be effective if properly designed, i.e. appropriate content and tone of voice for the target audience(s), and disseminated through the most appropriate selection of channels.
- Based on a review conducted by EFSA among EU actors, multimedia products demonstrate highest impact score, while social media and websites are the most frequently used dissemination channels. Communication tools supported by best practices in dissemination (e.g. use of amplifiers) perform much better and are used by a wider audience than tools that are merely published on an organisation's website.

Generic risk profiling

- Guidelines on risk profiling define it as the process of describing a food safety problem and its context, in order to identify those elements of the hazard or risk relevant to various risk management decisions.
- A typical risk profile is advised to include i) a brief description of the situation, product or commodity involved, ii) the values expected to be placed at risk, iii) potential consequences, iv) consumer perception of the risks and v) distribution of risks and benefits.
- A potential classification of risks adopts a 'traffic light system' dividing the risks in three clusters, namely normal (risks with small statistical uncertainty, low catastrophic potential and low complexity), intermediate and intolerable (risks characterised by low reliability of assessment, high statistical uncertainty and catastrophic potential).
- Based on the literature reviewed and the key factors identified, we provide a framework for developing generic risk profiles divided in four levels, i.e. i) hazard, ii) individual, iii) socio-cultural and iv) information, which can serve as basis for communication planning and development of specific risk profiles.

Risk communication models

- Risk messaging and information transmission models including the mental models and social amplification of risk approaches provide useful tools for generating the necessary inputs (understanding psychological and social/cultural factors influencing risk perceptions) to build risk communication narratives that address personal risk perceptions.
- However, there are limitations in ensuring these narratives are decodified effectively in relation to other sources of information or 'noise'.
- Also, there are inherent contradictions in any sender-to-receiver relationship – need for trust vs. loss of trust – which expose the models' limitations as frameworks for the downstream information delivery phase of risk communication.
- Solutions to these problems include increased consideration of noise and the 'social process of meaning creation and interpretation' and developing content that includes 'steps individuals can take during risk events' to cope with potential adversity.
- A risk information-seeking and processing approach helps to develop and deliver impactful messages about 'familiar risks' and behaviours in a variety of contexts to audiences segmented by their food safety knowledge needs. Increased attention is needed on the choice of formats and channels which need to be accessible to the broader public and/or specific target groups.
- Such approaches must transmit the 'availability' of actions to prevent or avoid risks and appear 'personalised' to affected populations, i.e. it should address their 'information sufficiency', the gap between people's knowledge and what they perceive they need to know to influence their information processing and information seeking.
- A protective action decision making approach may help deliver cooperative decision-making about the content of risk messaging with risks that are personal and high impact but is limited for broader societal risks or those considered to be 'low risk'.
- The risk government model and risk field models are tools for understanding risk communication as an instrument of power in modern societies.
- The risk dialogue model captures the key elements of many current engagement approaches, highlighting both the advantages and challenges of implementing effective dialogue mechanisms with representatives of competing interests in risk issues.
- Risk dialogue is essential on issues that are socially divisive, where the outcome of the scientific risk assessment is highly uncertain, or have major economic or political consequences. Further, it becomes particularly challenging during 'risk controversies' when interested parties have opposing intractable positions. Approaches oriented to co-design or co-production can help to address these problems, particularly in how to use risk communication strategies to develop risk management solutions.
- Most existing risk communication models do not account for the impact of social media on dissemination, audience targeting and heuristic processing by individuals.

Mechanisms for coordinated communication

- Complex Adaptive Systems theory allows a better understanding of underlying causes and interactions within systems, facilitating the search for commonalities in complex phenomena such as 'superorganisms' like the EU food safety system, and require clear definition of the relationships between the 'collective' and its constituent parts to ensure a common understanding of rights and responsibilities.
- Multi-level interaction for engagement and communication is shaped both by different legislative and institutional contexts, and social and cultural mechanisms that influence individual cognition and behaviour with regard to risks.
- Existing networks managed by EFSA and primarily comprising risk assessment bodies aid communication, with other EU and international networks also relevant. There are no parallel risk management networks at EU level liaising with national authorities on risk communication, however, there is strong coherence among Member States in international fora.
- A protocol specifying roles of organisations, the 'chain of command' and sharing of responsibilities would improve cooperation and coordination between authorities with clearly defined remits, mandates and tasks of all national, regional and local organisations involved. Any such mechanism must follow a partnership approach and take account of the considerable diversity and complexity of administrative structures, responsibilities and resources at national level and a multitude of competent authorities.

- The mechanisms of coordination described in the General Framework (Eds. Dreyer and Renn, 2009) are worthy of consideration since they were designed specifically for the EU food safety system.
- The Interface Committee model could suit EU-wide coordinated communications planning and execution if the basic structure is re-shaped to include representation of national risk assessors and managers.
- The purpose and mandate of such a committee would also require redesigning beyond the 'participatory-oriented' model proposed to capture additional core components of public information functions, e.g. communication strategy, audience segmentation, message and content development, dissemination and evaluation.

Foster public understanding of risk analysis

- There is limited knowledge among the public of the role and remit of risk assessors and managers.
- Scientists endeavour to evaluate risks objectively while the public often evaluate them subjectively, leading to a disparity between opinions of lay people and experts.
- To reduce the lay-expert gap, early stakeholder engagement in the process should be utilised.
- Scientific information can appear inconsistent to the public when experts update or change their opinion based on newly emerged information. The reverse may also hold.

Enhance confidence in risk analysis outcomes

- To enhance confidence in risk analysis outcomes, the public must be not only engaged in process but feel represented. Public participation in risk-related decision making democratises the process of decision making and improves the quality of resulting decisions.
- Scientific risk assessments should be complemented by environmental, economic, social and ethical assessments, in order to better reflect public concerns.
- Risk analysis must be independent of undue influence of any interested party, be it public institution, civil society or private sector.
- Communications should be clear, channelled through trusted sources (e.g. doctors, scientists) and conveyed regularly.
- Communications should clearly convey three things: the risk, how to prevent the risk, and how to integrate the risk-prevention behaviour into existing habits.
- There are challenges to incorporating and enacting an effective engagement process, such as the significant resources required to participate in engagement processes.
- To improve trust, it is recommended to build a positive reputation through consistent, proactive and informed communication.
- To overcome distrust, structural and procedural approaches should be implemented, such as engaging audiences and designing risk communication mechanisms.

Take account of risk perceptions of all interested parties

- Risk communication should embrace a two-way inclusive communication involving all relevant stakeholders, including the members of the public, characterised by participation in the risk analysis process that would facilitate identification of the public's knowledge and perceptions of risks and would support the building and maintenance of trust.
- To make two-way communication effective, a mix of quantitative and qualitative research methods is recommended for studying risk perception; subsequently adapted forms of participation need to be considered according to the type of risk and the audience.
- The need for dialogue between expert and lay publics including various stakeholders ('extended peer community') to improve the relevancy and quality of science for policy is also supported by Science and Technology Studies.

Reduce ambiguity of the perceived difference between hazard and risk

- The literature on the public perception of the difference between hazard and risk is scarce.
- The few studies identified show that the two terms are ambiguous or used interchangeably by both the general public and sometimes even by experts.
- Education in schools and universities and through continuous and ad-hoc trainings of workers who deal with risk analysis could help in increasing the knowledge, keeping in mind that short text modules have proved to result in only limited success.

- Cultural differences need to be taken into account, as the terminology is grounded in English and might differ in other languages.

Fight dissemination of 'false information' and its sources

- Socio-cognitive factors are crucial to how people select and process information, either reliable or not, and have to be taken into account to properly tackle disinformation phenomena.
- Echo chambers and strong polarisation are commonly observed on social media, and influence the way in which online users select and interact with online content and react to corrective attempts (i.e. debunking, fact-checking).
- Cognitive variables make it difficult to correct widespread belief in misinformation, causing a familiarity backfire effect.
- Both the information source and type seem to have an effect on the correction of misinformation; the type of news framing and technique used may impact differently on user responses.
- Strategies and interventions to promote information literacy depend on the characteristics of the target population and how deeply rooted misbeliefs are.

5. Recommendations

This section summarises our recommendations for follow-up activities after the completion of the request in Section 1.2, following final publication of this report and the related outsourcing (Section 1.3). These activities include: i) next steps needed to build upon the main conclusions of the report and to support the European Commission in implementing the GPRC, including research priorities to address critical data gaps; and ii) research needs of a more general nature resulting from the literature review undertaken, which could be of interest to the research community and to inform future research programmes.

Actions to consider when designing and implementing the GPRC

- Given the differences in roles of risk assessors and risk managers at EU, national, regional and local levels, a common starting point for coordinated communication should be identified. Such a common starting point could be in the form of a protocol that sets out agreed overall risk communication objectives at each stage of the risk analysis process, i.e. framing, assessment, evaluation and management. Transparency through the whole risk analysis process should be assured.
- We recommend testing the proposed framework for generic risk profiling, with a view to developing standard categories of risks, and appropriate communications content for these different categories of risks, for use during different phases of the risk analysis process. Insights obtained during such testing would allow translation of the draft framework for generic risk profiling into a practical tool for risk communication planning.
- Literature shows that regulators should be consistent in messages related to a single risk assessment and avoid multiple voices across food risk communicators in the food safety system. For coordinated communication to happen, a discussion is needed among EU and national risk managers and risk assessors on the possible repurposing of the Interface Committee[17] as a model for coordination and interaction. We propose the use of a template for synthesising the legislative and institutional mechanisms influencing communication at international/EU/national levels similar to or based on the model in the 'conceptual framework for risk communication' (Lin et al., 2020). Also, we recommend to further explore the proposal for a single coordinated platform jointly managed by risk managers, risk assessors and stakeholders along the lines of the proposed Internet Forum.[17] Finally, joint campaigns could be used as tool to raise public awareness on how the EU food safety system works and the role played by science.
- To implement an audience-first approach in risk communications, periodic EU research must capture: i) food safety knowledge; ii) risk perception and mental models of the general public; iii) use of information sources and iv) trust in different actors from farm to fork. We note it should include a mix of quantitative and qualitative methods and be: i) centrally conducted (initially), with one entity assuming coordination and identification role; ii) implemented in

[17] For details see Section 3.3.3 (Mechanisms for Coordinated Communication).

Member States, by competent national authorities, at an agreed interval, once a common research methodology is agreed upon (sustainable solution).

- Risk communicators in the EU food safety system should use the tested techniques and content types described in this report when attempting to tackle false information and its sources; at the same time, we recommend fostering further investigation of disinformation in the area of food safety. The latter is not covered extensively in the literature and additional evidence would facilitate effective implementation of the 'Tackling online disinformation' approach presented by the Commission in the area of food safety. This could be addressed by EFSA and the Communication Expert Network through the update of the EFSA Handbook on Risk Communication (EFSA, 2012, updated in 2017), scheduled to take place prior to implementation of the GPRC.

Research needs to further inform appropriate risk communication

- We would welcome academic research that explores the public perception of the difference between hazard and risk in more depth. There is probably a need to adapt this information to the specific cultures in different countries, e.g. the two terms in English are not always translatable into other languages. Addressing the lack of studies on the role of cultural differences and background on risk perceptions would also be welcome in future research.
- In the current communications context characterised by the immediacy of contacts and information sharing, social media listening should be an integral part of risk communication research and theory, and consider risk perception, and information seeking and processing behaviours. Use of technology-supported tools for automation of research at community level should also be explored, including use of flash polls or app-driven public opinion analyses.
- Evidence suggests that multiple formats can support open dialogue with interested parties. We would welcome research that explores how engagement initiatives in the EU, often deploying the public consultation format, have contributed to the robustness of final scientific or policy documents. These lessons should be considered when designing and choosing formats for future engagement with interested parties.
- Trade-offs play an important role in risk communication, as consumers may struggle to compare different risks or benefits of products or substances and processes used to develop them. Research on the most effective ways to deliver such information could provide insights into whether this can be tackled by risk communication solely, or whether it requires underlying assessments to include risk–risk or risk–benefit analyses.
- In general, we found that most research covering theories and models for behaviour change is often not linked to applied work and not integrated with research on other relevant psychological or socio-cultural factors. This is regrettable for risk communication as all these factors need to be integrated if communication is required to cover both assessment and management of risks. We recommend such interdisciplinary research be coordinated through EU research programmes; also, we encourage joint initiatives involving social scientists at regulatory bodies (e.g. Commission, EFSA, ECHA, EMA, ECDC, EEA, JRC, national authorities) to connect relevant societal insights along the risk analysis process.

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Abbreviations

BfR	German Federal Institute for Risk Assessment
CEN	Communications Experts Network
CCRPM	Climate Change Risk Perception Model
CDC	Centers for Disease Control and Prevention
CERC	Crisis and Emergency Risk Communication
ECDC	European Centre for Disease Prevention and Control
FAO	Food and Agricultural Organization
FAIR	Factor analysis of information risk
FSA	Food Standards Agency
GPRC	General Plan for Risk Communication
IRGC	International Risk Governance Council
ISSLG	International Social Science Liaison Group
JRC	Joint Research Centre
MACOSPOL	Mapping Controversies on Science for Politics
NCA	National Competent Authorities
NIST	National Institute of Standards and Technology
NZFSA	New Zealand Food Safety Authority
OECD	Organisation for Economic Co-operation and Development
RISP	Risk Information Seeking and Processing Model
RFM	Risk Field Model
RDM	Risk Dialogue Model
TCC	Trust, Confidence and Cooperation
PADM	Protective Action Decision Model
WHO	World Health Organization
WMO	World Meteorological Organization